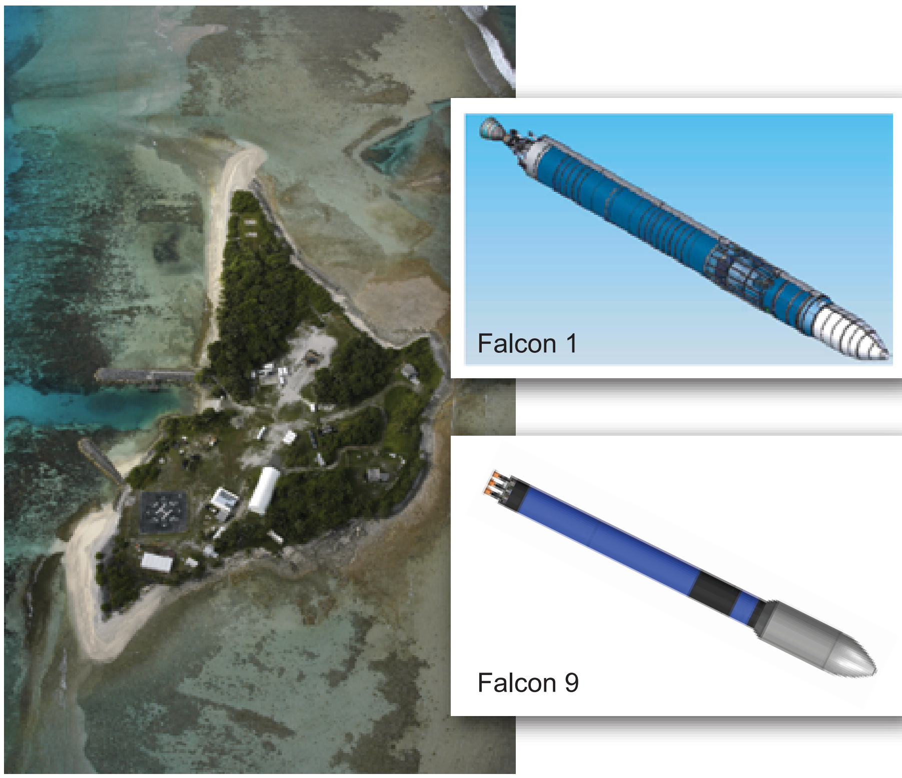
SpaceX Falcon Program



Environmental Assessment

27 September 2007

U.S. Army Space and Missile Defense Command/
U.S. Army Forces Strategic Command
P.O. Box 1500
Huntsville, AL 35807-3801

SPACEX FALCON PROGRAM
ENVIRONMENTAL ASSESSMENT

U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND/U.S. ARMY FORCES STRATEGIC COMMAND

AGENCY: U.S. Army Space and Missile Defense Command/U.S. Army Forces Strategic Command

ACTION: Finding of No Significant Impact

BACKGROUND: Pursuant to the Council on Environmental Quality regulations for implementing the procedural provisions of the National Environment; Policy Act (40 Code of Federal Regulations [CFR]; 32 CFR Part 651, *Environmental Analysis of Army Actions* (Army Regulation 200-2), and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, the U.S. Army Space and Missile Defense Command prepared an Environmental Assessment (EA) to analyze the environmental consequences of launches of Falcon 1 and Falcon 9 launch vehicles with satellite or sub-orbital payloads from Omelek Islet at the U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site (USAKA/RTS). The Falcon Launch Vehicle Program is a venture by Space Exploration Technologies, Inc. (SpaceX) to provide space launch operations of U.S. Government (Department of Defense [DoD] and other federal entities) and non-U.S. Government (commercial and foreign) payloads. SpaceX is a privately-held company that is developing the Falcon Launch Vehicle Program to put small spacecraft into orbit with high reliability and low cost.

As required by the Commercial Space Launch Activities Act, SpaceX will pursue a commercial launch license for non U.S. Government payloads. The Federal Aviation Administration, which is a Cooperating Agency, will use the analysis of this EA to support its environmental determination to issue the launch license for the Falcon Program.

The 2004 Proof-of-Principle Space Launches from Omelek Island EA only analyzed the impacts of two launches, and modifications (bringing temporary buildings to the island and improvements to island infrastructure) to the existing site were meant to be minimal or temporary. Equipment was removed from the island between missions, and the facilities were cleaned and secured after each launch. The two initial SpaceX launches were intended to test and verify the concept of the new launch vehicle before making a long-term investment at USAKA (Omelek). A Finding of No Significant Impact was signed on 8 February 2005.

A Record of Environmental Consideration (REC) was signed in August 2006 to authorize (1) an additional five Falcon 1 launches from Omelek, (2) installation of a trailer (with electrical connections) in an existing cleared area, (3) construction of a concrete secondary containment structure and, (4) installation of a 50-kilowatt (kW) generator to be used during non-launch periods to eliminate the need to operate the larger 400-kilovolt generators. SpaceX is interested in performing more Falcon 1 launches and expanding capabilities to accommodate launches of a larger vehicle, the Falcon 9, from Omelek.

DESCRIPTION OF THE PROPOSED ACTION: The Proposed Action is to conduct launch operations placing small and medium class payloads (less than 907 kilograms

[2,000 pounds]) to 6,804 kilograms [15,000 pounds]) into orbit from Omelek using Falcon 1 and Falcon 9 launch vehicles. Falcon 1 launches would continue as follow-on from the five flights authorized in the REC signed in August 2006. The Falcon 9 system launches would begin in 2008 after site preparation. An average of six Falcon 1 launches per year is planned for the next 10 years, and up to four Falcon 9 launches per year starting after 2008. All flights would have either a satellite or a sub-orbital payload.

The Falcon 1 is a light-lift, two-stage launch vehicle designed to put small spacecraft into orbit with high reliability and low cost. Only the first stage is recoverable. One SpaceX Merlin engine powers the Falcon 1 first stage, and one SpaceX Kestrel engine powers the second stage. The Falcon 1 uses the liquid propellants liquid oxygen (LOX) and RP-1 (kerosene). Some payloads could contain small amounts of liquid or solid propellants for use in orbit after the flight.

The Falcon 9 is a two-stage, medium class, liquid launch vehicle that would launch space systems and satellites into orbit. The first stage of the Falcon 9 includes nine Merlin engines—the same engine used on the first stage of the Falcon 1. The second stage uses one or two Merlin engines. For the near term, only unmanned missions are planned. The propellants for the vehicle itself (both stages) are LOX and RP-1. The payloads may carry quantities of these or other propellants including nitrogen tetroxide, monomethyl hydrazine, other hydrazine propellants, and solid propellants. Upon arrival at USAKA, the propellants would be transferred directly to the certified facility on Meck Islet. The first stage of the Falcon 9 would be recovered and reused. The second stage would be reused when launch inclination, payload requirements, and weight allow for its recovery.

Both vehicles would arrive at USAKA in two stages, each fully assembled. Depending on the landing craft schedules, the vehicles would be transferred to Omelek or stored in an existing physically secured area on Kwajalein. The stages would be inspected, assembled, tested, and moved to the launch site. The Falcon 1 and Falcon 9 vehicles would use separate launch sites on Omelek, though the Falcon 9 site may accommodate Falcon 1 launches on occasion. Both vehicles would be erected on the launch pad by hydraulic erector systems. Payloads would be processed at Omelek in the near term and on Kwajalein when facilities there are available. Both vehicles would be fueled on the pad, and RP-1 and LOX would be loaded the day of the launch. The goal is to launch within 1 month of payload arrival at the launch site.

Both launch vehicles would normally be equipped with a thrust termination system that terminates thrust of the stage engines in the event of an anomaly in flight causing the vehicle to fall intact along the trajectory path. For some missions, the Falcon 9 would have an alternative explosive termination package that would terminate the flight by opening the vehicle tanks to disperse propellants once the package was activated. The debris would fall over a wider area but in smaller pieces. The termination system type would be based on the required trajectory and the payload.

In addition to standard payloads, the Falcon 9 vehicle may also carry a capsule as a payload that is being developed to deliver cargo to the International Space Station under contract with the National Aeronautics and Space Administration. This capsule named Dragon would be processed similarly to any other payload. After completion of its mission to deliver cargo, the Dragon would re-enter the atmosphere on a pre-planned trajectory, soft-land in the ocean, and be recovered by a recovery vessel similar to the Falcon 9 first stage.

To support the proposed sustained launch activities, several improvements would be required on Omelek, including construction of a Falcon 9 launch pad and hangar facility, upgrades to existing propellant storage and loading facilities, and other site infrastructure improvements. SpaceX proposes to perform these activities in two construction phases. The first phase begins upon approval of the construction permit (anticipated in Fall 2007) and runs through Spring 2008. In this phase, the first few missions of the Falcon 9 vehicle would occur, and support for Falcon 1 launches would continue. The second phase would occur over several years (2008 through 2011) and would focus on upgrading site facilities to improve launch program efficiency.

Two facilities are proposed for Kwajalein: a LOX plant facility and a Payload Processing Facility. All construction and launch activities of the Falcon 1 and 9 launch programs would comply with the USAKA Environmental Standards (UES) and the USAKA/RTS Range Safety Requirements.

Falcon 1 launch activities have not substantially changed from those proposed in the Proof-of-Principle EA. However, most equipment would be stored on Omelek between missions rather than removed from the island. Falcon 9 pre-launch activities would be very similar to those of Falcon 1. Once the Falcon 9 stages arrive separately via landing craft or barge, they would be placed in the Falcon 9 processing hangar on Omelek. The stages would be checked and prepared for mating.

NO-ACTION ALTERNATIVE: Under the No-action Alternative, the proposed Falcon launch vehicle activities would not be conducted at Omelek, and SpaceX would not proceed with further new construction or modification efforts at USAKA or launches beyond the five that have been authorized. SpaceX would be unable to launch additional satellite payloads into orbit from USAKA/RTS and would be required to consider less suitable alternative launch sites to continue the program.

ENVIRONMENTAL EFFECTS: Thirteen broad areas of environmental consideration were considered to provide a context for understanding the potential effects of the Proposed Action and to provide a basis for assessing the severity of potential impacts. These areas included air quality, airspace, biological resources, cultural resources, environmental justice, geology and soils, hazardous materials and waste, health and safety, infrastructure, land use, noise, socioeconomics, and water resources. These areas were analyzed as applicable for the proposed location or activity. All activities would be carried out in compliance with applicable federal and USAKA/RTS regulations and requirements.

Air Quality

Site preparation emissions are not anticipated to cause exceedances of the UES. Additionally, implementation of standard dust suppression methods (frequent watering) and a vehicle maintenance program (proper tuning and preventive maintenance of vehicles) would minimize fugitive dust emissions and vehicle exhaust emissions, respectively, and would help to maintain the area’s current air quality. Due to the exclusion of the public from the immediate vicinity of construction, the public would not be exposed to emissions. Once construction is completed, air quality is anticipated to return to its former level.

Levels of generator emissions are considerably below the threshold levels and are not anticipated to impact the regional air quality or exceed the USAKA ambient air standard. However, the 2006 Air Quality Document of Environmental Protection (DEP) indicates that the smaller, currently operating generators may not comply with the incremental degradation standards allowed by the UES. If so, it can be assumed that compliance would not be achieved with the proposed generators. There are operational options that would achieve compliance with ambient air quality and incremental degradation standards. Options could include limiting the fuel consumption per year or increasing the stack heights of the generators. SpaceX is also considering the addition of a wind-based power generator for use between missions when power needs are reduced. The LOX plant proposed for Kwajalein would be operated using the existing power supply already subject to the DEP. It is not likely that any other element of the LOX plants would meet or exceed the emission thresholds for major stationary sources.

Each launch event is considered to be a discrete event that generates short-term impacts to the local air quality. An average of six Falcon 1 launches per year is planned for the next 10 years, and up to four Falcon 9 launches per year starting after 2008. Long-term effects resulting from launches are not expected because the launches would be infrequent and the resulting emissions would be rapidly dispersed and diluted by winds.

Airspace

Although site preparation activities (i.e., equipment delivery) could involve flights in and out of Bucholz Army Airfield on Kwajalein, they would not restrict access to, nor affect the use of, existing airfields and airports in the region of influence. Operation at the airfield would continue unobstructed. No modification to or new requirements for special use airspace would be required. No changes to existing air routes or additional restricted access to regional airfields and airports are anticipated. All arriving and departing aircraft and all participating military aircraft are under the control of the Bucholz Army Airfield Control Tower; thus, there would be no airfield conflicts in the region of influence, and no effect.

Omelek is located under international airspace and, therefore, has no formal airspace restrictions governing it. Commercial and private aircraft would be notified in advance of Falcon launch activities by USAKA/RTS as part of their routine operations through Notices to Airmen by the Federal Aviation Administration. Provision would be made for surveillance of the affected airspace in accordance with Army regulations. In addition, launch operations would be suspended when it is known or suspected that unauthorized aircraft have entered any part of the airspace above the launch hazard zone until the unauthorized entrant has been removed or a thorough check of the suspected area has been performed.

Only the proposed flight operations have the potential for impacts to airspace use in the ocean environment. Typically, a launch vehicle would be at very high altitude passing through Flight Level 600 (approximately 18,290 meters [60,000 feet]) in just a matter of minutes after launch, and thus well above the airspace subject to the rules and regulations of the International Civil Aviation Organization Convention. Aircraft transiting the Open Ocean on one of the low-altitude airways and/or high-altitude jet routes that would be affected by launch activities would be notified of any necessary rerouting before departing their originating airport and would therefore be able to take on additional fuel before takeoff.

Biological Resources

In order to accomplish the Falcon 1 and 9 launches, approximately an additional 10 percent of the total acreage of Omelek containing trees (primarily *Pisonia* trees) and other vegetation would need to be removed from a portion of the north point, south point, and along the west coast, currently low scrub of the island. These areas could be re-planted with palm trees and other vegetation that may help stabilize the coastline. Some trees would also need to be removed from around the Falcon 1 launch site for long-term use, and from the area of the Falcon 9 hangar. Continuation of habitat enhancement projects on Eniwetak Islet would be used to offset the vegetation removal.

Immediately prior to their shipment to Omelek, prefabricated buildings and all other materials would be inspected by a certified pest control inspector and, if necessary, treated for the removal of pests (e.g., rats, mice, and ants) and other non-native organisms to prevent their potential spread and introduction to other USAKA islands.

Construction noise and the increased presence of personnel could temporarily affect wildlife within the area. Construction ground disturbance and equipment noise-related impacts could include loss of habitat, displacement of wildlife, and short-term disruption of daily/seasonal behavior. Although construction activities could cause flushing (birds suddenly flying up), this is a common reaction to sudden natural sounds that only slightly increases the energy expenditure of individual birds, and while some might potentially leave the immediate area permanently, others may likely become accustomed to the increased noise and human presence. The removal of vegetation discussed above would likely result in the permanent removal of some of the habitat available for nesting seabirds or foraging shorebirds on Omelek.

If SpaceX later decides to no longer use Omelek for the Falcon Program, they would return the islet to its current condition (to the extent practicable) in coordination with USAKA/RTS. This action could include removal of some or all of the new roads and paved areas, removal of some or all of any new facilities, and re-foresting selected areas with regional vegetation that would provide nesting, roosting, and resting habitat for seabirds.

Sedimentation from installing pilings and a concrete barge dock 3 meters (10 feet) into the harbor could temporarily degrade water quality in the vicinity due to short-term turbidity. Effects to reef fish in the region of influence and to benthic species such as crabs from turbidity would be temporary. The area has been previously dredged. Best Management Practices such as silt curtains and operational controls to reduce turbidity would be used if required. Work would be delayed if threatened and endangered species (such as sea turtles) are observed in the area until any such species observed has moved out of harm’s way or leaves the area.

Prior to their arrival on Omelek, SpaceX personnel would be briefed on the need to respect and protect sensitive island resources, including the remaining native forest, and to avoid harassment of sensitive species. Personnel would be instructed to stay on existing roads and paths where possible. Onsite supervisors would ensure that personnel comply with the briefing objectives.

Within 2 hours prior to the launch, SpaceX personnel would survey the shoreline within 100 meters (328 feet) on both sides of the launch site to determine whether sea turtles are present in the water or hauling out at this area. If turtles are observed in the area, SpaceX would consult with USAKA Environmental before continuing with launch activities. Reasonable measures could be taken to return animals to the water prior to launch. If the survey indicates that the sand level increased and covers the rocky outcrop near the launch pad along the shore line, then a fence may be required in accordance with the requirements of the Proof-of-Principle EA if turtles are observed in the area. The survey would be documented and mitigation efforts would be kept on site readily available for inspection. If turtle nests are discovered, then SpaceX personnel would contact USAKA Environmental who would consult with the appropriate UES agencies.

Debris impact and booster drops in the broad ocean area would not occur within the 322-kilometer (200-mile) limit of the Exclusive Economic Zone of affected islands. Hydrocarbon fuels such as kerosene that reach the ocean surface would spread quickly on the surface from the effects of gravity, wind, and waves. Most of the fuel would evaporate from the ocean surface within a few hours. The remainder would disperse in the water column and degrade. Debris impact and booster drops in the open ocean area are not expected to adversely affect marine mammal species protected by the Marine Mammal Protection Act of 1972. There is a low probability that migratory whales or sea turtles would be within the area to be impacted by falling debris and boosters. The potential for an object or objects dropping from the air to affect marine mammals or other marine biological resources is less than 10^{-6} (1 in 1 million). The probability of a spent missile landing on a cetacean or other marine mammal is remote.

The first stage of the Falcon launch vehicles may be attached to a parachute system and recovered. The second stage of the Falcon 9 could also be recovered if so designed. Entanglement of a marine mammal or sea turtle in a parachute and potential drowning would be very unlikely since the parachute would either have to land directly on an animal, or an animal would have to swim blindly into it before it is recovered or sinks to the ocean floor. The potential for a marine mammal or sea turtle to be in the same area and have physical contact with a parachute is remote.

Cultural Resources

Ground-disturbing activities at Omelek would be planned so that archaeologically sensitive areas such as those areas in the northern portion of the islet that contain old broadleaf forest would be avoided to the extent possible. If the proposed facilities cannot be located to avoid these areas, archaeological monitoring with systematic sampling as necessary would accompany construction of any facilities. To minimize disturbance to cultural resources, appropriate measures would be taken, such as installing signage to designate sensitive areas and educating facility personnel on protecting sensitive island resources.

All of the buildings and structures on Omelek prior to SpaceX activity were constructed between 1962 and 1990 and have been recently determined not to be eligible for listing on the Republic of the Marshall Islands National Register.

Geology and Soils

Site preparation activities and other necessary prelaunch activities are not expected to result in any adverse geological or soil impacts. Although site preparation activities would subject soils to wind, possible erosion would be minimal due to the short duration and limited to the immediate vicinity of the construction site. Best Management Practices, such as regular watering of excavated material as required, would furthermore reduce the potential for soil erosion.

Since the Falcon launch vehicles use LOX and kerosene propellants, the emission products (carbon monoxide, carbon dioxide, hydrogen, and water) lack hazardous materials and would consist primarily of steam. In the unlikely event of an accidental release of kerosene, emergency response personnel would comply with the guidance provided in the UES and any applicable SpaceX plans.

Hazardous Material and Waste

All hazardous materials used and waste generated during site preparation activities would be handled, transported, stored, treated, and disposed of off-site in accordance with a Hazardous Materials Contingency Plan and Hazardous Waste Management Plan to be prepared by SpaceX. These plans would follow regulations established in the UES, the Kwajalein Environmental Emergency Plan, and SpaceX emergency plans. SpaceX personnel would perform pollution prevention, waste minimization, and recycling measure where applicable.

The Falcon 1 would carry small payloads, consisting mostly of non-hazardous materials. Some payloads may use small amounts of liquid or solid propellants for on-orbit maneuvering. Falcon 9 payloads would almost always include some additional propellants on board, for either orbit maintenance or orbital insertion burns. The propellants would be used only after the payload separates from the Falcon launch vehicle. A trained immediate response spill team would be established onsite and spills would be contained and cleaned up according to the procedures identified in the Kwajalein Environmental Emergency Plan and a SpaceX-specific emergency plan. USAKA would ensure compliance.

Health and Safety

Proposed construction activities for the Falcon 1 and Falcon 9 Launch Vehicle Program would comply with all applicable UES and USAKA/RTS Range Safety Requirements.

All operations involving explosives (including packaging and handling for movement) would require implementation of a written procedure, which has been approved by the USAKA/RTS Safety Office. These operations must be conducted under the supervision of an approved ordnance officer using explosive-certified personnel. Kwajalein Missile Range Regulation 385-75, *Explosive Safety,* currently specifies the required explosive safety quantity-distances for each facility to ensure safety in the event of explosion, based upon the maximum quantity of explosive material permitted for the facility. This would serve to prevent propagation of explosions to nearby facilities where explosives are also stored.

USAKA/RTS conducts missile flight safety, which includes overflights of the area around USAKA/RTS prior to any launch and analysis of missile performance capabilities and limitations of hazards inherent in missile operations and destruct systems, and of the electronic characteristics of missiles and instrumentation. It also includes computation and review of trajectories and hazard area dimensions; review and approval of destruct systems proposals; and preparation of the Range Safety Approval and Range Safety Operational Plans required of all programs. Falcon launches would not be permitted to occur without review and agreement by the Range Safety Officer. Protection circles, based on the payload, missile and launch azimuth, would be established for each launch. Access to Omelek would be limited to all but mission essential persons. Personnel would be evacuated from the islet prior to launch.

Infrastructure

Road design would also include an evaluation of rainwater drainage on Omelek, and rainwater control channels or conduit would be installed during paving construction. Rainwater run-off from paved areas on Omelek could be managed by allowing rainwater to collect in some low areas and diverting run-off via culverts to vegetated areas or to the harbor. SpaceX would like to use a combination of approaches: (1) allow run-off to drain naturally along the access road to the north and along the paved roads to the east towards vegetated areas and (2) construct surface or underground culverts to divert water from the central and southern portions of the island to the harbor.

The new helipad would allow access to Omelek by helicopter for emergency use and for occasional transportation to and from the island. Relocating the helipad to the southeast side would reduce the potential of impacting the approach and departure path when other new facilities are added. To facilitate access to Omelek by cargo barges in addition to the currently used landing craft vessels, a series of pilings would be installed on the south side of the harbor.

New facilities and upgrades are proposed for Omelek under Phase 1 and Phase 2 construction. Power, communications, water, and sewage would be routed through new underground conduits to and from the facilities. The new storage area located to the east on Omelek would store kerosene and diesel fuel in aboveground tanks or standardized containers, located within a concrete containment area. The storage and containment area could store enough fuel for at least three Falcon 9 launches.

In Phase 2, a reverse osmosis unit would be installed to generate approximately 11,356 liters (3,000 gallons) of water per day to support the deluge system and other non-potable uses. Other water uses including rinsing, washing, bathing, laundry, and cooking is prohibited. If at a later date the system is to be used for potable water applications, it would have to meet requirements of the UES, such as chlorination and monitoring. A DEP would also have to be developed and approved prior to any potable use of the water from the reverse osmosis unit.

Until Phase 1 construction is complete, the 400-kW generator is expected to provide site power 60 percent of the time. Under Phase 2 construction two 1,000-kVA generators would supply power on the island during launch activities. A 100-kVA generator would provide power during non-launch periods. Power would be transported to the various areas either through existing or newly constructed conduits below ground, or via temporary above-ground cable trays.

SpaceX is considering the addition of a wind-based power generator (not yet designed) for use between missions when power needs are reduced. The wind generator would likely be two commercial grade 50- to 100-kW generators.

Land Use

Site preparation activities are consistent with the mission of the island and would not conflict with any known land use plans, policies, or controls. Falcon 1 and 9 launches are entirely consistent with the mission of the island and would not conflict with any land use plans, policies, or controls of USAKA.

The establishment and activation of a launch hazard area would require the temporary clearance of the adjoining Pacific Ocean in front of the launch site. Temporary clearance of this launch hazard area should have no impacts on recreational or commercial use of these waters since the area off the island is not used frequently by commercial fishermen or for recreational use by USAKA personnel (all of whom work for the U.S. Government or U.S. Government contractors). As part of USAKA range safety practices, the Mid-atoll Corridor is maintained as a closed area during mission operations. All boat traffic is prohibited for a period encompassing any mission activity.

Noise

Noise produced during site preparation activities such as construction, upgrades, and relocation of facilities would be minor and short-term, resulting in little to no effect on construction workers or launch personnel.

No noise sensitive noise receptors are in the vicinity. Omelek has been developed as a launch support facility with no permanent inhabitants occupied in unrelated activities and there are no inhabited islets within 21 kilometers (13 miles); thus adverse impacts from launch activities due to launch noise are not anticipated.

Socioeconomics

Approximately 30 people would be involved in both Falcon 1 and Falcon 9 launch activities. Up to 8 of the 30 SpaceX personnel would live temporarily on Omelek in the SpaceX office facility, as required. The remaining transient personnel would be lodged on Kwajalein and transported daily between the two islands. No additional facilities would be required to house personnel.

Launch procedures on Omelek could continue to employ a small number of Marshallese from Ebeye and possibly from Majuro in support of ground and facility maintenance and technical support on the island. Personal income of the potential Marshallese employed in support of the increase in launches from Omelek may increase. There would be no impact on the permanent population size, employment characteristics, and the type of housing available on Ebeye or Majuro.

Water Resources

Construction of the new Falcon 9 launch pad and the Payload Processing Facility would be confined within the immediate construction area in compliance with the UES and would thus not impact water resources. Impacts to the waters surrounding Omelek, particularly the harbor area, due to the potential increase in stormwater runoff would be in compliance with the UES nonpoint source requirements and the Stormwater Management Plan. Installation of new pilings and the proposed concrete barge dock would produce short-term water quality degradation, or turbidity and sediment transport. Best Management Practices would be used to limit turbidity, such as silt curtains if required. The installation would be in accordance with the 2003 Routine Maintenance Dredging and Filling DEP. Water resources could also be impacted by potential accidental spills of petroleum and other materials during construction activities. However, emergency response personnel would comply with the Kwajalein Environmental Emergency Plan prepared by USAKA in accordance with the UES and standard operating procedures for spill prevention, control and countermeasures would be used to minimize any impacts.

The steam produced during launch is anticipated to have the same pH as rainwater; that, combined with the fact that most of the steam from the exhaust plume is expected to rapidly evaporate, should produce no long-term effects.

CONCLUSION: The resulting environmental analysis shows that no significant impacts would occur from the proposed Falcon Program activities. Preparation of an Environmental Impact Statement, therefore, is not required. A follow-up action list will be developed and completed by the Executing Agent to ensure compliance with the actions described in the EA. The EA and draft Finding of No Significant are available at: http://www.smdcen.us/spacex.

DEADLINE FOR RECEIPT OF WRITTEN COMMENTS: 30 October 2007

POINT OF CONTACT: Submit written comments or requests for a copy of the SpaceX Falcon Program EA to:

U.S. Army Space and Missile Defense Command/
U.S. Army Forces Strategic Command
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SPACEX FALCON PROGRAM
ENVIRONMENTAL ASSESSMENT

U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND/
U.S. ARMY FORCES STRATEGIC COMMAND

ACTION: Finding of No Significant Impact

REVIEWED:

DATE: 5 DEC 07

HAROLD BUHL
Lieutenant Colonel, AR
Commanding
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SPACEX FALCON PROGRAM
ENVIRONMENTAL ASSESSMENT

U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND/
U.S. ARMY FORCES STRATEGIC COMMAND

ACTION: Finding of No Significant Impact

REVIEWED:

[signature] DATE: 6 DEC 04

WILLIAM WHITNEY
Lieutenant Colonel, AV
Director, Kwajalein Support Directorate

SPACEX FALCON PROGRAM
ENVIRONMENTAL ASSESSMENT

U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND/
U.S. ARMY FORCES STRATEGIC COMMAND

ACTION: Finding of No Significant Impact

APPROVED:

______________________ DATE: 12/6/07

STEVENSON L. REED
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This Environmental Assessment (EA) analyzes the impacts of launching Falcon 1 and Falcon 9 launch vehicles with satellite or sub-orbital payloads from Omelek Islet at the U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site (USAKA/RTS). The Falcon Launch Vehicle Program is a venture by Space Exploration Technologies, Inc. (SpaceX), a privately-held company, to provide U.S. Government and non-U.S. Government space launch operations.

The Falcon 1 is a light-lift, two-stage launch vehicle. Its first stage would be recovered and its parts reused; the second stage would not be recovered. The Falcon 9 is a two-stage launch vehicle in the medium launch class. Its first stage would also be recovered and reused, and the second stage would be recovered and reused under some circumstances. SpaceX plans an average of six Falcon 1 launches per year for the next 10 years. The Falcon 9 system launches would begin in 2008 after site preparation and would include up to four Falcon 9 launches per year thereafter.

Several improvements would be required on Omelek, including construction of a Falcon 9 launch pad and hangar facility, upgrades to existing propellant storage and loading facilities, and several other site infrastructure improvements. Two facilities are proposed for Kwajalein: a Liquid Oxygen Plant Facility and a Payload Processing Facility.

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Introduction

This Environmental Assessment (EA) has been prepared by the U.S. Army Space and Missile Defense Command/U.S. Army Forces Strategic Command (USASMDC/ARSTRAT) to analyze the impacts of launches of Falcon 1 and 9 launch vehicles with satellite or sub-orbital payloads from Omelek Islet at the U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site (USAKA/RTS). The Falcon Launch Vehicle Program is a venture by Space Exploration Technologies, Inc. (SpaceX) to provide U.S. Government and non-U.S. Government space launch operations.

SpaceX is a privately-held company that is developing the Falcon Launch Vehicle Program to put small spacecraft into orbit with high reliability and low cost. The Falcon 1 is a light-lift, two-stage launch vehicle (meaning, the first stage would be recovered and its parts reused, whereas the second stage would not be recovered). The Falcon 9 is a two-stage launch vehicle in the medium launch class. As such, the first stage would be recovered and its parts reused, and the second stage would be recovered and reused under some circumstances.

In 2004, USASMDC/ARSTRAT prepared the *Proof-of-Principle Space Launches from Omelek Island Environmental Assessment* that analyzed the impacts of conducting two space launches of the Falcon 1 launch vehicle with satellite payloads from Omelek. The Finding of No Significant Impact was signed in 2005. Because launch activities had not been conducted at Omelek since 1996, SpaceX performed limited refurbishment of existing buildings on Omelek, added temporary buildings, and made minimal infrastructure improvements in order to operate a temporary launch facility for the Falcon 1 launch vehicle.

A Record of Environmental Consideration (REC) was signed in August 2006 to allow an additional five Falcon 1 launches from Omelek. This REC authorized installation of a trailer (with electrical connections) in an existing cleared area adjacent to the J.A. Jones Building and construction of a concrete secondary containment structure to replace the temporary RP-1 fuel (kerosene) storage. The REC also authorized installation of a 50-kilowatt (kW) generator (to be used during non-launch periods) that would eliminate the need to operate the larger 400-kilovolt generators analyzed in the EA, thus minimizing fuel consumption and air emissions.

Proposed Action

The purpose of the Proposed Action is to conduct launches, beyond the proof-of-principle launches, of small and medium class satellites and sub-orbital payloads into space from Omelek using the Falcon 1 launch vehicle and expanding SpaceX capabilities on the islet to accommodate launches of the Falcon 9 vehicle.

The Falcon Launch Vehicle Program is designed to reduce vehicle assembly and payload processing times on the launch pad by completing much of the assembly at the SpaceX facilities in El Segundo, California. The goal is to launch within 1 month of payload arrival at the launch site. To meet this goal, payload processing must be accelerated and launch pad use must be limited. SpaceX plans an average of six Falcon 1 launches per year for the next 10 years. The Falcon 9 system launches would begin in 2008 after site preparation and would include up to four Falcon 9 launches per year thereafter.

Located near the equator at approximately 9° north latitude, USAKA/RTS provides the only U.S.-controlled equatorial launch site. An equatorial launch site is preferred because low inclination launch vehicles receive extra velocity from the Earth's rotation, which reduces the amount of fuel needed to launch spacecrafts and increases the size of the payload that can be lifted to a given orbit with a given amount of fuel. Launching near the equator also reduces the energy required for orbit plane change maneuvers, which saves fuel and increases the operational lifetime of satellite payloads.

The Falcon 1 is a light-lift, two-stage launch vehicle designed to put small spacecraft into orbit with high reliability and low cost. Only the first stage is recoverable. The Falcon 1 uses the liquid propellants liquid oxygen (LOX) and RP-1, a type of kerosene commonly used as a rocket propellant. Some payloads could contain small amounts of liquid or solid propellants for use in orbit after the flight.

The Falcon 9 is a two-stage, medium class, liquid launch vehicle that would launch space systems and satellites into orbit. For the near term, only unmanned missions are planned. The propellants for the vehicle itself (both stages) are LOX and kerosene. The payloads may carry quantities of these or other propellants including nitrogen tetroxide, monomethyl hydrazine, other hydrazine propellants, and solid propellants. Upon arrival at USAKA, the propellants would be transferred directly to the certified facility on Meck Islet. The first stage of the Falcon 9 would be recovered and reused. The second stage would be reused when launch inclination, payload requirements, and weight allow for its recovery.

The Falcon 1 and 9 launch vehicles would arrive at USAKA in two stages, each fully assembled. Depending on the landing craft schedules, the vehicles would be transferred to Omelek or stored in an existing physically secured area on Kwajalein Islet. The stages would be inspected, assembled, tested, and moved to the launch site. The Falcon 1 and Falcon 9 vehicles would use separate launch sites on Omelek, though the Falcon 9 site may accommodate Falcon 1 launches on occasion. Both vehicles would be erected on the pad by hydraulic erector systems. Payloads would be processed at Omelek in the near term and on Kwajalein when facilities there are available. Both vehicles would be fueled on the pad, and kerosene and LOX would be loaded the day of the launch. The goal is to launch within 1 month of payload arrival at the launch site.

Several improvements would be required on Omelek, including construction of a Falcon 9 launch pad and a hangar facility, upgrades to existing propellant storage and loading facilities, and several other site infrastructure improvements. Two facilities are proposed for Kwajalein: a LOX plant facility and a Payload Processing Facility.

In addition to standard payloads, the Falcon 9 vehicle may also carry a capsule as a payload that is being developed to deliver cargo to the International Space Station (ISS) under contract with the National Aeronautics and Space Administration (NASA). This capsule, named Dragon, is between 3.7 and 5.2 meters (12 to 17 feet) tall and similar in design to the Apollo command capsule. Prior to launch, the Dragon would be processed similarly to any other payload. After completion of its mission to deliver cargo to the ISS, the Dragon will re-enter the atmosphere on a pre-planned trajectory, soft-land in the ocean, and be recovered by a recovery vessel similar to the Falcon 9 first stage. The capsule may contain down-cargo from the ISS for return to Earth, and may also carry trash for disposal. All materials brought down from the station will be delivered to NASA unless directed otherwise. The capsule may or may not be refurbished and re-used. Recovery zones are currently being planned; however, locations in the Gulf of Mexico, the coast of California, and the Kwajalein Atoll are being considered.

Approximately 30 people would be involved in both Falcon 9 and Falcon 1 launch preparation activities. Up to eight SpaceX personnel would live temporarily on Omelek in the SpaceX office facility, as required. The remaining personnel would be lodged on Kwajalein and transported between the two islands on a daily basis.

Both the Falcon 1 and Falcon 9 flight vehicles allow recovery of the spent first stage by use of a parachute attached to the front end of the first stage. The location of the stage's ocean impact would vary with each mission. The first stage would be recovered by USAKA/RTS or commercial recovery personnel and returned to Kwajalein. Residual kerosene would remain on-board until the vehicle arrives at the refurbishment facility. Residual LOX would generally boil-off before recovery operations begin, vaporizing before arriving at Kwajalein. SpaceX would transport the recovered booster to their facilities in El Segundo for reconditioning and reuse. The second stage of Falcon 1 would eventually reenter the atmosphere, burning up on reentry; it is unlikely that debris would reach the earth. The Falcon 9 second stage could be recovered if so designed. In this event, the stage would reenter the atmosphere upon a pre-programmed trajectory and would impact a predetermined position. Recovery of the second stage would be similar to recovery of the first stage.

SpaceX would continue to use many of the existing facilities as authorized in the 2004 Proof-of-Principle Space Launches from Omelek Island EA. Additionally, SpaceX proposes to construct several new facilities, relocate select facilities, and improve the general infrastructure to support Falcon 1 and 9 launch vehicle operations. These facility and infrastructure improvements would occur in two construction phases. The first phase begins upon approval of the construction permit (anticipated in Fall 2007) and runs through Spring 2008. In this phase, the first few missions of the Falcon 9 vehicle would occur, and support for Falcon 1 launches would continue. The second phase would occur over several years (2008 through 2011) and would focus on upgrading site facilities to improve launch program efficiency.

In order to accomplish the Falcon 1 and 9 launches, trees and other vegetation would need to be removed from a portion of the north point of the islet. In addition, vegetation would need to be removed from the south point and along the west coast, currently low scrub. These areas could be re-planted with palm trees and other vegetation that may help stabilize the coastline. Some trees would also need to be removed from around the Falcon 1 launch site for long-term use, and from the area of the Falcon 9 hangar. To prevent erosion of the coastline, particularly on the ocean side, some shoreline reinforcement is planned.

If SpaceX later decides to no longer use Omelek for the Falcon Program, they would return the islet to its current condition (to the extent practicable) in coordination with USAKA/RTS. This action could include removal of some or all of the new roads and paved areas, removal of some or all of any new facilities, and re-foresting selected areas with regional vegetation that would provide nesting, roosting, and resting habitat for seabirds.

No-Action Alternative

Under the No-action Alternative, the proposed Falcon launch activities would not be conducted at Omelek, and SpaceX would not proceed with further new construction or modification efforts at USAKA or launches beyond the five that have been authorized. SpaceX would be unable to launch additional satellite payloads into orbit from USAKA/RTS and would be required to consider less suitable alternative launch sites to continue the program.

Impact Assessment Methodology

Thirteen broad areas of environmental consideration were originally considered to provide a context for understanding the potential effects of the Proposed Action and to provide a basis for assessing the severity of potential impacts. These areas included air quality, airspace, biological resources, cultural resources, environmental justice, geology and soils, hazardous materials and waste, health and safety, infrastructure, land use, noise, socioeconomics, and water resources. These areas were analyzed as applicable for the proposed location or activity.

Results

This section summarizes the conclusions of the analyses made for each of the areas of environmental consideration.

Air Quality

Site preparation emissions are not anticipated to cause exceedances of the USAKA Environmental Standards (UES). Additionally, implementation of standard dust suppression methods (frequent watering) and a vehicle maintenance program (proper tuning and preventive maintenance of vehicles) would minimize fugitive dust emissions and vehicle exhaust emissions, respectively, and would help to maintain the area's current air quality. Due to the exclusion of the public from the immediate vicinity of construction, the public would not be exposed to emissions. Once construction is completed, air quality is anticipated to return to its former level.

Levels of generator emissions are considerably below the threshold levels and are not anticipated to impact the regional air quality or exceed the USAKA ambient air standard. However if, as the 2006 Air Quality Document of Environmental Protection (DEP) indicates, the smaller, currently operating generators may not comply with the incremental degradation standards allowed by the UES, it can be assumed that compliance will not be achieved with the proposed generators. There are operational options that would achieve compliance with ambient air quality and incremental degradation standards. Options could include limiting the fuel consumption per year or increasing the stack heights of the generators. SpaceX is also considering the addition of a wind-based power generator for use between missions when power needs are reduced. The LOX plant proposed for Kwajalein would be operated using the existing power supply that is already subject to the DEP. It is not likely that any other element of the LOX plants would meet or exceed the emission thresholds for major stationary sources.

Each launch event is considered to be a discrete event that generates short-term impacts to the local air quality. An average of six Falcon 1 launches per year is planned for the next 10 years, and up to four Falcon 9 launches per year starting after 2008. Long-term effects resulting from launches are not expected because the launches would be infrequent and the resulting emissions would be rapidly dispersed and diluted by winds.

Airspace

Although site preparation activities (i.e., equipment delivery) could involve flights in and out of Bucholz Army Airfield on Kwajalein, they would not restrict access to, nor affect the use of, existing airfields and airports in the region of influence. Operation at the airfield would continue unobstructed. Similarly, the existing airfield or airport arrival and departure traffic flows would not be affected. No modification to or new requirements for special use airspace would be required. No changes to existing air routes or additional restricted access to regional airfields and airports are anticipated. All arriving and departing aircraft and all participating military aircraft are under the control of the Bucholz Army Airfield Control Tower; thus, there would be no airfield conflicts in the region of influence, and no effect.

Omelek is located under international airspace and, therefore, has no formal airspace restrictions governing it. Commercial and private aircraft would be notified in advance of Falcon launch activities by USAKA/RTS as part of their routine operations through Notices to Airmen by the Federal Aviation Administration. Provision would be made for surveillance of the affected airspace in accordance with Army regulations. In addition, safety regulations dictate that launch operations would be suspended when it is known or suspected that any unauthorized aircraft have entered any part of the airspace above the launch hazard zone until the unauthorized entrant has been removed or a thorough check of the suspected area has been performed. No new special use airspace would be required as a result of launch activities.

Only the proposed flight operations have the potential for impacts to airspace use in the ocean environment. Typically, a missile would be at very high altitude passing through Flight Level 600 (approximately 18,290 meters [60,000 feet]) in just a matter of minutes after launch, and thus well above the airspace subject to the rules and regulations of the International Civil Aviation Organization Convention. Aircraft transiting the Open Ocean on one of the low-altitude airways and/or high-altitude jet routes that would be affected by launch activities would be notified of any necessary rerouting before departing their originating airport and would therefore be able to take on additional fuel before takeoff.

Biological Resources

In order to accomplish the Falcon 1 and 9 launches, approximately an additional 10 percent of the total acreage of Omelek containing trees (primarily *Pisonia* trees) and other vegetation would need to be removed from a portion of the north point of the island. In addition, vegetation would need to be removed from the south point and along the west coast, currently low scrub. These areas could be re-planted with palm trees and other vegetation that may help stabilize the coastline. Some trees would also need to be removed from around the Falcon 1 launch site for long term use, and from the area of the Falcon 9 hangar.

Immediately prior to their shipment to Omelek, prefabricated buildings and all other materials would be inspected by a certified pest control inspector and, if necessary, treated for the removal of pests (e.g., rats, mice, and ants) and other non-native organisms to prevent their potential spread and introduction to other USAKA islands.

Construction noise and the increased presence of personnel could temporarily affect wildlife within the area. Construction ground disturbance and equipment noise-related impacts could include loss of habitat, displacement of wildlife, and short-term disruption of daily/seasonal behavior. Although construction activities could cause flushing (birds suddenly flying up), this is a common reaction to sudden natural sounds that only slightly increases the energy expenditure of individual birds, and while some might potentially leave the immediate area permanently, others may likely become accustomed to the increased noise and human presence. The removal of vegetation discussed above would result in the more or less permanent removal of some habitat available for nesting seabirds or foraging shorebirds on Omelek. Continuation of habitat enhancement projects on Eniwetak Islet would be used to offset effects of the planned vegetation removal.

Sedimentation from installing pilings and a concrete barge dock 3 meters (10 feet) into the harbor could temporarily degrade water quality in the vicinity due to short-term turbidity. Effects to reef fish in the region of influence and to benthic species such as crabs from turbidity would be temporary. The area has been previously dredged. Best Management Practices such as silt curtains and operational controls to reduce turbidity would be used if required. Work would be delayed if threatened and endangered species (such as sea turtles) are observed in the area until any such species observed has moved out of harm's way or leaves the area.

Prior to their arrival on Omelek, SpaceX personnel would be briefed on the need to respect and protect sensitive island resources, including the remaining native forest, and to avoid harassment of sensitive species. Personnel would be instructed to stay on existing roads and paths where possible. Onsite supervisors would ensure that personnel comply with the briefing objectives.

Within 2 hours of the launch, SpaceX personnel would survey the shoreline within 100 meters (328 feet) on both sides of the launch site to determine whether sea turtles are present in the water or hauling out at this area. If turtles are observed in the area, then SpaceX would consult with USAKA Environmental before continuing with launch activities. Reasonable measures could be taken to return animals to the water prior to launch. If the survey indicates that the sand level increased and covers the rocky outcrop near the launch pad along the shore line, then a fence may be required in accordance with the requirements of the Proof-of-Principle Space Launches from Omelek Island EA if turtles are observed in the area. The survey would be documented and mitigation efforts would be kept on site readily available for inspection. If turtle nests are discovered, then SpaceX personnel would contact USAKA Environmental, who would consult with the appropriate UES agencies.

If SpaceX later decides to no longer use Omelek for the Falcon Program, they would return the islet to its current condition (to the extent practicable) in coordination with USAKA/RTS. This action could include removal of some or all of the new roads and paved areas, removal of some or all of any new facilities, and re-foresting selected areas with regional vegetation that would provide nesting, roosting, and resting habitat for seabirds.

The proposed flight operations would have no discernible or measurable effect on the ocean's overall physical and chemical properties, and thus would have no impacts to the overall marine biology of the ocean area. The Pacific Ocean depth in the vicinity of the launch area is thousands of meters (feet) deep, and any area affected by release of the propellant would be relatively small due to the size of the Falcon's motor or propellant relative to the quantity of seawater. Consequently, any impact from the fuel is expected to be minimal.

Debris impact and booster drops in the broad ocean area would not occur within the 322-kilometer (200-mile) limit of the Exclusive Economic Zone of affected islands. Hydrocarbon fuels such as kerosene that reach the ocean surface would spread quickly on the surface from the effects of gravity, wind, and waves. Most of the fuel would evaporate from the ocean surface within a few hours. The remainder would disperse in the water column and degrade. Debris impact and booster drops in the open ocean area are not expected to adversely affect marine mammal species protected by the Marine Mammal Protection Act of 1972. There is a low probability that migratory whales or sea turtles would be within the area to be impacted by falling debris and boosters. The potential for an object or objects dropping from the air to affect marine mammals or other marine biological resources is less than 10^{-6} (1 in 1 million). The probability of a spent missile landing on a cetacean or other marine mammal is remote.

The first stage of the Falcon launch vehicles may be attached to a parachute system and recovered. The second stage of the Falcon 9 could also be recovered if so designed. Entanglement of a marine mammal or sea turtle in a parachute and potential drowning would be very unlikely since the parachute would either have to land directly on an animal, or an animal would have to swim blindly into it before it is recovered or sinks to the ocean floor. The potential for a marine mammal or sea turtle to be in the same area and have physical contact with a parachute is remote.

Cultural Resources

Ground-disturbing activities at Omelek would be planned so that archaeologically sensitive areas such as those areas in the northern portion of the islet that contain old broadleaf forest would be avoided to the extent possible. If the proposed facilities cannot be located to avoid these areas, archaeological monitoring with systematic sampling as necessary would accompany construction of any facilities. To minimize disturbance to cultural resources, appropriate measures would be taken, such as installing signage to designate sensitive areas and educating facility personnel on protecting sensitive island resources.

All of the buildings and structures on Omelek prior to SpaceX activity were constructed between 1962 and 1990 and have been recently determined not to be eligible for listing on the Republic of the Marshall Islands National Register.

Geology and Soils

Site preparation activities and other necessary prelaunch activities are not expected to result in any adverse geological or soil impacts. Although site preparation activities would subject soils to wind, possible erosion would be minimal due to the short duration and limited to the immediate vicinity of the construction site. Best Management Practices, such as regular watering of excavated material as required, would furthermore reduce the potential for soil erosion.

Since the Falcon launch vehicles use LOX and kerosene propellants, the emission products (carbon monoxide, carbon dioxide, hydrogen, and water) lack hazardous materials and would consist primarily of steam. In the unlikely event of an accidental release of kerosene, emergency response personnel would comply with the guidance provided in the UES and any applicable SpaceX plans.

Hazardous Materials and Waste

All hazardous materials used and waste generated during site preparation activities would be handled, transported, stored, treated, and disposed of off-site in accordance with a Hazardous Materials Contingency Plan and Hazardous Waste Management Plan to be prepared by SpaceX. These plans would follow regulations established in the UES, the Kwajalein Environmental Emergency Plan, and SpaceX emergency plans. SpaceX personnel would perform pollution prevention, waste minimization, and recycling measure where applicable.

The Falcon 1 would carry small payloads, consisting mostly of non-hazardous materials. Some payloads may use small amounts of liquid or solid propellants for on-orbit maneuvering. Falcon 9 payloads would almost always include some additional propellants on board, for either orbit maintenance or orbital insertion burns. The propellants would be used only after the payload separates from the Falcon launch vehicle. A trained immediate response spill team would be established onsite and spills would be contained and cleaned up according to the procedures identified in the Kwajalein Environmental Emergency Plan and a SpaceX-specific emergency plan.

Health and Safety

Proposed construction activities for the Falcon 1 and Falcon 9 Launch Vehicle Program would comply with all applicable UES and USAKA/RTS Range Safety Requirements.

All operations involving explosives (including packaging and handling for movement) would require implementation of a written procedure, which has been approved by the USAKA/RTS Safety Office. These operations must be conducted under the supervision of an approved ordnance officer using explosive-certified personnel. Kwajalein Missile Range Regulation 385-75, *Explosive Safety,* currently specifies the required explosive safety quantity-distances for each facility to ensure safety in the event of explosion, based upon the maximum quantity of explosive material permitted for the facility. This would serve to prevent propagation of explosions to nearby facilities where explosives are also stored.

USAKA/RTS conducts missile flight safety, which includes overflights of the area around USAKA/RTS prior to any launch and analysis of missile performance capabilities and limitations of hazards inherent in missile operations and destruct systems, and of the electronic characteristics of missiles and instrumentation. It also includes computation and review of trajectories and hazard area dimensions; review and approval of destruct systems proposals; and preparation of the Range Safety Approval and Range Safety Operational Plans required of all programs. Falcon launches would not be permitted to occur without review and agreement by the Range Safety Officer. Protection circles, based on the payload, missile and launch azimuth, would be established for each launch. Access to Omelek would be limited to all but mission essential persons. Personnel would be evacuated from the islet prior to launch.

Infrastructure

Road design would also include an evaluation of rainwater drainage on Omelek, and rainwater control channels or conduit would be installed during paving construction. Rainwater run-off from paved areas on Omelek could be managed by allowing rainwater to collect in some low areas and diverting run-off via culverts to vegetated areas or to the harbor. SpaceX would like to use a combination of approaches: (1) allow run-off to drain naturally along the access road to the north and along the paved roads to the east towards vegetated areas and (2) construct surface or underground culverts to divert water from the central and southern portions of the island to the harbor.

The new helipad would allow access to Omelek by helicopter for emergency use and for occasional transportation to and from the island. Relocating the helipad to the southeast side would reduce the potential of impacting the approach and departure path when other new facilities are added. To facilitate access to Omelek by cargo barges in addition to the currently used landing craft vessels, a series of pilings would be installed on the south side of the harbor.

New facilities and upgrades are proposed for Omelek under Phase 1 and Phase 2 construction. Power, communications, water, and sewage would be routed through new underground conduits to and from the facilities. The new storage area located to the east on Omelek would store kerosene and diesel fuel in aboveground tanks or standardized containers, located within a concrete containment area. The storage and containment area could store enough fuel for at least three Falcon 9 launches.

In Phase 2, a reverse osmosis unit would be installed to generate approximately 11,356 liters (3,000 gallons) of water per day to support the deluge system and other non-potable uses. Other water uses including rinsing, washing, bathing, laundry, and cooking is prohibited. If at a later date the system is to be used for potable water applications, it would have to meet requirements of the UES, such as chlorination and monitoring. A DEP would also have to be developed and approved prior to any potable use of the water from the reverse osmosis unit.

Until Phase 1 construction is complete, the 400-kW generator is expected to provide site power 60 percent of the time. Under Phase 2 construction, two 1,000-kilovolt-amperes (kVA) generators would supply power on the island during launch activities. A 100-kVA generator would provide power during non-launch periods. Power would be transported to the various areas either through existing or newly constructed conduits below ground, or via temporary above-ground cable trays.

SpaceX is considering the addition of a wind-based power generator (not yet designed) for use between missions when power needs are reduced. The wind generator would likely be two commercial grade 50- to 100-kW generators.

Land Use

Site preparation activities are consistent with the mission of the island and would not conflict with any known land use plans, policies, or controls.

Falcon 1 and 9 missile launches are entirely consistent with the mission of the island and would not conflict with any land use plans, policies, or controls of USAKA. The establishment and activation of a launch hazard area would require the temporary clearance of the adjoining Pacific Ocean in front of the launch site. Temporary clearance of this launch hazard area should have no impacts on recreational or commercial use of these waters since the area off the island is not used frequently by commercial fishermen or for recreational use by residents of USAKA (all of whom work for the U.S. Government or U.S. Government contractors). As part of USAKA range safety practices, the Mid-atoll Corridor is maintained as a closed area. All boat traffic is prohibited for a period encompassing any flight test activity.

Noise

Noise produced during site preparation activities such as construction, upgrades, and relocation of facilities would be minor and short-term, resulting in little to no effect on construction workers or launch personnel.

No noise sensitive noise receptors are in the vicinity. Omelek has been developed as a launch support facility with no permanent inhabitants occupied in unrelated activities and there are no inhabited islets within 21 kilometers (13 miles); thus adverse impacts from launch activities due to launch noise are not anticipated.

Socioeconomics

Approximately 30 people would be involved in both Falcon 1 and Falcon 9 launch activities. Up to 8 of the 30 SpaceX personnel would live temporarily on Omelek in the SpaceX office facility, as required. The remaining transient personnel would be lodged on Kwajalein and transported daily between the two islands. No additional facilities would be required to house personnel.

Launch procedures on Omelek could continue to employ a small number of Marshallese from Ebeye and possibly from Majuro in support of ground and facility maintenance and technical support on the island. Personal income of the potential Marshallese employed in support of the increase in launches from Omelek may increase. There would be no impact on the permanent population size, employment characteristics, and the type of housing available on Ebeye or Majuro.

Water Resources

Construction of the new Falcon 9 launch pad and the Payload Processing Facility would be confined within the immediate construction area in compliance with the UES and would thus not impact water resources. Impacts to the waters surrounding Omelek due to stormwater runoff would be in compliance with the UES nonpoint source requirements and the Stormwater Management Plan. Installation of new pilings and the proposed concrete barge dock would produce short-term water quality degradation, or turbidity and sediment transport. Best Management Practices would be used to limit turbidity, such as silt curtains if required. The installation would be in accordance with the 2003 Routine Maintenance Dredging and Filling DEP. Water resources could also be impacted by potential accidental spills of petroleum and other materials during construction activities. However, emergency response personnel would comply with the Kwajalein Environmental Emergency Plan prepared by USAKA in accordance with the UES and standard operating procedures for spill prevention, control and countermeasures would be used to minimize any impacts.

The steam produced during launch is anticipated to have the same pH as rainwater; that, combined with the fact that most of the steam from the exhaust plume is expected to rapidly evaporate, should produce no long-term effects.

Cumulative Impacts

The Proposed Action would consist of six Falcon 1 launches and four Falcon 9 launches per year. The proposed activities would not occur at the same time as other programs such as Ground-Based Midcourse Defense or Minuteman III planned for the region. The increased size and use of the power station may not comply with the allowable UES incremental degradation standards. There are operational options that would achieve compliance with ambient air quality and incremental degradation standards. SpaceX is considering the addition of a wind-based power generator for use between missions when power needs are reduced. Other operational options could include limiting the fuel consumption per year or increasing the stack heights of the generators. If one or a combination of these options was implemented, it is not likely that the Proposed Action at Omelek would result in cumulative impacts to the regional air quality.

Missile launches are short-term, discrete events actively managed by USAKA/RTS range safety, thus allowing time between launches for emission products to be dispersed and minimizing the potential for impacts to airspace users, biological resources, and public health and safety. Using the required scheduling process for international airspace would minimize the potential for cumulative impacts to the airspace above the open ocean. The loss of an additional 12 percent of the vegetation on Omelek would contribute cumulatively to the reduction of wildlife habitat in the area. No significant cumulative impacts to terrestrial or marine biological resources have been identified as a result of prior launch-related activities in the region. Overall avoidance would minimize the potential for cumulative cultural resources impacts. Preparation of the launch site and adherence to established hazardous waste and spill prevention procedures and regulations would minimize the potential for cumulative impacts to geology or soils.

Adherence to the hazardous materials and waste management systems of USAKA/RTS and SpaceX would preclude the potential accumulation of hazardous materials or waste. The UES establishes emergency response procedures that would aid in the evaluation and cleanup of any hazardous materials released. Adherence to the high safety standards at USAKA/RTS would serve to keep any cumulative safety impacts attributable to all USAKA/RTS operations within acceptable standards to both workers and the public. The additional demand on transportation, electrical, wastewater, solid waste, and water systems to support the small number of project-related personnel would be accomplished by the proposed infrastructure upgrades or be within the current capacity of USAKA/RTS. The sound level generated by each Falcon launch would be a short, discrete event and no cumulative impacts are anticipated. Adherence to established hazardous waste and spill prevention procedures and regulations would minimize the potential for cumulative impacts to water resources.

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ACRONYMS AND ABBREVIATIONS

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$\mu g/m^3$	Micrograms per Cubic Meter
μPa	Micropascal
AFB	Air Force Base
ARTCC	Air Route Traffic Control Center
C	Celsius
CFR	Code of Federal Regulations
dB	Decibel(s)
dBA	A-weighted Decibel(s)
DEP	Document of Environmental Protection
DoD	Department of Defense
DOT	Department of Transportation
EA	Environmental Assessment
EIS	Environmental Impact Statement
F	Fahrenheit
FAA	Federal Aviation Administration
FL	Flight Level
FONSI	Finding of No Significant Impact
HVAC	Heating, Ventilation, and Air Conditioning
ICAO	International Civil Aviation Organization
ISS	International Space Station
KEEP	Kwajalein Environmental Emergency Plan
kVA	Kilovolt Ampere
kW	Kilowatt
LHA	Launch Hazard Area
LN2	Liquid Nitrogen
LOX	Liquid Oxygen
MMH	Monomethyl Hydrazine
MON	Mixed Oxides of Nitrogen
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
NTO	Nitrogen Tetroxide
pH	Hydrogen Ion Concentration

PHT	Propellant Hazard Team
PVC	Polyvinyl Chloride
RCC	Range Commanders Council
REC	Record of Environmental Consideration
RF	Radiofrequency
RMI	Republic of the Marshall Islands
RTS	Ronald Reagan Ballistic Missile Test Site
SCAPE	Self-Contained Atmospheric Protective Ensemble
SpaceX	Space Exploration Technologies, Inc.
UDMH	Unsymmetrical Dimethylhydrazine
UES	U.S. Army Kwajalein Atoll Environmental Standards
USAKA	U.S. Army Kwajalein Atoll
USASMDC/ARSTRAT	U.S. Army Space and Missile Defense Command/U.S. Army Forces Strategic Command
VOC	Volatile Organic Compound

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PURPOSE AND NEED FOR PROPOSED ACTION

1.0 PURPOSE AND NEED FOR PROPOSED ACTION

This Environmental Assessment (EA) has been prepared by the U.S. Army Space and Missile Defense Command/U.S. Army Forces Strategic Command (USASMDC/ARSTRAT) to analyze the impacts of launches of Falcon 1 and 9 launch vehicles with satellite or sub-orbital payloads from Omelek Islet (Figures 1-1 through 1-3) at the U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site (USAKA/RTS). The Falcon Launch Vehicle Program is a venture by Space Exploration Technologies, Inc. (SpaceX) to provide U.S. Government and non-U.S. Government space launch operations.

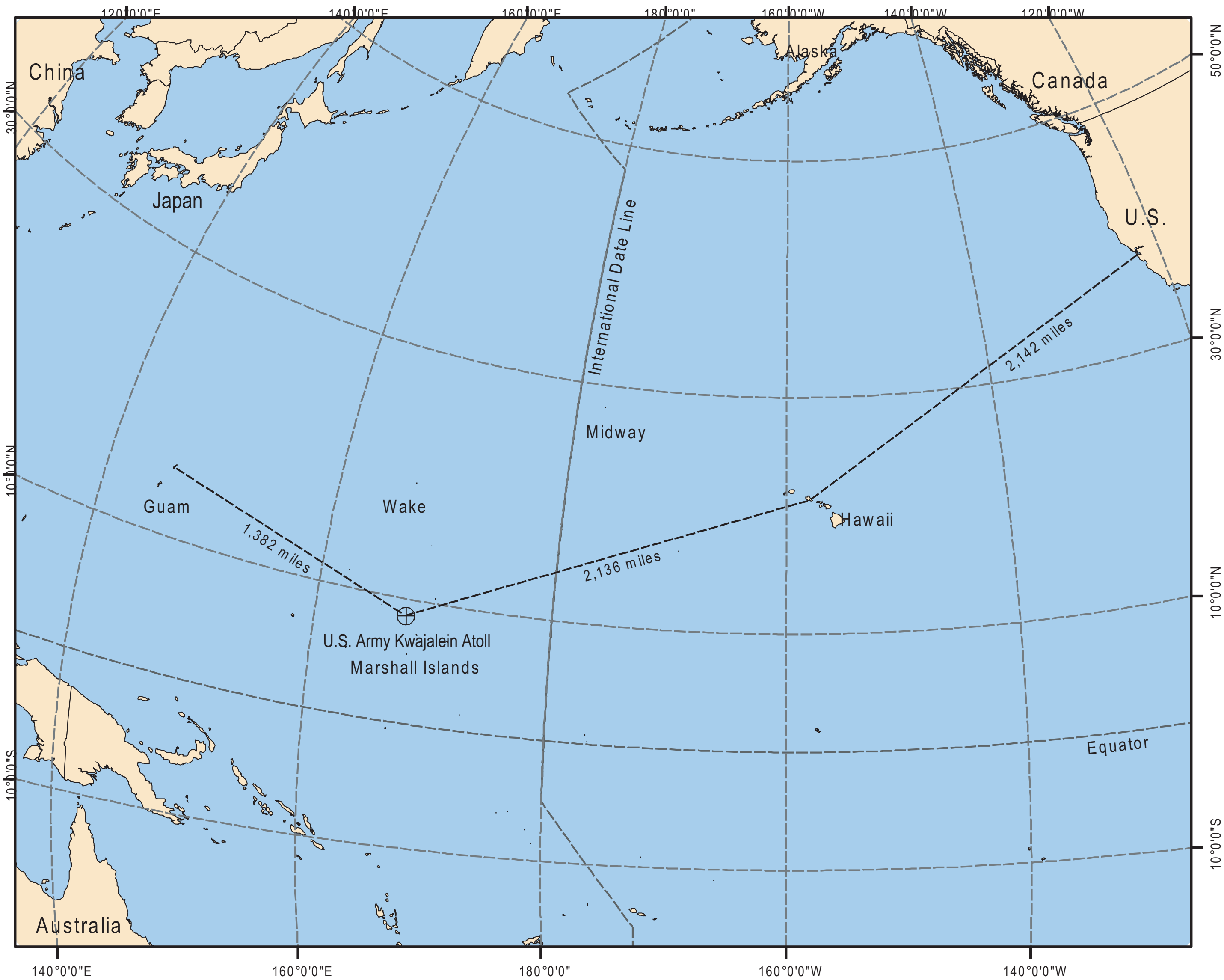
1.1 BACKGROUND

SpaceX is a privately-held company that is developing the Falcon Launch Vehicle Program to put small spacecraft into orbit with high reliability and low cost. The Falcon 1 (Figure 1-4) is a light-lift, two-stage launch vehicle (meaning, the first stage would be recovered and its parts reused, whereas the second stage would not be recovered). The Falcon 9 (Figure 1-5) is a two-stage launch vehicle in the medium launch class. As such, the first stage would be recovered and its parts reused, and the second stage would be recovered and reused under some circumstances.

The Falcon 1 and 9 launch vehicles use only liquid fuels; however, some payloads could use limited quantities of liquid or solid propellants in orbit after the flight. The Falcon Launch Vehicle Program is designed to reduce vehicle assembly and payload processing times on the launch pad by completing much of the assembly at the SpaceX facilities in El Segundo, California. The goal is to launch within 1 month of payload arrival at the launch site. To meet this goal, payload processing must be accelerated and launch pad use must be limited. SpaceX plans an average of six Falcon 1 launches per year for the next 10 years. The Falcon 9 system launches would begin in 2008 after site preparation and would include up to four Falcon 9 launches per year thereafter.

In 2004, USASMDC/ARSTRAT prepared the Proof-of-Principle Space Launches from Omelek Island EA that analyzed the impacts of conducting two space launches of the Falcon 1 launch vehicle with satellite payloads from Omelek Island at the USAKA/RTS. The Finding of No Significant Impact (FONSI) was signed in 2005. Because launch activities had not been conducted at Omelek since 1996, SpaceX performed limited refurbishment of existing buildings on Omelek, added temporary buildings, and made minimal infrastructure improvements in order to operate a temporary launch facility for the Falcon 1 launch vehicle. The term “proof-of-principle launches” used in this document refers to the 2004 EA and the two space launches approved in that EA.

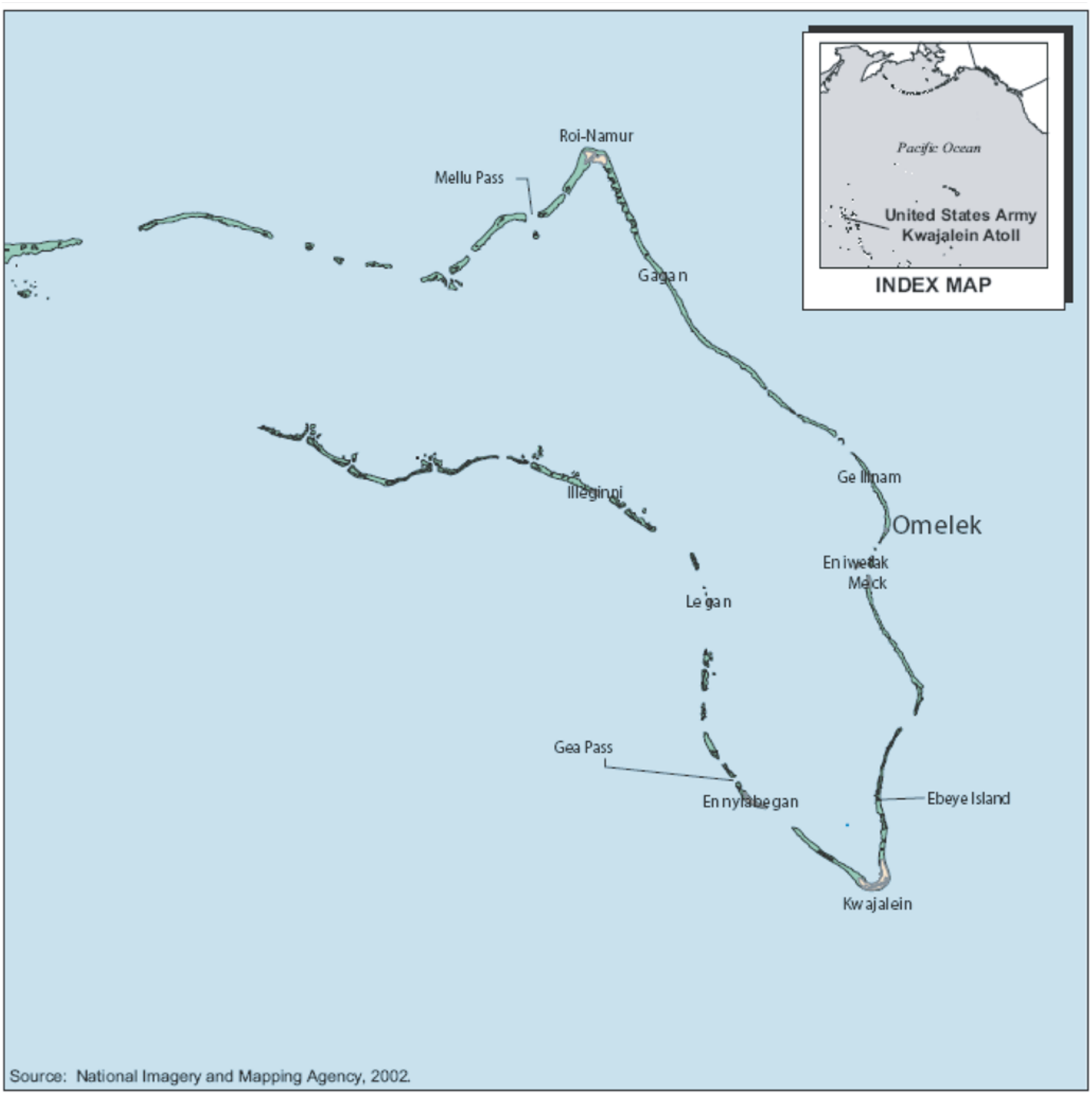
The Proof-of-Principle Space Launches from Omelek Island EA only analyzed the impacts of two launches, and modifications to the existing site were meant to be minimal or temporary. Equipment was removed from the island between missions, and the facilities were cleaned and secured after each launch. The two initial SpaceX launches were intended to test and verify the concept of the new launch vehicle before making a long-term investment at USAKA (Omelek).



Regional Location of Kwajalein Atoll

Pacific Ocean

Figure 1-1



Source: National Imagery and Mapping Agency, 2002.

U.S. Army Kwajalein Atoll

Pacific Ocean

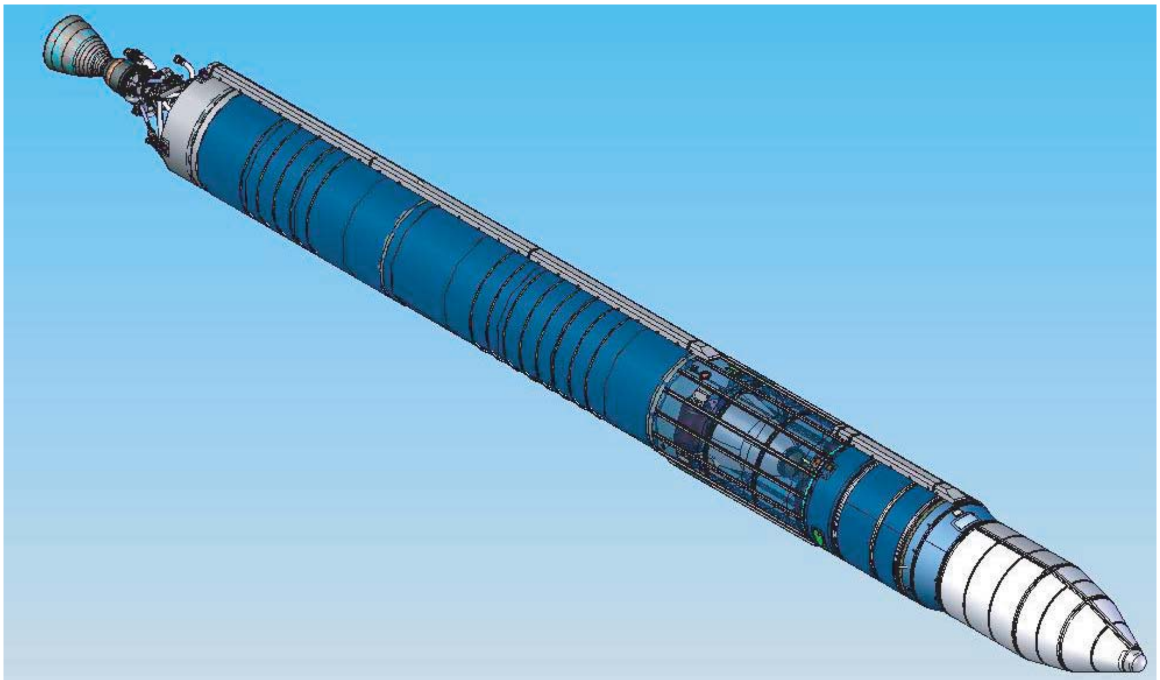
NORTH

Figure 1-2

Omelek Islet

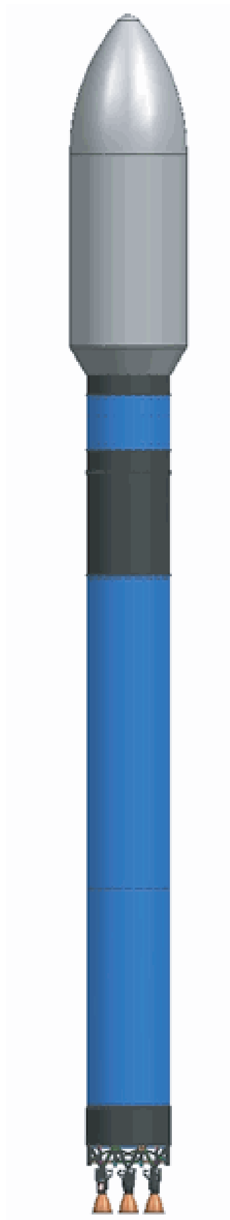
U.S. Army Kwajalein Atoll

Figure 1-3



Falcon 1 Launch Vehicle

Figure 1-4



Falcon 9 Launch Vehicle

Figure 1-5

A Record of Environmental Consideration (REC) was signed in August 2006 to allow an additional five Falcon 1 launches from Omelek. This REC authorized installation of a trailer (with electrical connections) in an existing cleared area adjacent to the J.A. Jones Building and construction of a concrete secondary containment structure to replace the temporary RP-1 fuel storage. The REC also authorized installation of a 50-kilowatt (kW) generator (to be used during non-launch periods) that would eliminate the need to operate the larger 400-kilovolt generators, thus minimizing fuel consumption and air emissions. SpaceX is interested in performing more Falcon 1 launches and expanding capabilities to accommodate launches of a larger vehicle, the Falcon 9, from Omelek.

In order to accomplish the Falcon 1 and 9 launches, trees and other vegetation would need to be removed from a portion of the north point of the islet. In addition, vegetation would need to be removed from the south point and along the west coast, currently low scrub. These areas could be re-planted with palm trees and other vegetation that may help stabilize the coastline. Some trees would also need to be removed from around the Falcon 1 launch site for long-term use, and from the area of the Falcon 9 hangar. To prevent erosion of the coastline, particularly on the ocean side, some shoreline reinforcement is planned.

If SpaceX later decides to no longer use Omelek for the Falcon Program, they would return the islet to its current condition (to the extent practicable) in coordination with USAKA/RTS. This action could include removal of some or all of the new roads and paved areas, removal of some or all of any new facilities, and re-foresting selected areas with regional vegetation that would provide nesting, roosting, and resting habitat for seabirds.

1.2 SCOPE OF ENVIRONMENTAL ASSESSMENT

USASMDC/ARSTRAT complied with the following statutes and regulations that direct Department of Defense (DoD) lead-agency officials to consider potential environmental consequences when authorizing or approving federal actions:

- The National Environmental Policy Act (NEPA) of 1969, as amended
- The Council on Environmental Quality regulations that implement NEPA (Code of Federal Regulations [CFR], Title 40, Parts 1500-1508)
- DoD Instruction 4715.9, Environmental Planning and Analysis
- Executive Order 12114, Environmental Effects Abroad of Major Federal Actions
- 32 CFR Part 651 Environmental Analysis of Army Actions (Army Regulation 200-2)
- Environmental Standards and Procedures for United States Army Kwajalein Atoll (USAKA) Activities in the Republic of the Marshall Islands, Tenth Edition, January 2006

This EA describes the events necessary to conduct the proposed satellite and sub-orbital launches from Omelek, including new construction on the island. It also presents the decision-maker with a concise analysis of anticipated environmental consequences that would result from conducting the proposed flights. Actions occurring within the United States, or within the Republic of the Marshall Islands (RMI) per the Compact of Free Association, will be evaluated under NEPA. Actions occurring in the Broad Ocean Areas will be evaluated per Executive Order 12114, Environmental Effects Abroad of Major Federal Actions. A Document of Environmental Protection (DEP), which also addresses impacts from the Proposed Action and further describes environmental controls the installation intends to implement in accordance with comments and recommendations from U.S. and RMI agencies and the affected population, is being prepared concurrently with this EA.

1.3 PURPOSE AND NEED FOR THE PROPOSED ACTION

1.3.1 PURPOSE

The purpose of the Proposed Action is to conduct launches, beyond the proof-of-principle launches, of small and medium class satellites and sub-orbital payloads into space from Omelek Island at USAKA/RTS using the Falcon 1 launch vehicle and expanding SpaceX capabilities on the island to accommodate launches of the Falcon 9 vehicle.

1.3.2 NEED

The Proposed Action is needed to establish and maintain the capability at USAKA/RTS to launch small and medium class payloads into orbit. The Falcon launch vehicle is designed to provide advances in reliability, cost, flight environment, and time to launch for the DoD, National Aeronautics and Space Administration (NASA), and private and foreign users. The Proposed Action supports the DoD's goal of a launch-on-demand capability through increased privatization of the launch vehicles and infrastructure. The Falcon program also supports the USAKA/RTS space launch goal to capitalize on the unique attributes of Kwajalein Atoll.

Located near the equator at approximately 9° North latitude, USAKA/RTS provides the only U.S.-controlled equatorial launch site. An equatorial launch site is preferred because low inclination launch vehicles receive extra velocity from the Earth's rotation, which reduces the amount of fuel needed to launch spacecraft and increases the size of the payload that can be lifted to a given orbit with a given amount of fuel. Launching near the equator also reduces the energy required for orbit plane change maneuvers, which saves fuel and increases the operational lifetime of satellite payloads.

1.4 COOPERATING AGENCIES

The Federal Aviation Administration (FAA) is a cooperating agency in the preparation of this EA. SpaceX would apply for a launch license from the FAA for launches with commercial payloads. The FAA will rely on the analysis of this EA to support its environmental determination for launch licenses for the Falcon launch vehicles or a reentry license for the Dragon reentry capsule. The Dragon capsule is a payload that is being developed to deliver cargo to the International Space Station (ISS) under contract with NASA. This capsule is similar in design to the Apollo command capsule. In addition to the environmental review and the determination, applicants for a launch or reentry license must complete a policy review and approval, safety review and approval, payload review, and a financial responsibility determination. All of these reviews must be completed prior to receiving a launch or reentry license.

1.5 DECISION TO BE MADE

Based on information presented in this EA, the USAKA/RTS Commander will decide whether to allow SpaceX to:

- Continue to conduct Falcon 1 launches from Omelek beyond the proof-of-principle flights.
- Expand their capabilities on Omelek to include launches of the larger Falcon 9.

1.6 RELATED ENVIRONMENTAL DOCUMENTATION

As appropriate, the conclusions of these NEPA studies are summarized and included in this document:

- *Draft Environmental Impact Statement Proposed Actions at U.S. Army Kwajalein Atoll*, June 1989
- *Final Environmental Impact Statement Proposed Actions at U.S. Army Kwajalein Atoll*, October 1989
- *Final Supplemental Environmental Impact Statement Proposed Actions at U.S. Army Kwajalein Atoll*, December 1993
- *Final Environmental Assessment for the Falcon Launch Program*, July 2003
- *Final Environmental Assessment Proof-of-Principle Space Launches from Omelek Island*, December 2004

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2.0
DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

2.0 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

This chapter describes the Proposed Action, the No-action Alternative, and alternatives considered but eliminated from further study.

2.1 PROPOSED ACTION

The Proposed Action is to conduct launch operations placing small and medium class payloads into orbit from the islet of Omelek using Falcon 1 and Falcon 9 launch vehicles. Small class payloads weigh up to 907 kilograms (2,000 pounds), and medium class payloads range from 907 kilograms up to 6,804 kilograms (2,000 pounds to 15,000 pounds). Falcon 1 launches would continue as follow-on from the proof-of-principle flights authorized in the 2005 FONSI for the *Proof-of-Principle Space Launches from Omelek Island Environmental Assessment*. The Falcon 9 system launches would begin in 2008 after site preparation. An average of six Falcon 1 launches per year is planned for the next 10 years, and up to four Falcon 9 launches per year starting after 2008. All flights would have either a satellite or a sub-orbital payload.

The Falcon 1 is a light-lift, two-stage launch vehicle designed to put small spacecraft into orbit with high reliability and low cost. Only the first stage is recoverable. The Falcon 1 uses the liquid propellants: liquid oxygen (LOX) and RP-1, a type of kerosene commonly used as a rocket propellant (cited as kerosene in the rest of this document). Some payloads could contain small amounts of liquid or solid propellants for use in orbit after the flight.

The Falcon 9 is a two-stage, medium class, liquid launch vehicle that would launch space systems and satellites into orbit. For the near term, only unmanned missions are planned. The propellants for the vehicle itself (both stages) are LOX and kerosene. The payloads may carry quantities of these or other propellants including nitrogen tetroxide (NTO), monomethyl hydrazine (MMH), other hydrazine propellants, and solid propellants. Upon arrival at USAKA, the propellants would be transferred directly to the certified facility on Meck Islet. The first stage of the Falcon 9 would be recovered and reused. The second stage would be reused when launch inclination, payload requirements, and weight allow for its recovery.

The Falcon 1 and 9 launch vehicles require minimal vehicle assembly and processing at the launch site because most of the vehicle assembly occurs at the SpaceX facilities in El Segundo, California. Both vehicles would arrive at USAKA in two stages, each fully assembled. Depending on the landing craft schedules, the vehicles would be transferred to Omelek or stored in an existing physically secured area on Kwajalein. The stages would be inspected, assembled, tested, and moved to the launch site. The Falcon 1 and Falcon 9 vehicles would use separate launch sites on Omelek, though the Falcon 9 site may accommodate Falcon 1 launches on occasion. Both vehicles would be erected on the pad by hydraulic erector systems. Payloads would be processed at Omelek in the near term and on Kwajalein when facilities there are available. Both vehicles would be fueled on the pad, and kerosene and LOX would be loaded the day of the launch. The goal is to launch within 1 month of payload arrival at the launch site.

To support the proposed sustained launch activities, several improvements would be required on Omelek, including construction of a Falcon 9 launch pad and a hangar facility, upgrades to existing propellant storage and loading facilities, and several other site infrastructure improvements.

Two facilities are proposed for Kwajalein: a LOX plant facility and a Payload Processing Facility. All construction and launch activities of the Falcon 1 and 9 launch programs would comply with the USAKA Environmental Standards (UES) and the USAKA/RTS Range Safety Requirements. To minimize disturbance to biological and cultural resources, appropriate measures would be taken, such as installing signage to designate sensitive areas, educating facility personnel on protecting sensitive island resources, and to avoid harassing sensitive species.

The following sections provide descriptions of the launch vehicles and launch operations.

2.1.1 FALCON 1 LAUNCH VEHICLE

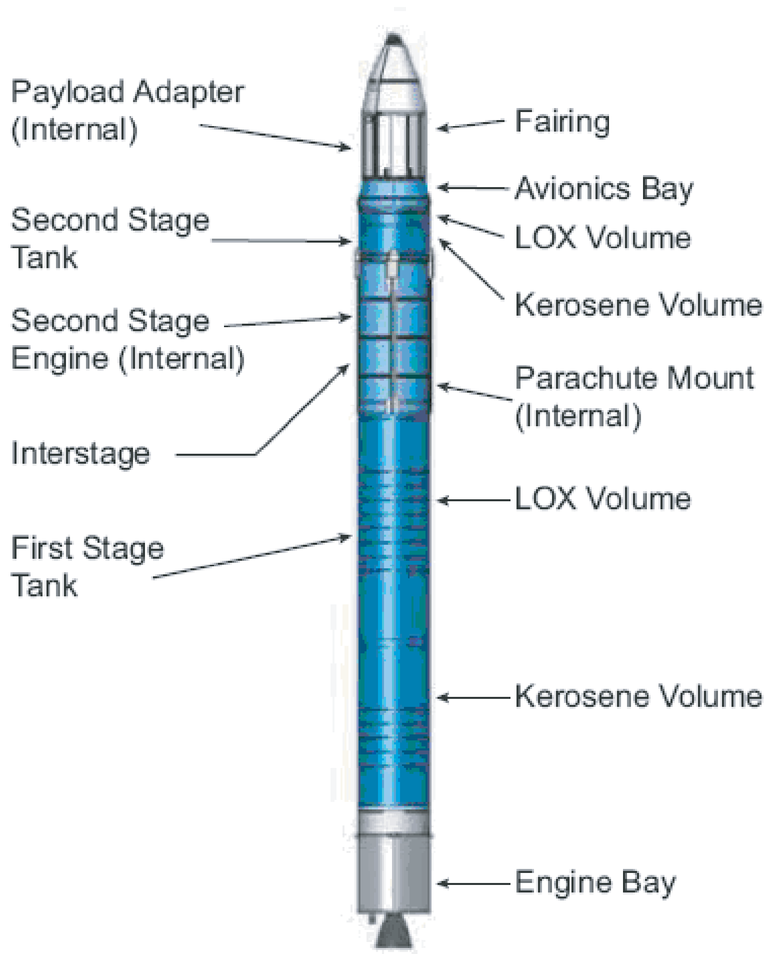
The Falcon 1 is a small, unmanned launch vehicle with a gross lift-off weight of approximately 27,216 kilograms (60,000 pounds). A single SpaceX Merlin engine powers the Falcon 1 first stage. A single SpaceX Kestrel engine powers the second stage. The Falcon 1 uses LOX and kerosene to carry payloads into orbit. The first stage uses a turbo-pump to feed the propellant, while the second stage is pressure-fed. Figure 2-1 shows a view of the main components of the Falcon 1 launch vehicle.

2.1.1.1 First and Second Stages

The first stage consists of LOX and kerosene tanks that hold 12,708 liters (3,357 gallons) of LOX and 8,245 liters (2,178 gallons) of kerosene. The second stage consists of 2,203 liters (582 gallons) of LOX and 1,325 liters (350 gallons) of kerosene in tanks with a common bulkhead. The Falcon launch vehicle uses helium gas stored in high-pressure, composite over wrapped cylinders to pressurize the propellant tanks. Quantities of helium required for Falcon 1 processing are 16.5 kilograms (36.9 pounds) for first stage pressurization, engine spin start, and purging and 9.8 kilograms (21.7 pounds) for second stage pressurization. The helium flow is controlled through solenoid valves.

2.1.1.2 Thrust Termination System

The launch vehicle is equipped with a thrust termination system, rather than a destructive flight termination system, that activates if the Falcon 1 launch vehicle varies from its planned trajectory. The thrust termination system is activated by a command from the Range Safety Officer and disables power to the vehicle engines. Once power ceases, there are up to six different valves that close and immediately shut off the first stage engine. Four valves close on the second stage, again shutting down the stage's engine. Thus, the Falcon 1 launch vehicle would fall to the ocean intact and may explode upon impact, depending on the circumstances and timing of the termination.



EXPLANATION

LOX - Liquid Oxygen

Main Components - Falcon 1 Launch Vehicle

Figure 2-1

2.1.2 FALCON 9 LAUNCH VEHICLE

The Falcon 9 is a medium-class launch vehicle with a gross lift-off weight of approximately 314,000 kilograms (693,000 pounds). The Falcon 9 uses LOX and kerosene to carry payloads into orbit and is basically a scaled up version of the Falcon 1 vehicle. Figure 2-2 shows a view of the main components of the Falcon 9 launch vehicle.

2.1.2.1 First and Second Stages

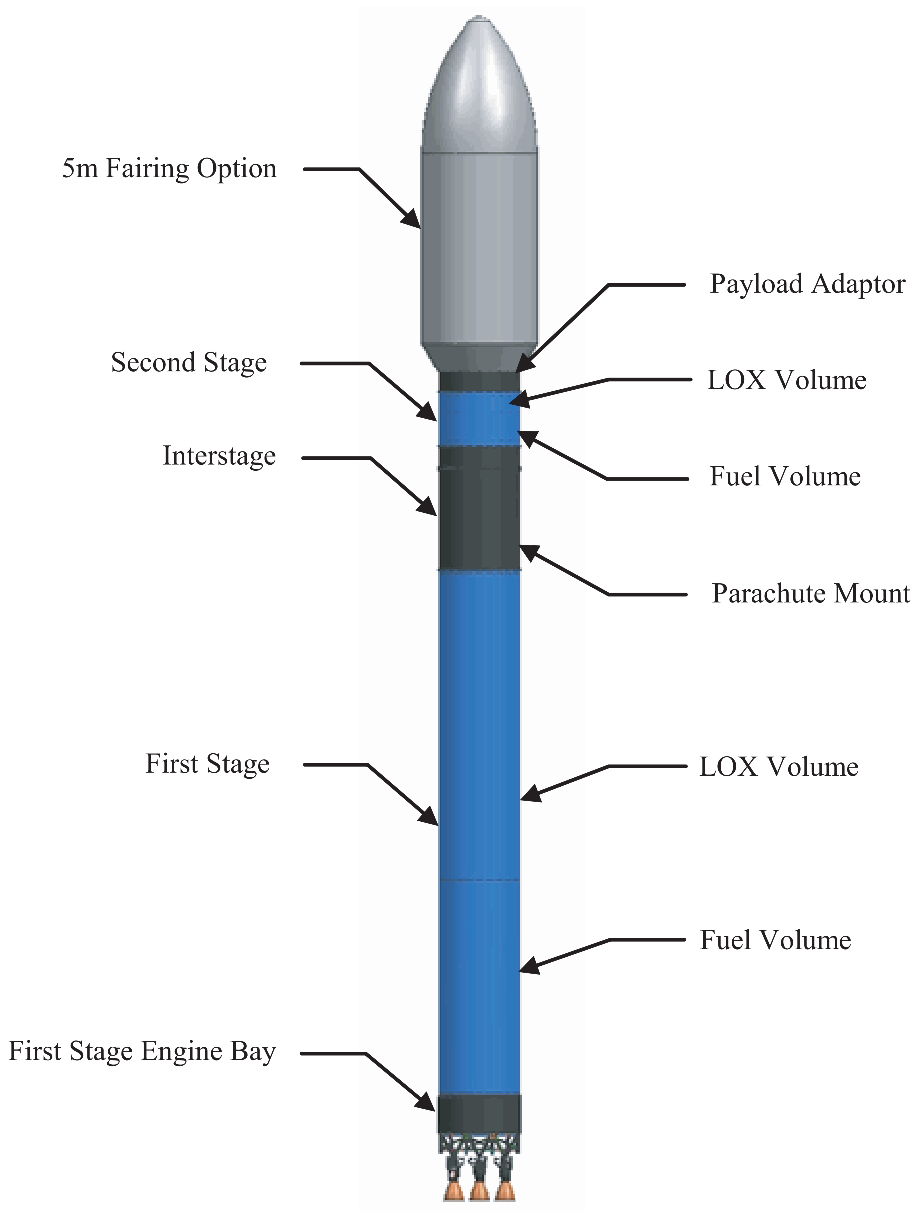
The first stage of the Falcon 9 is approximately 4 meters by 30.5 meters (12 feet by 100 feet), and includes nine Merlin engines—the same engine used on the first stage of the Falcon 1. The second stage is approximately 4 meters by 12.5 meters (12 feet by 41 feet), not including the fairing and payload, and uses one or two Merlin engines. The fairing would be 5 meters by 15 meters (17 feet by 50 feet); a smaller version may be used. The first stage consists of LOX and kerosene tanks that hold 146,000 liters (38,600 gallons) of LOX and 94,000 liters (24,800 gallons) of kerosene. The second stage consists of 27,600 liters (7,300 gallons) of LOX and 17,400 liters (4,600 gallons) of kerosene in tanks with a common bulkhead. Like the Falcon 1, the Falcon 9 launch vehicle uses helium gas stored in high-pressure, composite over wrapped cylinders to pressurize the propellant tanks. Falcon 9 processing requires 59 kilograms (130 pounds) of helium for first stage pressurization, engine spin start, and purging and 24.6 kilograms (54 pounds) of helium for second stage pressurization. The helium flow is controlled through solenoid valves.

2.1.2.2 Flight Termination System

The Falcon 9 launch vehicle would normally be equipped with a thrust termination system similar to that of the Falcon 1 vehicle. This system would terminate thrust of the stage engines in the event of an anomaly in flight. In this event, the vehicle would fall intact along the trajectory path, depending on the location at which it was terminated. For some missions, the Falcon 9 vehicle would have an alternative termination package (an explosive package) that would terminate the flight by opening the vehicle tanks to disperse propellants once the package was activated. In this event, the debris would fall over a wider area but in smaller pieces. The termination system type would be based on the required trajectory and the payload.

2.1.3 FALCON 1 AND 9 PAYLOADS

The Falcon 1 would carry small payloads (approximately 454 kilograms, or 1,000 pounds), consisting mostly of non-hazardous materials. Some payloads may use small amounts of liquid or solid propellants for on-orbit maneuvering. Falcon 9 payloads, weighing up to 5,443 kilograms (12,000 pounds), would almost always include some additional propellants on board, for either orbit maintenance or orbital insertion burns. The propellants would be used only after the payload separates from the Falcon launch vehicle. Propellants for payloads of both vehicles may include unsymmetrical dimethylhydrazine (UDMH), MMH, NTO, pressurized gasses including helium and nitrogen, and some solid propellants such as ammonium perchlorate. Quantities would vary but could be up to 1,514 liters (400 gallons) for each of two components. Prior to their use, propellants would be stored in a certified facility on Meck, and transported to Omelek for fueling the payload. Residual propellants would be returned to Meck for storage. All hazardous materials would be handled in accordance with the UES.



EXPLANATION

LOX - Liquid Oxygen

Main Components - Falcon 9 Launch Vehicle

Figure 2-2

Payloads may include beryllium alloy structural components. The beryllium components would arrive at USAKA incorporated into the payload. SpaceX would not conduct operations that would release beryllium into the environment (e.g., grinding or welding would be avoided).

In addition, a small amount of ordnance, such as small explosive bolts, and on-board batteries are typically associated with the payloads.

In addition to standard payloads, the Falcon 9 vehicle may also carry a capsule as a payload that is being developed to deliver cargo to the ISS under contract with NASA. This capsule, named Dragon, is between 3.7 and 5.2 meters (12 to 17 feet) tall and similar in design to the Apollo command capsule. Prior to launch, the Dragon would be processed similarly to any other payload. After completion of its mission to deliver cargo to the ISS, the Dragon would re-enter the atmosphere on a pre-planned trajectory, soft-land in the ocean, and be recovered by a recovery vessel, similar to the Falcon 9 first stage. The capsule may contain down-cargo from the ISS for return to Earth, and may also carry trash for disposal. All materials brought down from the station would be delivered to NASA unless directed otherwise. The capsule may or may not be refurbished and re-used. Recovery zones are currently being planned; however, locations in the Gulf of Mexico, the coast of California, and the Kwajalein Atoll are being considered.

2.1.3.1 Propellants and Other Hazardous Materials

Unsymmetrical dimethylhydrazine (UDMH)

UDMH is a hypergolic (spontaneous ignition without an igniter) rocket fuel ingredient, used as a bipropellant in combination with the oxidizer, nitrogen tetroxide. UDMH is a derivative of hydrazine and can also be called a hydrazine.

UDMH is a toxic volatile hygroscopic (attracts moisture from the atmosphere) clear liquid, with a melting point of -57° Celsius (C) (-70.6° Fahrenheit [F]), a boiling point of 63°C (154.4°F), density 0.793 grams per cubic centimeter (0.458 ounces per cubic inch), and a sharp, fishy, ammonia-like smell typical of organic amines. It turns yellowish when exposed to air and absorbs oxygen and carbon dioxide. It mixes completely with water, ethanol, and kerosene. Its vapors are flammable in concentrations between 2.5 percent and 95 percent in air. It is not sensitive to shock.

UDMH is storable and can remain loaded in the rocket fuel system for long periods. It is toxic, however, and tends to absorb through skin. UDMH is more stable than hydrazine (especially at elevated temperatures) and can be mixed with or used as a replacement for hydrazine.

Monomethylhydrazine (MMH)

MMH is a volatile, colorless liquid with an ammonia-like odor, a melting point of -52°C (-61.6°F), and a boiling point of 88°C (190.4°F). It is used as a rocket fuel in bipropellant rocket engines. The compound is toxic and carcinogenic. It is easily stored in space and provides moderate performance with very low tankage and fuel maintenance system weight. MMH provides slightly higher specific impulse, and as such, is preferred in some applications (e.g., some maneuvering engines).

Nitrogen Tetroxide (NTO)

NTO is a powerful oxidizer that is toxic and corrosive. It is a hypergolic oxidizer when used with hydrazine family fuels. NTO is often used with the addition of a small percentage of nitric oxide, which inhibits stress-corrosion cracking of titanium alloys; in this form, propellant-grade NTO is referred to as "Mixed Oxides of Nitrogen" or MON. MON is a fuming liquid that varies in color from reddish brown to green depending on the nitric oxide content. The visible fumes are orange or reddish brown with a characteristic pungent, acrid odor that produces a burning sensation in the nasal passages.

2.1.3.2 Ammonium Perchlorate

Perchlorates are colorless, odorless salts derived from perchloric acid. One of the perchlorates, ammonium perchlorate, is used as an oxidizer in spacecraft fuel. Ammonium perchlorate is highly reactive with a melting point of 450°C (842°F) and a decomposition temperature of 66°C (150.8°F). Perchlorates are found in the environment in two forms. If water is absent, as in a drum or on top of dry ground, then perchlorates would exist as solids. If water is present, then they would quickly dissolve. When perchlorates dissolve, they separate into two parts—one charged positively, the other negatively. The part with the negative charge is called the perchlorate anion. Perchlorate anion has become a chemical of interest over the last 10 years because it has been detected in water supplies and may have adverse health effects. For the Falcon program, all ammonium perchlorate materials will occur in solid forms.

2.1.3.3 Beryllium

Beryllium metal is used in light-weight structural materials in space vehicles and communication satellites because of its stiffness, light weight, and dimensional stability over a wide temperature range. Beryllium is a toxic substance that can be harmful if inhaled; the effects depend on the period of exposure. The proposed use of beryllium components at USAKA/RTS would not present an inhalation hazard.

2.1.4 LAUNCH OPERATIONS

2.1.4.1 Pre-Launch Activities

2.1.4.1.1 Launch Preparation Activities

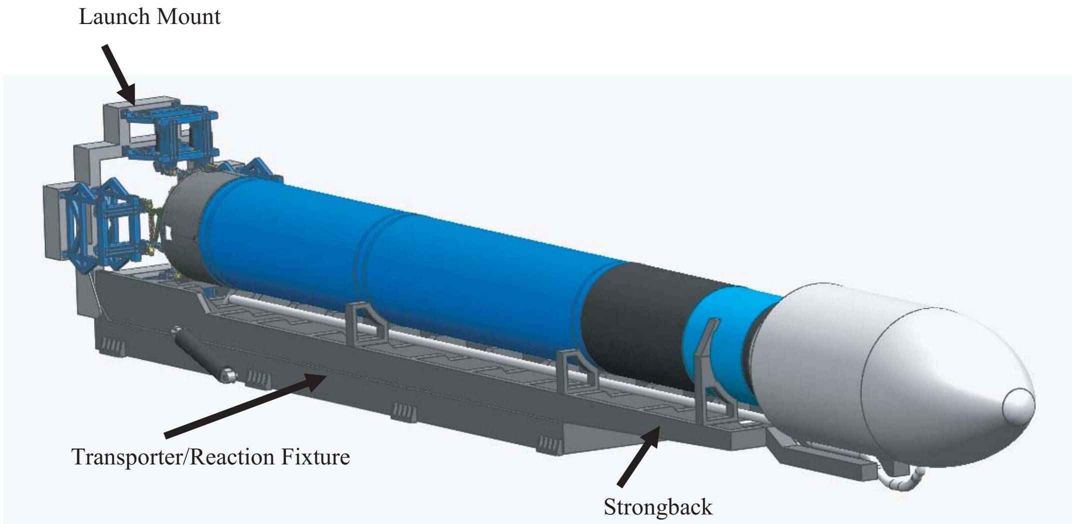
Falcon 1 launch activities have not substantially changed from those proposed in the Proof-Of-Principle Space Launches from Omelek Island EA. One notable change, however, is that most equipment would be stored on Omelek between missions rather than removed from the island. The Falcon 1 launch vehicle arrives at USAKA via government or commercial cargo carrier and would be transferred to Omelek using a landing craft. SpaceX equipment and the launch vehicle may or may not be stored on Kwajalein Island before movement to Omelek, depending on landing craft schedules. While on Kwajalein, the launch vehicle would be stored in an existing physically-secured area. The equipment containers could be stored in any unsecured location. Once the landing craft arrives at Omelek, the launch vehicle would be off-loaded and placed within the Falcon 1 processing hangar. If the ramp angle of the landing craft requires adjustment to properly offload the launch vehicle, then either lumber, steel, washed gravel, crushed coral, and/or other inert materials would be used. Materials that are unlikely to be transported into the lagoon, and engineering practices that promote material recovery (stockpiling) after loading/unloading occurs would be selected.

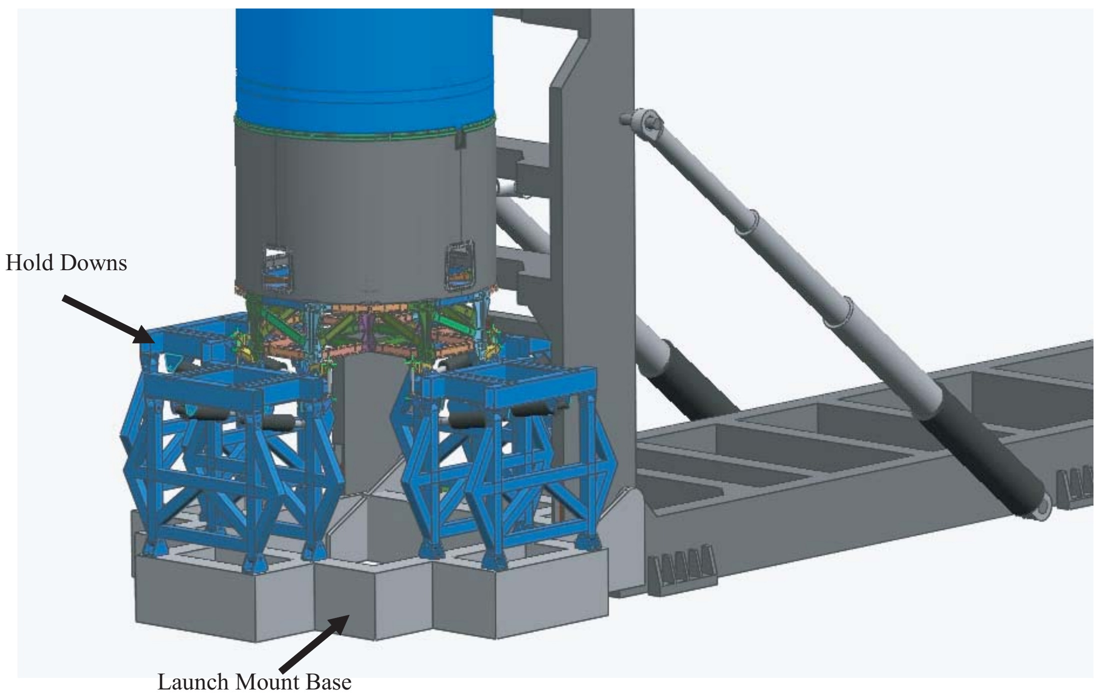
In the hangar, the vehicle is functionally checked and the stages are mated. Payload preparation activities would be conducted in parallel with most launch vehicle preparation activities. Payload activities include payload checkout, spacecraft propellant loading, and payload encapsulation in the fairing. Hazardous materials including hypergolic fuels and those materials used with payloads would be handled according to the UES and other applicable safety standards. An emergency response team would be established, and spills would be contained and cleaned up according to the procedures identified in the Kwajalein Environmental Emergency Plan (KEEP) and a SpaceX specific emergency plan.

Approximately 6 days prior to launch, the Falcon 1 launch vehicle would move to the launch pad on the launcher/erector as shown in Figure 2-3. The launcher/erector is 2.67 meters (8.75 feet) wide, 17 meters (57 feet) long, and 4 meters (13 feet) tall with the vehicle installed. Once moved to the pad, the launcher/erector and vehicle are connected to the stand. The vehicle is then erected and secured when vertical. On launch day, once fueling operations for the launch vehicle begin, the drainage system valve on the launch pad remains closed to avoid possible soil contamination. Dead limbs from trees and shrubs, as well as leaves and other organic debris on the ground near the launch pad would be removed to eliminate fuel for fires.

Falcon 9 pre-launch activities would be very similar to those of Falcon 1. Once the Falcon 9 stages arrive separately via landing craft or barge, they would be placed in the Falcon 9 processing hangar on Omelek. The stages would be checked and prepared for mating. At the same time, the payload would be processed in the cleanroom section of the processing hangar. Typically, payloads would be fueled 2 weeks prior to launch. When ready, the payload would be encapsulated horizontally and mated to the launch vehicle. Approximately 6 days prior to launch, the Falcon 9 would be moved to the Falcon 9 pad and connected to the stand. The vehicle would then undergo an additional series of tests while horizontal at the pad. The day before launch, the vehicle would be erected and final checks completed. The launch vehicle would be fueled 2 hours prior to launch on the day of the launch.

Approximately 30 people would be involved in both Falcon 9 and Falcon 1 launch preparation activities. Up to eight SpaceX personnel would live temporarily on Omelek in the SpaceX office facility, as required. The remaining personnel would be lodged on Kwajalein and transported between the two islands on a daily basis. All SpaceX and payload customer personnel would be trained on natural and cultural resources protection on USAKA islands and in RMI waters with emphasis on Kwajalein, Meck, and Omelek. Signs designating sensitive areas would be posted at areas such as the northern part of Omelek and at the biologically and archaeologically sensitive old broadleaf forest at Omelek. Personnel would be warned against harassing the organisms at USAKA. Within 2 hours of the launch, SpaceX personnel would survey the shoreline within 100 meters (328 feet) on both sides of the launch site to determine whether sea turtles are present in the water or hauling out at this area. If turtles are observed in the area, then SpaceX would consult with USAKA Environmental before continuing with launch activities. Reasonable measures could be taken to return animals to the water prior to launch. If the survey indicates that the sand level increased and covers the rocky outcrop near the launch pad along the shore line, then a fence may be required in accordance with the requirements of the Proof-of-Principle Space Launches from Omelek Island EA if turtles are observed in the area. The survey would be documented and mitigation efforts would be kept on site readily available for inspection. If turtle nests are discovered, then SpaceX personnel would contact USAKA Environmental, who would consult with the appropriate UES agencies (i.e., U.S. Fish and Wildlife Service and National Marine Fisheries Service) prior to the launch.





Launcher/Erector

Figure 2-3

2.1.4.1.2 Fuel Storage

For the near term, LOX for both vehicles would most likely be imported from Hawaii and stored on Omelek. In the long term, a LOX plant is planned for installation on Kwajalein that would produce up to 6.4 metric tons (7 tons) per day of LOX, and may produce liquid nitrogen (LN2) as a by-product. Helium is used by the Falcon 1 vehicle system as a pressurant for the main tanks during flight and as a purge during fueling operations and at engine start. The helium is stored in standard, over-the-road supply trailers and is re-supplied by shipments from the United States. The trailers are U.S. Department of Transportation (DOT) certified. Kerosene for both vehicles would be delivered from the United States and stored in bulk containers located in a concrete containment system on the east side of Omelek. Permanent above-ground lines would connect both the LOX area and the kerosene storage area to the Falcon 1 and 9 launch pads. Spills would be contained and cleaned up in accordance with the procedures identified in the KEEP and site specific emergency plan.

2.1.4.1.3 Pre-Flight Testing and Training

Two dress rehearsals are typical in the launch preparation schedule to allow for team training and coordination of activities between the SpaceX crew and USAKA/RTS. As required, wet dress rehearsals, which include fully fueling the launch vehicle, may be conducted. Under some circumstances, static fire tests of both vehicles may be conducted at the launch site, where the vehicle is fully fueled and the first stage engine is fired for approximately 5 seconds as a thorough test of all systems. The engine is then shut down, the fuel is removed, and the vehicle is returned to storage. Static fire tests would only be executed during the initial launches of the Falcon 1 and Falcon 9 as further developmental testing. Once the Falcon Program is operational, the static tests would no longer be necessary.

2.1.4.2 Launch Activities

2.1.4.2.1 Day of Launch

The Falcon 1 and 9 launch countdowns are each a 2-hour procedure that would be submitted for USAKA/RTS review and approval before implementation. The back-out crew would perform the following activities 4 hours prior to launch:

1. Complete final launch pad preparations, including removal of all loose items, such as tarpaulins and tool boxes.
2. Configure all ground support equipment for remote operation.
3. Prepare fire fighting equipment.
4. Perform final inspections of the island and the pad area; environmental monitor(s) would walk around the island to determine the presence/absence of species of concern prior to evacuation of the island.
5. Evacuate island.

The deluge system begins approximately 10 seconds before launch and would continue until 10 seconds after launch. After launch, the remaining water would be contained within the containment area of the launch pad. The Falcon 1 launch vehicle has a burn zone of approximately 30 meters (100 feet). Falcon 9 is predicted to have a burn zone of up to 46 meters (150 feet) from the pad.

2.1.4.2.2 Launch Control

Launch control would be executed remotely from Kwajalein. A SpaceX facility is housed in Building 1500, from which SpaceX controls 26 stations. For Falcon 9, SpaceX would require up to 50 additional stations in an existing RTS facility to provide launch control support. Communication with Omelek from Kwajalein is by fiber optic cable, and all required communications to Omelek pass through a redundant network system.

2.1.4.2.3 Launch Trajectory

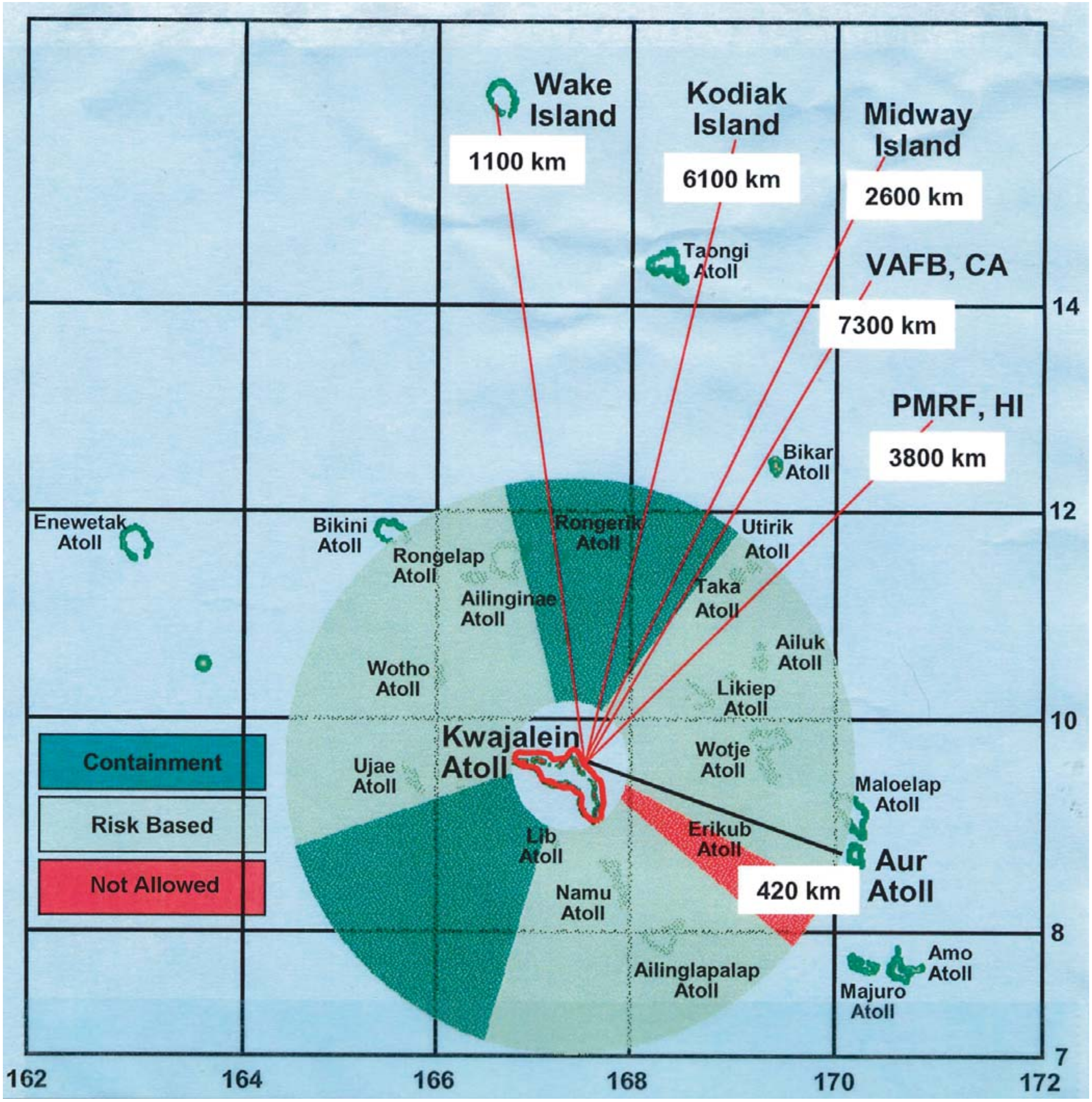
The Omelek launch site can accommodate safe trajectories for almost any orbital inclination. Orbital inclination is the angle between the earth's geographical equatorial plane and the satellite's orbital plane. It basically describes how far north and south of the equator the satellite would go during its orbit. Figure 2-4 shows potential launch azimuths characterized by the flight safety approach taken to ensure public safety.

Launch azimuths within the areas labeled "Containment" would be planned so that missiles would not fly over populated islands. Missile trajectories would be designed so that if the missile malfunctions during the flight it would be destroyed and no debris from the missile would fall over a populated island.

The sectors labeled "Risk Based" on Figure 2-4 represent launch azimuths in which it is difficult to design launch trajectories to avoid overflight of a populated island. Within this sector, USAKA/RTS would require the launch customer to develop trajectories that minimize overflight of populated islands. Additionally, USAKA/RTS would perform a risk analysis based upon the trajectory; assess potential missile failure modes and the probabilities of these failures; and determine the population density of islands near the trajectory. Using this data, an analysis to determine the expected level of public risk associated with the mission would be performed. This risk estimate would be compared to acceptable risk criteria defined in Range Commanders Council (RCC) Standard 321-02, Common Risk Criteria for National Test Ranges. USAKA/RTS would allow the mission to proceed if the calculated mission risk is less than RCC-321 criteria. If the calculated mission risk is higher than the standard, then that mission trajectory would not be allowed.

The sector labeled "Not Allowed" on Figure 2-4 cannot be used for launch azimuths unless specifically approved by a range safety waiver. Waivers are granted only by the USASMDC/ARSTRAT National Range Commander, or his/her designated representative, and are granted only if mission objectives are considered sufficiently important; if the objective cannot be otherwise met; and if, in his/her judgment, the risk involved is reasonable and acceptable.

Both the Falcon 1 and Falcon 9 flight vehicles allow recovery of the spent first stage by use of a parachute attached to the front end of the first stage. The location of the stage's ocean impact would vary with each mission (two *representative* locations for a Falcon 1 mission are shown in Tables 2-1 and 2-2). A salvage ship would locate the floating first stage by pinpointing the transponder or light beacon that would signal the location. Approximately 30.3 liters (8 gallons) of LOX and 19 liters (5 gallons) of kerosene could remain in the expended first stage of Falcon 1, and approximately 303 liters (80 gallons) of LOX and 190 liters (50 gallons) of kerosene could remain on Falcon 9. The first stage would be recovered by USAKA/RTS or commercial



EXPLANATION

VAFB - Vandenberg Air Force Base
PMRF - Pacific Missile Range Facility
km - Kilometers

NORTH

Potential Launch Azimuths from Omelek

Pacific Ocean

Figure 2-4

recovery personnel and returned to Kwajalein. Residual kerosene would remain on-board until the vehicle arrives at the refurbishment facility. Residual LOX would generally boil-off before recovery operations begin, vaporizing before arriving at Kwajalein. SpaceX would transport the recovered booster to their facilities in El Segundo, California, for reconditioning and reuse.

Table 2-1. Impact Locations for First Stage and Fairing (-3 Degrees)

	Latitude	Longitude	Impact Ellipse Estimate
First Stage	18.003 degrees	167.043 degrees	64 kilometers x 32 kilometers (40 miles x 20 miles)
Fairing	18.782 degrees	166.694 degrees	80 kilometers x 64 kilometers (50 miles x 40 miles)

Table 2-2. Impact Locations for First Stage and Fairing (90 Degrees)

	Latitude	Longitude	Impact Ellipse Estimate
First Stage	8.9155 degrees	176.814 degrees	64 kilometers x 32 kilometers (40 miles x 20 miles)
Fairing	8.899 degrees	177.589 degrees	80 kilometers x 64 kilometers (50 miles x 40 miles)

The second stage would enter orbit with the payload. The second stage of Falcon 1 would eventually reenter the atmosphere, burning up on reentry; it is unlikely that debris would reach the earth. The Falcon 9 second stage could be recovered if so designed. In this event, the stage would reenter the atmosphere on a pre-programmed trajectory and would impact a predetermined position. Recovery of the second stage would be similar to recovery of the first stage.

2.1.4.2.4 Post-Launch Activities

The back-out crew (the same crew that completes the on-Omelek tasks 4 hours prior to launch) would be located at Meck for mission abort operations and post-flight operations. This crew would arrive and depart Meck by boat and would communicate with the launch organization at Meck. After launch and approval by ground safety, the crew would approach Omelek and begin post-launch procedures.

SpaceX back-out personnel would assess the island and use fresh water to douse fires if necessary. After each launch, the remaining deluge water is either containerized and disposed of according to UES requirements, or allowed to evaporate within the pad containment if test results indicate the water is not hazardous. The deluge water for the first Falcon 1 proof-of-principle launch was analyzed for contaminants; the results of all detected analytes are provided in Table 2-3. The only analyte that exceeded the UES Standards for Groundwater Quality was pH. The deluge water from the first Falcon 9 launch would be similarly analyzed to establish a baseline for proper disposition. The drainage system would remain open to allow rainwater to drain from the launch pad after the remaining deluge water is removed or evaporates.

Table 2-3. Results of Deluge Water Contaminant Test

Analyte	Result (milligrams/liter)	UES Standards for Groundwater Quality (milligrams/liter)*
Fuel		
Diesel Range Organics	1.5	-
Motor Oil Range Organics	0.71	-
Unidentified Extractable Hydrocarbons	1.7	-
Total Metals		-
Barium	0.58	2
Chromium	0.0065	0.1
Volatile Organic Compounds		-
Benzene	0.0013	0.005
Naphthalene (EPA Method 8260B)	0.036	-
Toluene	0.0085	1
1,2,4-Trimethylbenzene	0.0048	-
1,3,5-Trimethylbenzene	0.0014	-
Xylenes (total)	0.0017	10
Semi-volatile Organic Compounds		
Phenol	0.077	-
Benzyl Alcohol	0.018	-
4-Methylphenol	0.0087	-
Benzoic Acid	0.050	-
Naphthalene (EPA Method 8270C)	0.032	-
2-Methylnaphthalene	0.039	-
Other		
pH	10 pH units	6.5 – 8.5

* The symbol "-"indicates no primary or secondary standard for groundwater quality.

All hazardous and non-hazardous waste from launch operations on Omelek would be disposed of in accordance with USAKA/RTS regulations and the UES. Equipment would be moved into the storage hangar or protected and left in place. Facilities at Omelek would be cleaned and prepared for storage within approximately 7 days after launch. After each mission, environmental monitors would walk around the island to look for any observable effects of the launch to sensitive species and resources. Observable effects would be reported to applicable agencies through USAKA/RTS as required.

2.1.4.3 Emergency Preparedness

2.1.4.3.1 Hazardous Materials Team

SpaceX would assemble a Propellant Hazard Team (PHT) that would be responsible for responding to hazards and spills for all Falcon program propellants, including both launch vehicle propellants, such as LOX and kerosene, as well as payload related propellant, such as NTO and MMH. Emergency preparedness and response activities would be coordinated with USAKA/RTS according to the procedures identified in the KEEP and a SpaceX-specific emergency plan. This team would be staffed and trained according to the UES safety and environmental standards, and would include an incident commander, response technicians, hypergolic product expert, and decontamination team lead. The team would be equipped with personal protective equipment and remediation equipment and supplies relevant to the hazard, including cryogenic gloves for handling LOX, Self-Contained Atmospheric Protective Ensemble equipment, leak detection instruments for hypergolic fluid spills, containers, shovels, and absorbent materials. The team would receive refresher training annually and must complete one training exercise every 6 months. USAKA would ensure compliance.

LOX and LN2 spills would be allowed to dissipate naturally because they are not toxic to the environment. Kerosene and diesel fuel spills, however, would be contained in concrete containment areas or temporarily bermed using portable rubber berm material, and cleaned up using suitable absorbent materials. Hypergolics and other toxic materials would be diluted using approved fluids and cleaned up using approved procedures. All hazardous spill materials would be loaded in drums and labeled appropriately per UES requirements. All hazardous waste would be disposed of in accordance with the UES in coordination with USAKA/RTS.

The transportation and storage of hypergolic payload fuels would be conducted in accordance with USAKA safety requirements and applicable safety regulations. These fuels would be stored in certified facilities with leak detection sensors and specially-designed ventilation systems. When fuels are not stored in certified facilities (such as when in transport), the minimum energetic liquid quantity distances (provided in Table 2-4) would be used to establish safety.

Hypergolic fuel or other hazardous liquid releases would be managed according to the KEEP and the SpaceX emergency response plan developed with USAKA Safety. The preliminary distances provided in Table 2-4 would be used for minimum isolation distances. The distances provided are for general guidance; more stringent distances may be established by USAKA Safety or according to the emergency response requirements provided in the SpaceX emergency plan.

Releases of hazardous solid materials would also be managed according to the KEEP and the SpaceX emergency response plan developed with USAKA Safety.

Table 2-4: Hypergolic Fuels Preliminary Quantity Distance and Spill Isolation Zones

Material Name	Minimum Energetic Liquid Quantity Distance[1] (feet)	Small Spills[2]			Large Spills[2]		
		First Isolate in all Directions (feet)	Then Protect Persons Downwind		First Isolate in all Directions	Then Protect Persons Downwind	
			Day (miles)	Night (miles)		Day (miles)	Night (miles)
Unsymmetrical Dimethylhydrazine	50	100	0.1	0.1	200	0.4	0.8
Monomethylhydrazine	800[3] 300[4]	100	0.2	0.3	500	0.9	1.8
Nitrogen Tetroxide	50	100	0.1	0.3	500	1.0	2.5

[1] DoD 6055.9-STD, DoD Ammunition and Explosives Safety Standards, 2004
[2] DOT Emergency Response Guidebook, 2004
[3] Vehicle propellant tank burst pressure > 100 pounds per square inch (psi)
[4] Vehicle propellant tank burst pressure ≤ 100 psi

2.1.4.3.2 Explosive Quantity Distance

The LOX and fuels must be isolated from each other and from the loaded Falcon launch vehicles. Figure 2-5 shows that a preliminary radius of 117 meters (385 feet) must be maintained around the LOX storage area, and a preliminary radius of 55 meters (180 feet) must be maintained around the kerosene storage area (Figure 2-5). Figure 2-6 depicts the preliminary explosive safety quantity-distance for the Falcon 9 launch vehicle, which represents the personnel exclusion zone during launches. A preliminary radius of 565 meters (1,855 feet) must be maintained around the Falcon 9 launch pad during launches (Figure 2-6).

2.1.4.3.3 Worst Case Scenario

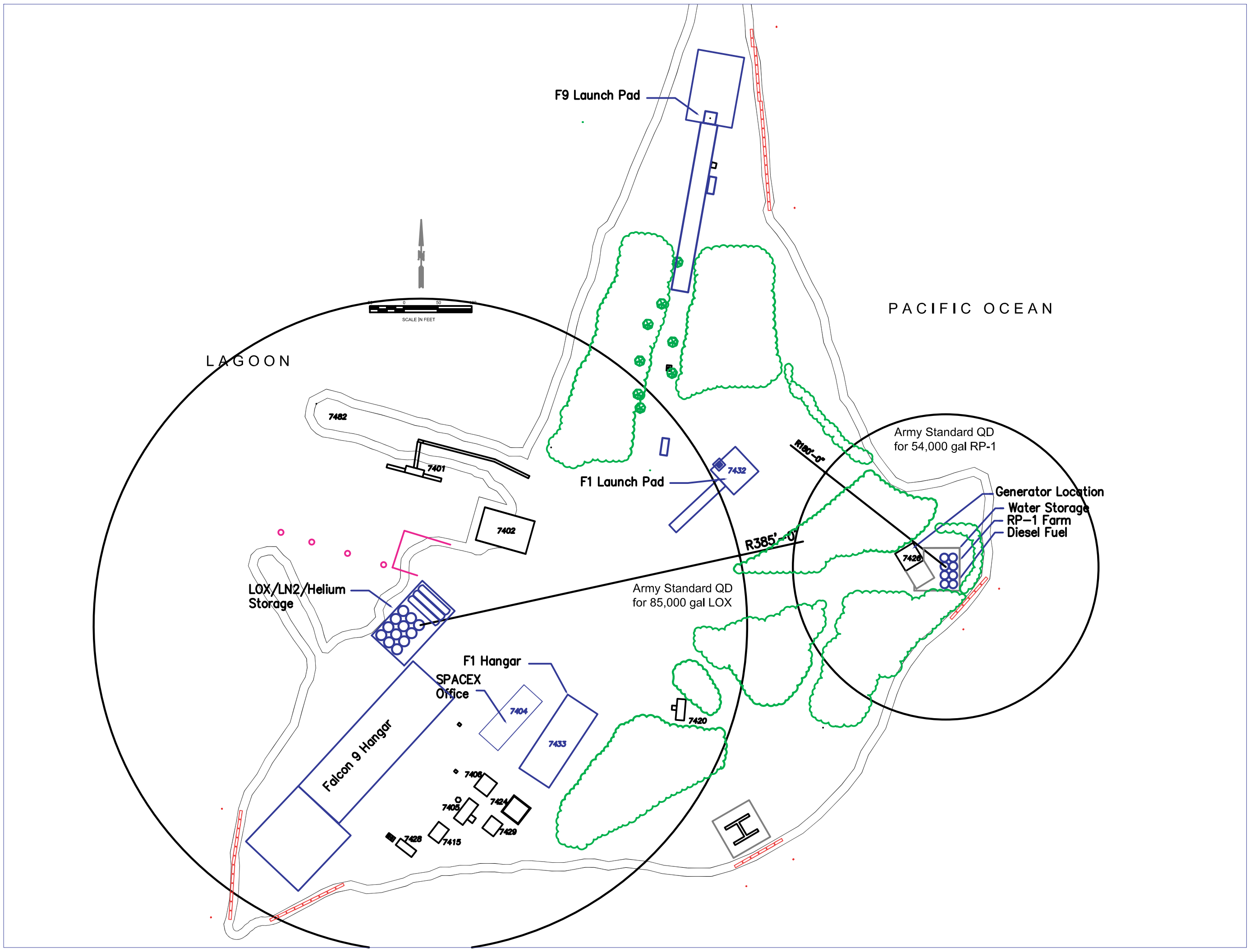
A catastrophic failure of the Falcon 9 on the launch pad represents the worst case scenario. Should this occur, a number of possible outcomes could result, the most likely being a fire on the launch pad. A water fire extinguishing system designed to manage vehicle engine fires would be used. An explosion on the launch pad would likely spread debris across Omelek. Trees within 91 meters (300 feet) of the vehicle may be impacted by debris and denuded of leaves by debris and/or blast effects; loosely rooted trees may be knocked over. Similarly, damage to facilities and vegetation across the island would likely result if an explosion occurred on the pad. In the event of an in-flight anomaly, the vehicle would either break-up in flight or fall into the water intact. In the worst case scenario, the vehicle would land on the reef.

2.1.5 SITE CONSTRUCTION DESCRIPTION AND PHASES

SpaceX would continue to use many of the existing facilities as authorized in the 2004 Proof-of-Principle Space Launches from Omelek Island EA. Additionally, SpaceX proposes to construct several new facilities, relocate select facilities, and improve the general infrastructure to support Falcon 1 and 9 launch vehicle operations. These facility and infrastructure improvements would occur in two construction phases. The first phase begins upon approval of the construction permit (anticipated in Fall 2007) and runs through Spring 2008. In this phase, the first few missions of the Falcon 9 vehicle would occur, and support for Falcon 1 launches would continue. The second phase would occur over several years (2008 through 2011) and would focus on upgrading site facilities to improve launch program efficiency.

The current layout of existing facilities on Omelek is shown in Figure 2-7. The proposed layout for Phase 1 construction is shown in Figure 2-8. The layout at the completion of Phase 2 is shown in Figure 2-9. The following facilities currently exist on Omelek and were approved and used for the proof-of-principle launches. Use of these facilities would continue for follow-on Falcon 1 and 9 launch operations:

- Pier and harbor
- Generator building – use would change to storage or workshop area under Phase 2
- Communications building
- Falcon 1 Hangar facility
- Falcon 1 launch pad
- Reverse osmosis unit (for non-potable water)
- Restrooms



EXPLANATION

QD - Quantity-Distance
LOX - Liquid Oxygen
LN2 - Liquid Nitrogen
Tree
Vegetation

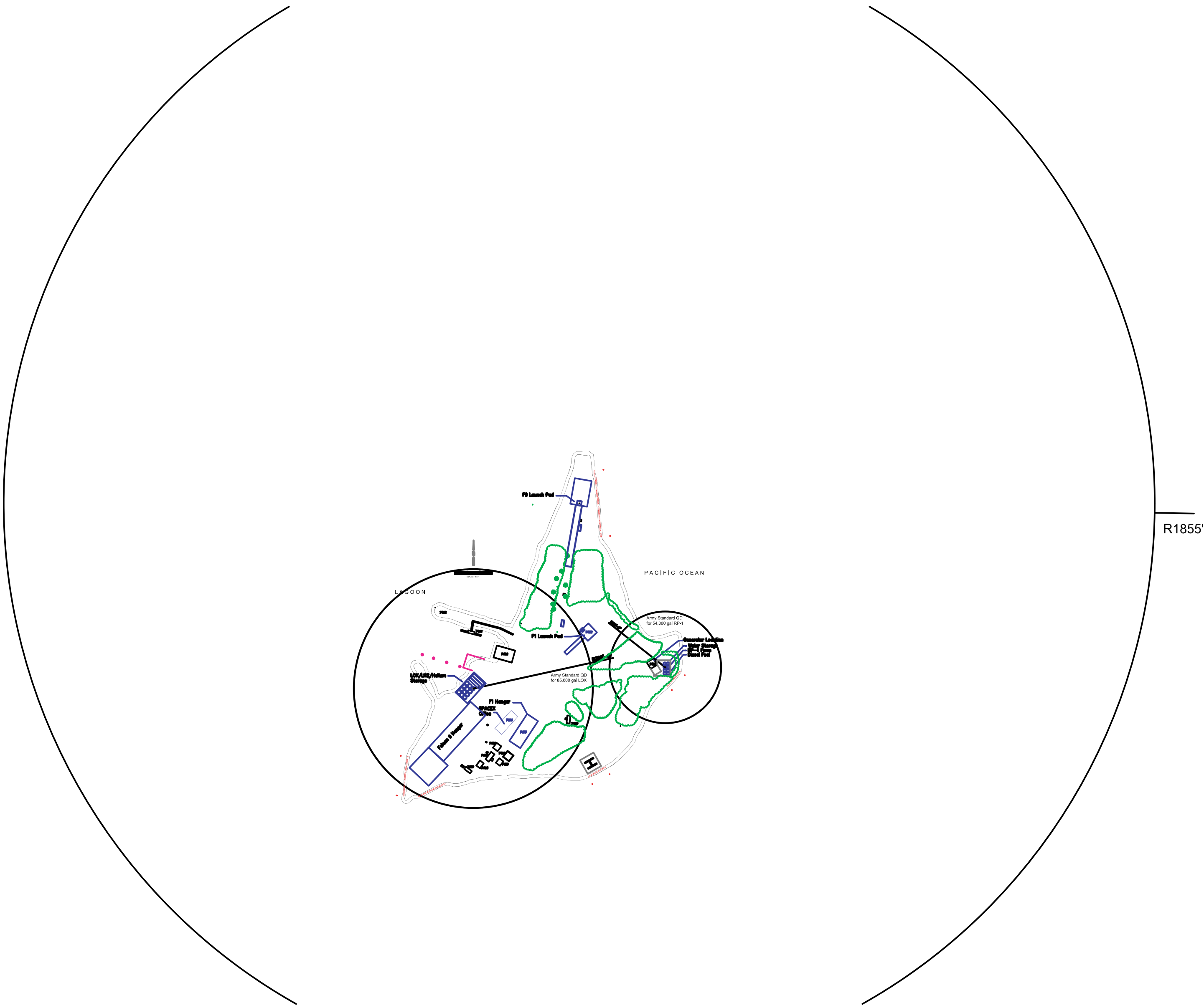
Proposed Facilities
Proposed Shoreline Reinforcement

NORTH

Preliminary Safe Distance Circles from the Liquid Oxygen and Fuels Storage Areas

Omelek Islet

Figure 2-5



Preliminary Explosive Safety - Quantity Distance for Falcon 9 Launch Vehicle

Omelek Islet

NORTH

Figure 2-6

EXPLANATION

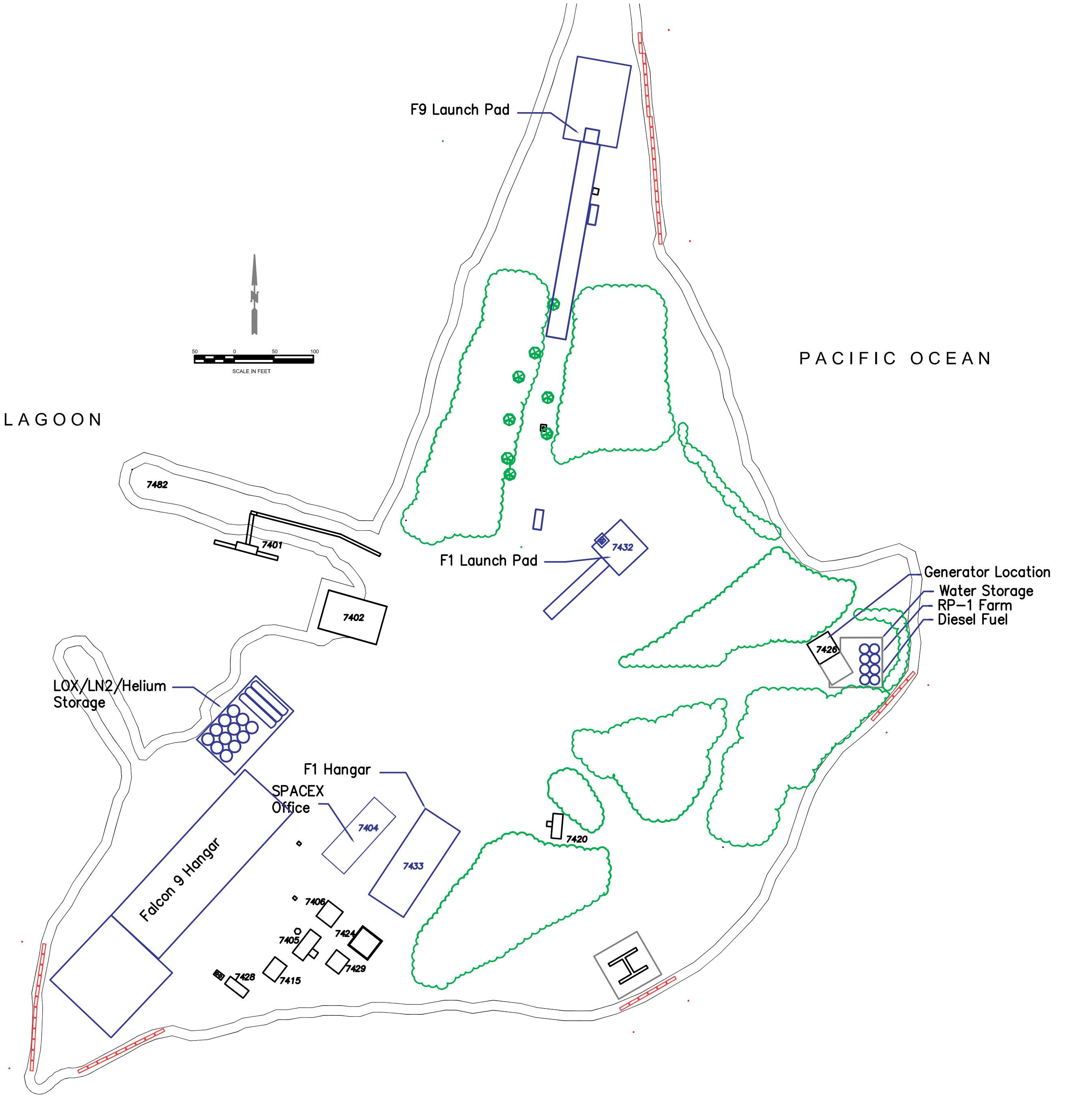
- Tree
- Vegetation
- Existing Road

NORTH

Current Layout

Omelek Islet

Figure 2-7



EXPLANATION

LOX - Liquid Oxygen

LN2 - Liquid Nitrogen

Tree

Vegetation

Proposed Facilities

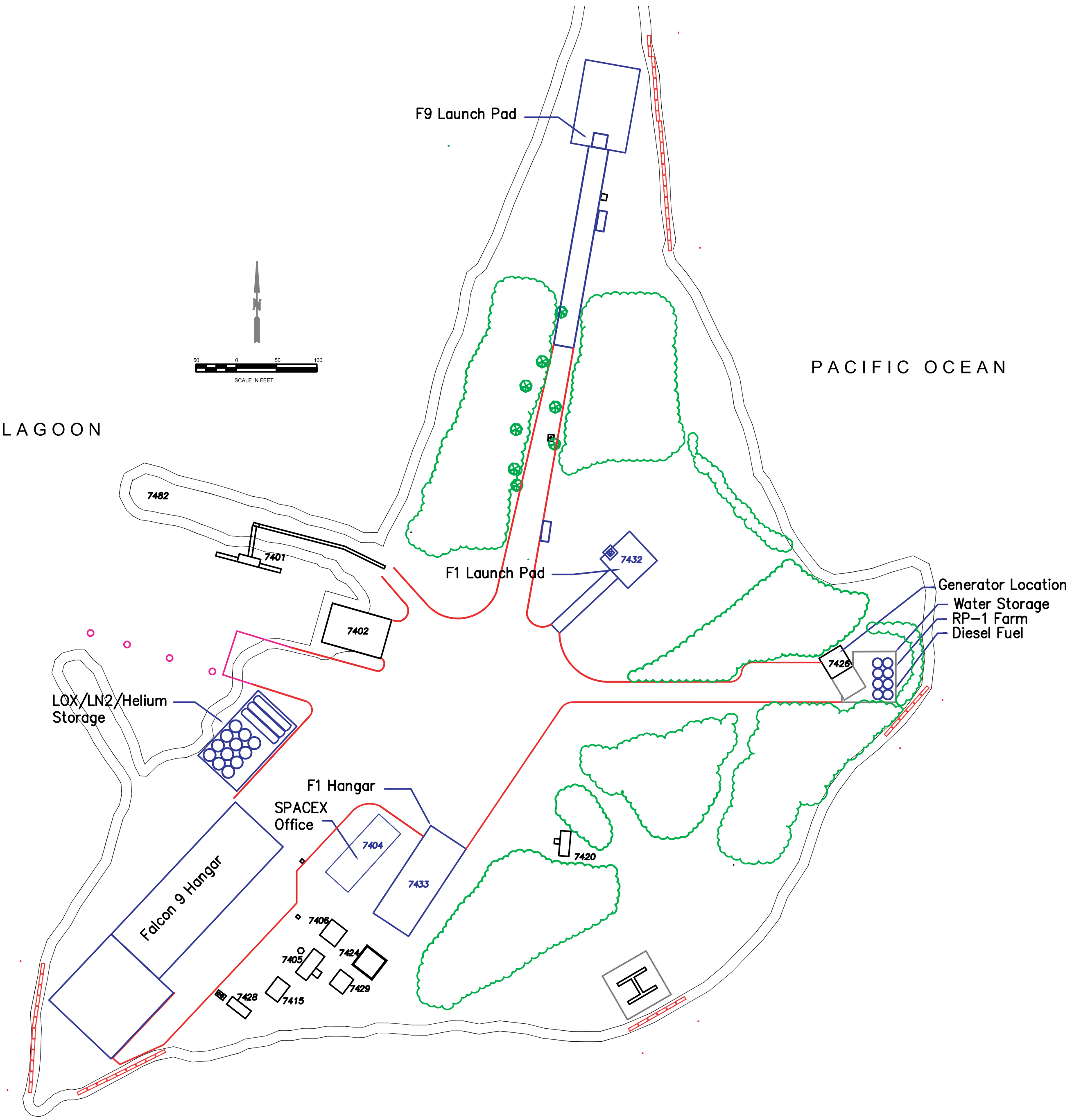
Proposed Shoreline Reinforcement

NORTH

Launch Site Proposed Layout, Phase 1

Omelek Islet

Figure 2-8



EXPLANATION

LOX - Liquid Oxygen
LN2 - Liquid Nitrogen
Tree
Vegetation

Proposed Facilities
Proposed Shoreline Reinforcement
Proposed Paved Area

NORTH

Launch Site Proposed Layout, Phase 2

Omelek Islet

Figure 2-9

The following existing facility would be relocated as part of Phase 1:

- SpaceX Office Trailer and Customer Trailer

The following new construction and upgrades are proposed for this EA as part of Phase 1:

- New Falcon 9 launch pad and runway
- New Falcon 9 hangar facility
- Helipad (The existing helipad would be demolished and a new one built)
- New kerosene and diesel fuel containment facility and water storage area
- New LOX, helium, and LN2 storage facility
- New propellant line paths and some trenching
- Vegetation removal around both launch pads and in some facility areas
- Trenching for water, communications, and power lines

The following new construction and upgrades are proposed as part of Phase 2:

- New storage facility
- New generator facility
- Additional or replacement reverse osmosis unit (for production of non-potable water)
- Wind-based power generator
- New roads and paved areas between key areas, including rainwater control
- Harbor modifications to enable barge access
- Shoreline reinforcement in some areas
- Additional trenching for water, communications, and power lines
- LOX production plant on Kwajalein
- Payload Processing Facility on Kwajalein

2.1.5.1 Existing Facilities

The Omelek pier is built into the embayment that is formed by a natural projection of the island and a constructed breakwater. The breakwater is a built-up soil mound armored with large pieces of coral rock (riprap). A walkway with handrail was installed on the riprap from the pier to the island under the proof-of-principle launch effort. This dock is used by personnel and receives limited cargo delivery. Two mooring buoys were installed under the proof-of-principle launch effort, and they would be used to moor small powerboats when the landing craft is present. The power boats ferry personnel and material to and from Omelek.

The generator building is a small facility in the south end of the island that distributes island power. Generators are located outside the facility and connected to an automatic transfer switch inside the facility. This switch transfers power generation from one generator to the other if a problem occurs. Power lines are routed from this facility to facilities around the island, primarily via existing underground conduits. This facility would be used as-is during Phase 1 construction and during early missions for both Falcon 1 and 9. The facility currently uses two 400-kilovolt ampere (kVA) portable generators previously approved for operations in the Proof-of-Principle Space Launches from Omelek Island EA. A 50-kVA generator provides power during sustainment periods between missions.

The communications facility is a concrete building located next to the generator building on the south end of the island. The fiber optic cable that services Omelek terminates at this facility, which SpaceX uses as a communications hub. Additionally, this building stores sensitive equipment because the building is air conditioned. The use of this facility would not change under Falcon 9 operations.

The Falcon 1 hangar is located north of the communications facility and is a fabric-over-steel frame, temporary structure measuring 12 meters by 30 meters by 8 meters (40 feet by 100 feet by 25 feet) high. The facility processes the Falcon 1 launch vehicle before launch. The facility also includes a small cleanroom facility for payload processing. The function of the facility would not change under Falcon 1 launches.

The Falcon 1 launch pad is a 12-meter by 12-meter (40-foot by 40-foot) concrete pad with a concrete runway that is 24 meters by 4 meters (80 feet by 12 feet) wide. The launch pad includes an impermeable berm to contain an accidental release of kerosene prior to launch. The berm, with a minimum height of 10 centimeters (4 inches), includes a section of removable rubber or steel curb that is positioned after the launch vehicle is in place at the stand. The berm is of sufficient height to contain up to approximately 9,463 liters (2,500 gallons) of deluge water spray used during launch.

Rainwater exits the pad through a drain when the pad is not in use; the drain is plugged when vehicle fueling operations begin. Freshwater is used for pad cleanup, deluge spray, and firefighting. The water for the deluge system is supplied from a pressurized water tank that is filled with water from the water system. The deluge system uses ocean water that has been desalinated in a reverse osmosis system and stored in a 37,854-liter (10,000-gallon) tank. The reverse osmosis system also provides water for other non-potable uses. Spray nozzles on the launch stand direct deluge water to structures such as the flame diverter and the concrete. The deluge spray keeps surfaces below their respective melting points. The deluge rate is approximately 3,785 liters (1,000 gallons) in 30 seconds. Approximately 35 to 50 percent of the deluge water is reduced to steam. After each launch, the deluge water that remains on the launch pad is containerized and tested for contaminants. Disposal of contaminated deluge water would occur in accordance with the UES.

The existing site restrooms were refurbished and are in use as intended. Waste water is diverted to the existing site septic/leach field system. Salt water from the island lens well pump provides flush water. Non-potable fresh water for cleaning equipment and facilities and flushing toilets would continue to be supplied from a reverse osmosis system that was approved for the proof-of-principle launches. This system produces 4,542.5 liters (1,200 gallons) per day and discharges brine waste into the harbor area. Bottled or potable water for drinking, food preparation, hand-washing, and bathing would be shipped from Kwajalein and stored on the island.

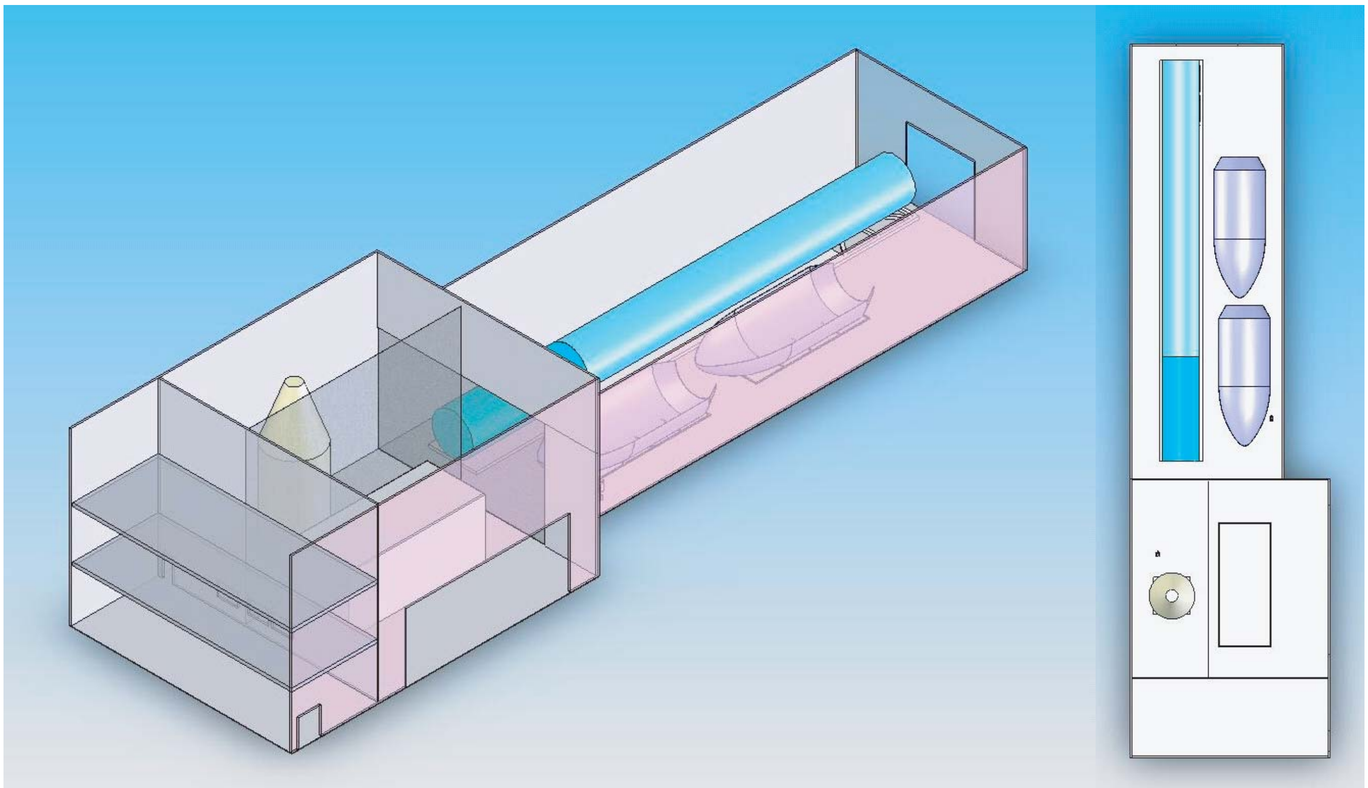
2.1.5.2 Phase 1 Construction

The existing trailer used as offices for the Falcon 1 proof-of-principle launches would be moved as part of Phase 1 construction to accommodate the Falcon 9 hangar and the new LOX storage facility. The trailer would be moved north of its existing location and placed next to the Falcon 1 hanger, as shown in Figure 2-8. Either in conjunction with this move in Phase 1 or as part of Phase 2, this trailer would be replaced by a newer facility. The new facility would not exceed 12 by 24 meters (40 by 80 feet) and may rise two stories. This change would accommodate the increased number of personnel expected on Omelek on a daily basis during combined Falcon 1 and Falcon 9 operations. The facility would be composed of modern trailers linked in a similar way to the existing trailer facility or constructed as a new butler building. If constructed of trailer modules, the facility would be placed on undisturbed ground. If a new facility is constructed, a concrete pad would be necessary to support the facility. Power, communications, water, and sewage would be routed through new underground conduits to and from the facility.

As part of Phase 1 construction, the helipad would be moved to the southeast side of the island. The new helipad would allow access to Omelek by helicopter for emergency use and for occasional transportation to and from the island. Relocating the helipad to the southeast side reduces the potential of impacting the approach and departure path when other new facilities are added. The helipad would be constructed with concrete or asphalt under Phase 1; lights would be added to enable nighttime access for helicopters under Phase 2.

The largest piece of new construction for the Phase 1 activity would be the Falcon 9 launch pad and stand. As indicated in Figure 2-8, this pad would be located on the northern tip of Omelek. The pad would include an elevated stand or platform, with a concrete basin located under and around the stand for fuel spill and deluge water containment. The stand would measure approximately 6 meters by 6 meters (20 feet by 20 feet) and have a height between 6 and 11 meters (20 and 35 feet). The containment area beneath and in front of the pad would measure at least 15 meters by 15 meters (50 feet by 50 feet) and be capable of holding the entire load of kerosene (or deluge water) from Falcon 9 (approximately 113,562 liters [30,000 gallons]). Additionally, a concrete runway 61 meters (200 feet) long by 6 meters (20 feet) wide would be constructed to provide a level area used to bring the launch vehicle to the stand prior to erection. This runway would be concrete, approximately 30.5 centimeters (12 inches) thick. A hydraulic system would be installed at the Falcon 9 pad to erect the launch vehicle, and a flame diverter would be used to control the flow of the vehicle plume during lift-off. Flame would be diverted to the sides and front of the pad, away from the island. The pad would be contoured to minimize the acoustic impact to the launch vehicle during lift-off.

The second largest piece of construction, and the largest in square footage, would be the new launch vehicle processing hangar (Figure 2-10). This facility, located on the southern tip of Omelek, would measure 88 meters (290 feet) long. The width would vary from 15 meters (50 feet) to the north, to 26 meters (85 feet) near the southern end. This is to accommodate a built-in payload processing facility in this building. The facility would measure approximately 15 meters (50 feet) high at its northern end, and approximately 20 meters (65 feet) high at its southern end; the additional height at the southern end assists payload processing. The building would include a large processing area for launch vehicle processing; a smaller facility that may be divided by movable walls for payload processing; and an office and equipment area that would also support payload processing. The facility would be constructed of pre-fabricated steel framework with steel or aluminum sheet walls. The facility would have air conditioning, and the cleanroom facility would have an independent Heating, Ventilation, and Air Conditioning (HVAC) system with a scrubber system to minimize emissions to the environment in the event of a payload fuel spill inside the facility. A number of safety systems would support the hazardous fuels and operations planned for this facility.



Falcon 9 Hangar Facility Conceptual Design

Figure 2-10

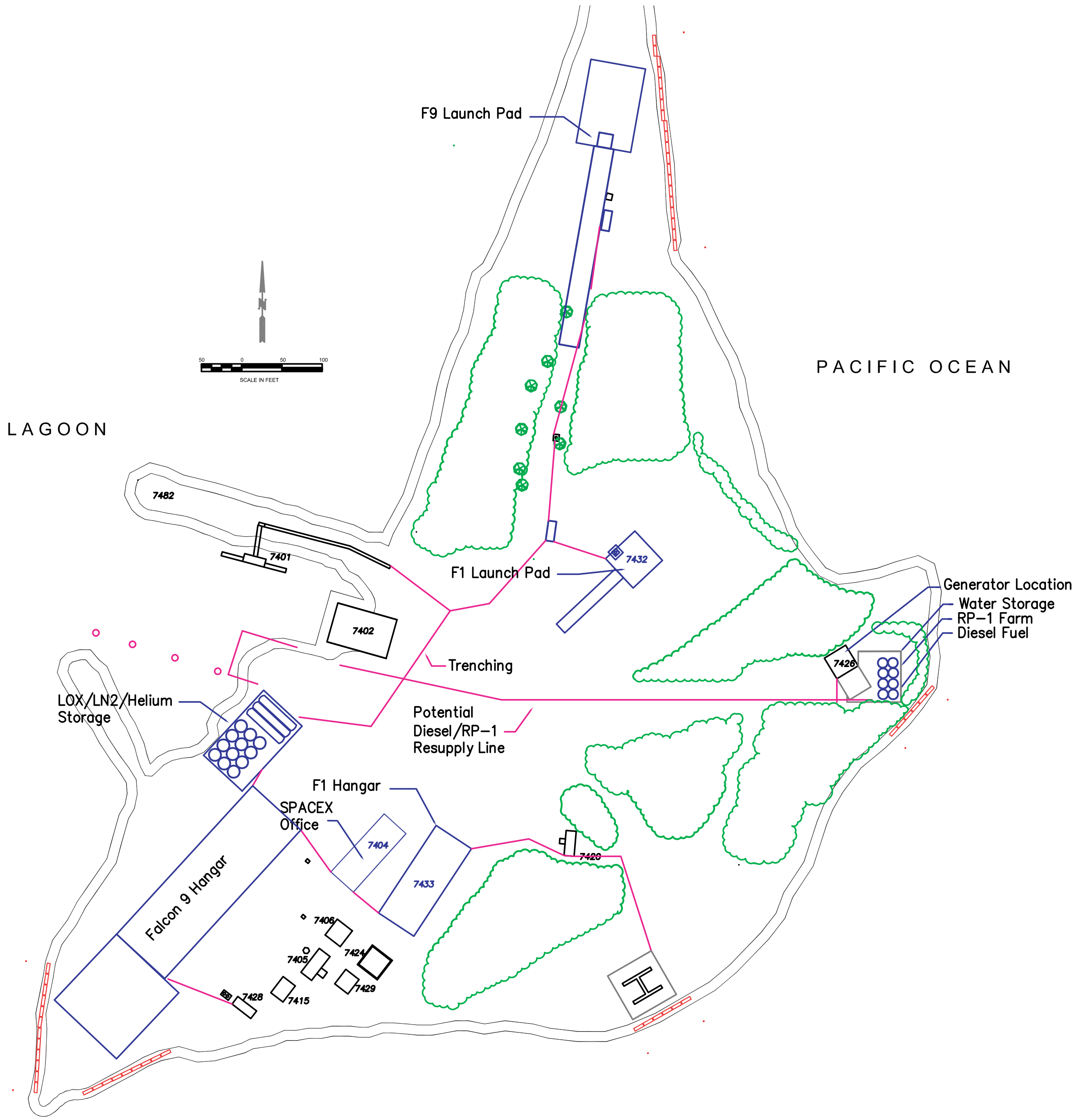
A new storage and containment area would be constructed to support the storage of kerosene propellant for both the Falcon 1 and Falcon 9 launch vehicles, as well as diesel storage for island generators. The new storage area would be located to the east on Omelek. Kerosene and diesel fuel would be stored in aboveground tanks or standardized containers (trailer mounted, DOT approved, horizontal bulk shipping containers), located within a concrete containment area. This area would contain 110 percent of the amount of the largest storage tank, per environmental regulations. Rainwater would be drained if testing shows the water is free of fuel contaminants. The storage and containment area could store enough fuel for at least three Falcon 9 launches (up to 378,541 liters [100,000 gallons]). The kerosene would be delivered in 22,712-liter (6,000-gallon) tanker trailers that would be transported by barge to Omelek and either offloaded at the dock to the storage area through a pipeline (Figure 2-11) or moved from the barge to the storage area and offloaded there. Kerosene would be carried by aboveground piping to both the Falcon 1 and Falcon 9 launch pads. If pipe runs pass through traffic areas, then surface level trenches would be constructed to facilitate traffic flow and enable inspection and repair of the piping. Water from the reverse osmosis system would be stored in this area; however, it would not be located within the containment area.

Helium, LOX, and nitrogen would be stored in the newly constructed storage location on Omelek (Figure 2-12). A concrete pad at least 12 by 18 meters (40 by 60 feet) and at least 0.3 to 0.9 meter (1 to 3 feet) thick in some areas would be constructed to support up to eight vertical storage tanks for LOX and two to four tube trailers of helium. As with the kerosene system, lines would route LOX, helium, and nitrogen to both launch pads via over-ground lines. Short runs in surface level trenches would be constructed in areas that receive traffic. LOX would be delivered to the island in standardized containers such as those used for Falcon 1 launches; LOX would not be generated on the island.

To support new facilities, vegetation removal would be required on Omelek in several locations. Limited removal of established hardwoods would be necessary. To the extent possible, shoreline vegetation would be pruned instead of removed to retain root systems and their erosion protection.

Vegetation removal would occur primarily at the north end of the island near the Falcon 9 launch pad. Removal of trees and vegetation in the margin between the launch pad and 46 meters (150 feet) back from the pad is required to avoid damage to remaining vegetation, reduce fire hazards, and reduce the impact on birds that may be present during launch operations. On the North Point of Omelek approximately 1,486 square meters (16,000 square feet) of vegetation would be removed; 25 percent of which is trees (about 372 square meters, or 4,000 square feet).

Vegetation removal would also occur around the Falcon 1 pad (30.5 meters [100 feet]), the southern tip of the island around the Falcon 9 hangar, and the site of the new helipad. Around the Falcon 1 pad, approximately 929 square meters (10,000 square feet) of vegetation would be removed, 50 percent of which is trees (465 square meters [5,000 square feet]). Around the new helipad location, approximately 929 square meters (10,000 square feet) of vegetation would be removed, 60 percent of which is trees (557 square meters [6,000 square feet]). The area around the Falcon 9 hangar is composed entirely of shrubs, and approximately 93 square meters (1,000 square feet) of vegetation would be removed. Remaining areas would be left undisturbed. Figure 2-13 compares the current island vegetation with the amount of vegetation that is estimated to remain after Phase 2 construction. The total amount of vegetation that would be removed is 3,887 square meters (41,850 square feet), of which 1,394 square meters (15,000 square feet) is trees and 2,495 square meters (26,850 square feet) is shrubs.



EXPLANATION

LOX - Liquid Oxygen

LN2 - Liquid Nitrogen

Tree

Vegetation

Resupply Line

Proposed Facilities

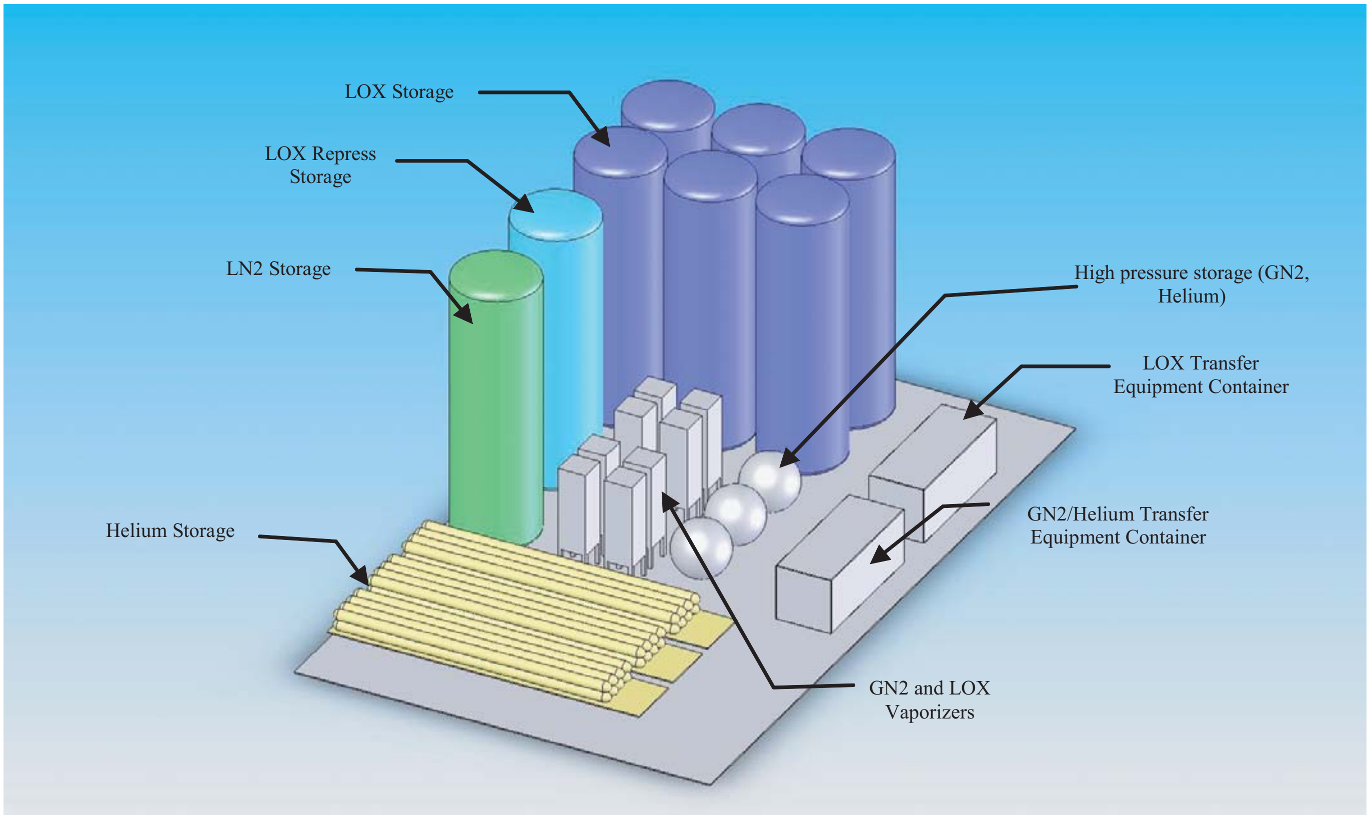
Proposed Shoreline Reinforcement

NORTH

Trenching Map - Potential Diesel/ Kerosene Resupply Line

Omelek Islet

Figure 2-11

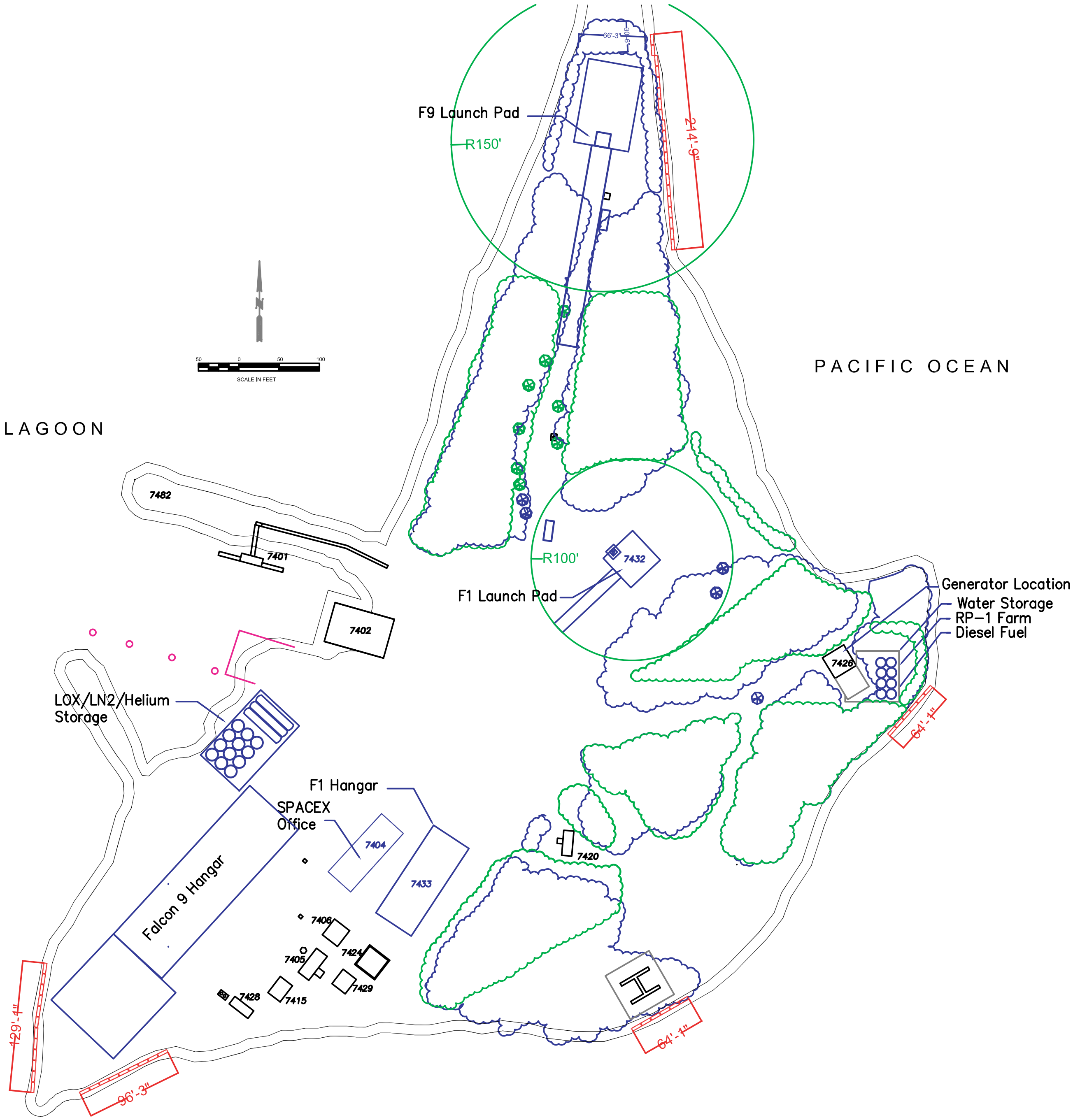


EXPLANATION

LOX - Liquid Oxygen
LN2 - Liquid Nitrogen
GN2 - Gaseous Nitrogen

Conceptual Layout of LOX Storage Area

Figure 2-12



EXPLANATION

LOX - Liquid Oxygen

LN2 - Liquid Nitrogen

Tree

Current Vegetation

Vegetation After Phase 2 Construction

Proposed Facilities

Proposed Shoreline Reinforcement

NORTH

Current Island Vegetation vs. Vegetation After Phase 2 Construction

Omelek Islet

Figure 2-13

Power, communications, water, and sewage would be routed to the new facilities via an underground conduit. Power and communications are already distributed to key areas on Omelek via existing underground conduit. Additional trenching would be required in several areas to extend these services to the new facilities. Estimated trenching is illustrated in Figure 2-11, although additional trenching may be necessary. Trenching would avoid vegetated areas to the extent possible. The toilets in the new facilities would be connected to the existing septic/leach system located on the southern end of the island.

During and after Phase 1 activities, island power would be supplied by portable generators located near the existing generator facility. One 400-kW generator would be used to support construction operations and launch operations. On launch day, two 400-kW generators would be active, with an automatic transfer switch system that would transition island power from one generator to the other in the event of a problem. During non-construction periods and between launch operations, Omelek would be placed in a caretaker mode and powered by a small 50-kW portable generator. Until Phase 1 construction is complete, the 400-kW generator is expected to provide site power 60 percent of the time.

Concrete debris from removed buildings would be used for shoreline reinforcement if deemed suitable by USAKA Environmental Management Officer. Otherwise, small concrete debris would be used as fill in construction areas that require it. Remaining debris would be removed from Omelek and placed in the Kwajalein waste management areas.

2.1.5.3 Phase 2 Construction

Phase 2 construction would upgrade certain services on Omelek and ensure the island can support space launch for the long term. There are several aspects of Phase 2 construction. First, the generator facility would be relocated to the east of the island near the kerosene storage area constructed in Phase 1. Two 1,000-kVA generators would supply power on the island during launch activities. Power would be transported to the various areas either through existing or newly constructed conduits below ground, or via temporary above-ground cable trays. A smaller 100-kVA generator would be used during sustainment periods, 3 to 8 months per year, when no launches would occur. One of the two 1,000-kVA generators would be operating for the remainder of the time, and both 1,000-kVA generators would be active on launch days. Lines running site power would be routed through existing underground conduit when possible. Additional trenching would be required to provide power to facilities without underground conduits, such as the new office trailer location and the storage facility. Power lines in new trenches would be laid in 10- to 15-centimeter (4- to 6-inch) PVC conduit. Communication and data hook-ups from all facilities to the communications building would also be routed through existing or new buried conduits.

SpaceX is considering the addition of a wind-based power generator for use between missions when power needs are reduced. The wind generator would likely be two commercial grade 50- to 100-kW generators. The system has yet to be designed or sized beyond the stated generation requirement. When implemented, the wind turbine would be mounted on the far eastern spur of the island near the generator building.

In Phase 2, a reverse osmosis unit would be installed to generate approximately 11,356 liters (3,000 gallons) of water per day to support the deluge system and other non-potable uses. Other water uses, including rinsing, washing, bathing, laundry, and cooking, are prohibited. If at a later date the system is to be used for potable water applications, it would have to meet requirements of the UES, such as chlorination and monitoring. A Document of Environmental Protection would also have to be developed and approved prior to any potable use of the water from the reverse osmosis unit.

Also in this phase, a new storage facility would be constructed at the location of the existing ordnance storage facility, which would be demolished as part of the construction effort. The facility would store launch site spares and equipment, as well as provide an indoor storage location for motor vehicles on Omelek, which would significantly reduce corrosion problems. Power and communications would be routed to this new facility via new underground conduit in a trench that follows the new access road to this location, as shown in Figure 2-11.

During this phase, the unimproved paths used to access the island would be paved to provide safe, reliable transportation routes. The paving material would be primarily concrete, but asphalt may be laid in some locations, depending on cost and availability of equipment. Roads would generally measure 6 meters (20 feet) wide and would support the weight of the Falcon 9 vehicle. Some areas of general paving would be constructed to provide adequate turning radii for large vehicle transporters and parking locations for island motor vehicles. Road design would also include an evaluation of rainwater drainage on Omelek, and rainwater control channels or conduit would be installed during paving construction.

Rainwater run-off from paved areas on Omelek could be managed by:

- Allowing rainwater to collect in low areas. This would be acceptable for some areas near vegetation on Omelek, but not for areas that endure traffic.
- Diverting run-off via culverts to vegetated areas or to the harbor.

SpaceX would like to use a combination of approaches:

- Allow run-off to drain naturally along the access road to the north and along the paved roads to the east towards vegetated areas.
- Construct surface or underground culverts to divert water from the central and southern portions of the island to the harbor.

The culvert drainage area is approximately 2,787 square meters (30,000 square feet). If a rain event generated 1.27 centimeters (0.5 inch) of precipitation, then the culverts would divert approximately 34,068 liters (9,000 gallons) of water, assuming all the water is diverted.

Harbor modifications are also planned for Phase 2. To facilitate access to Omelek by cargo barges in addition to the currently used landing craft vessels, a series of pilings would be installed on the south side of the harbor. The pilings would support the barge as it approaches the island. Additionally, a concrete barge dock would be installed (refer to Figure 2-9). The barge dock would extend approximately 3 meters (10 feet) into the harbor from the current shoreline and would be 6 to 12 meters (20 to 40 feet) wide. This dock would provide a flat front surface for the barge to dock against when off-loading equipment. Dredging the harbor is not anticipated.

Shoreline reinforcement in some areas around Omelek would occur during this phase, although reinforcement of select areas may also occur in Phase 1. The areas that need reinforcement are shown in Figure 2-13. Reinforcement would be accomplished by placing large rocks and debris per standard practice. The reinforcement would slow the dramatic shoreline erosion observed in areas along Omelek.

There are two facilities that may be constructed on Kwajalein during Phase 2, the first of which is a potential LOX production plant to supply LOX for launches on Omelek. If implemented, this plant would produce up to 6.4 metric tons (7 tons) per day when active and store up to 37,854 liters (10,000 gallons) on Kwajalein during production. Approximately 232 square meters (2,500 square feet) is needed to construct the facility, which most likely would be sited on the western, industrial side of Kwajalein. Tentatively, the facility would be located at Building 1500 in the existing LN2 facility.

The second facility is a Payload Processing Facility to supplement or replace the facility in the hangar on Omelek. Approximately 2,322.5 square meters (25,000 square feet) is needed to construct this facility (Figure 2-14). USAKA planning has two tentative locations for this facility on Kwajalein, shown in Figure 2-15. These locations would also serve as alternative locations for the LOX production plant. In addition to normal processing activities, fueling of payloads would also occur in this facility; as such, hazardous materials would be present for short periods (up to 2 weeks). These materials would be stored in an approved facility on Meck when not in use. The processing facility would be equipped with special HVAC systems with scrubbers that would reduce or eliminate the potential for toxic emissions in the event of a spill.

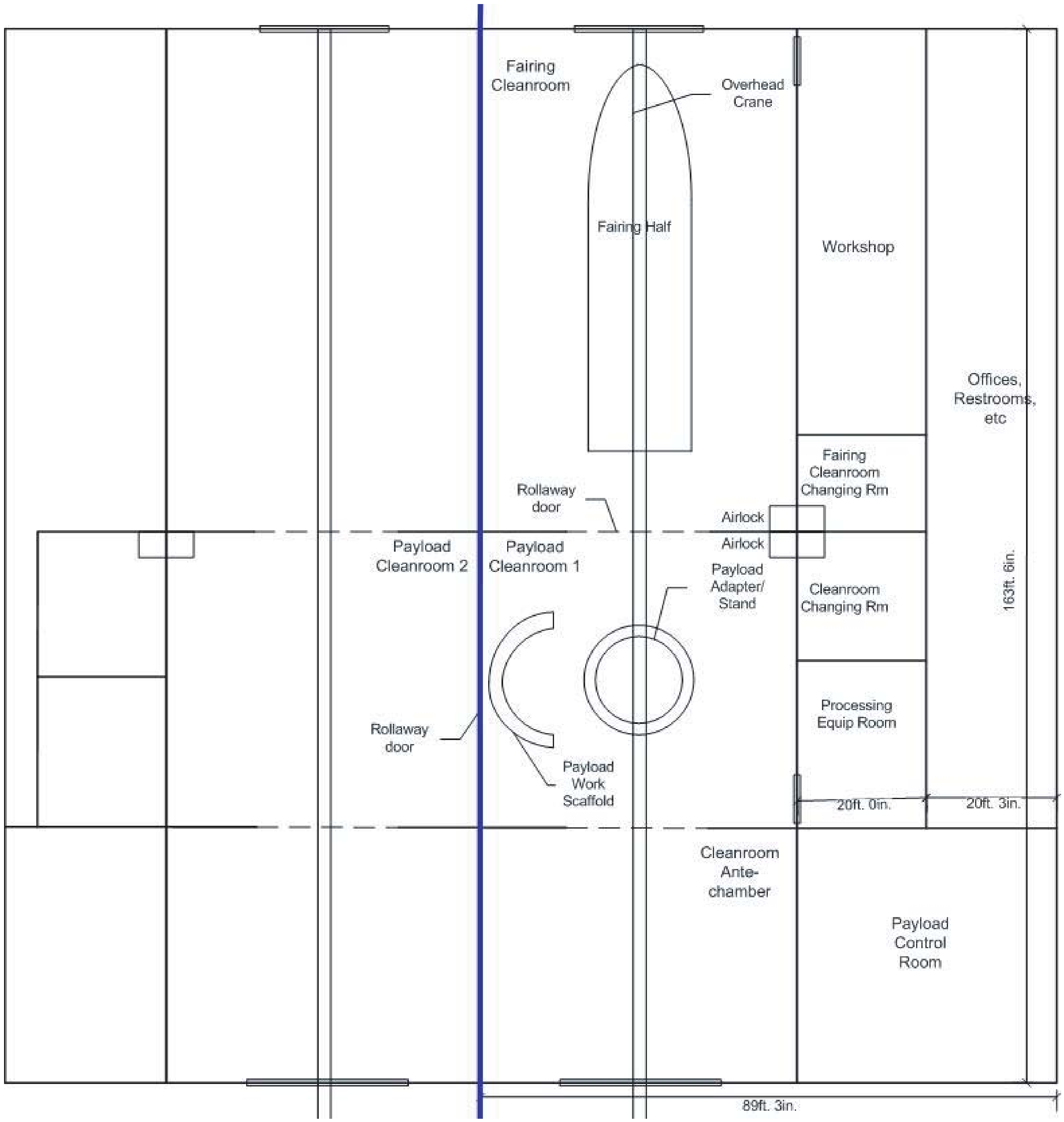
2.2 NO-ACTION ALTERNATIVE

Under the No-action Alternative, the proposed Falcon launch vehicle activities would not be conducted at Omelek, and SpaceX would not proceed with further new construction or modification efforts at USAKA or launches beyond the five that have been authorized. SpaceX would be unable to launch additional satellite payloads into orbit from USAKA/RTS and would be required to consider less suitable alternative launch sites to continue the program.

2.3 ALTERNATIVES CONSIDERED BUT NOT CARRIED FORWARD

2.3.1 OMELEK ALTERNATIVE SITE CONSIDERED

A site located on the southern portion of Omelek was considered as an alternative location for the Falcon 9 launch pad (Figure 2-16). This alternative site would not allow adequate separation distances from oxidizers and fuels. The safe distance circles from the LOX and fuel storage areas completely cover the alternative location for the launch pad, leaving only the northern portion of Omelek suitable for placement of the Falcon 9 launch pad (refer to Figure 2-5 for safe distance data). This alternative site was not carried forward for further consideration.



Conceptual Design of Payload Processing Facility Located on Kwajalein

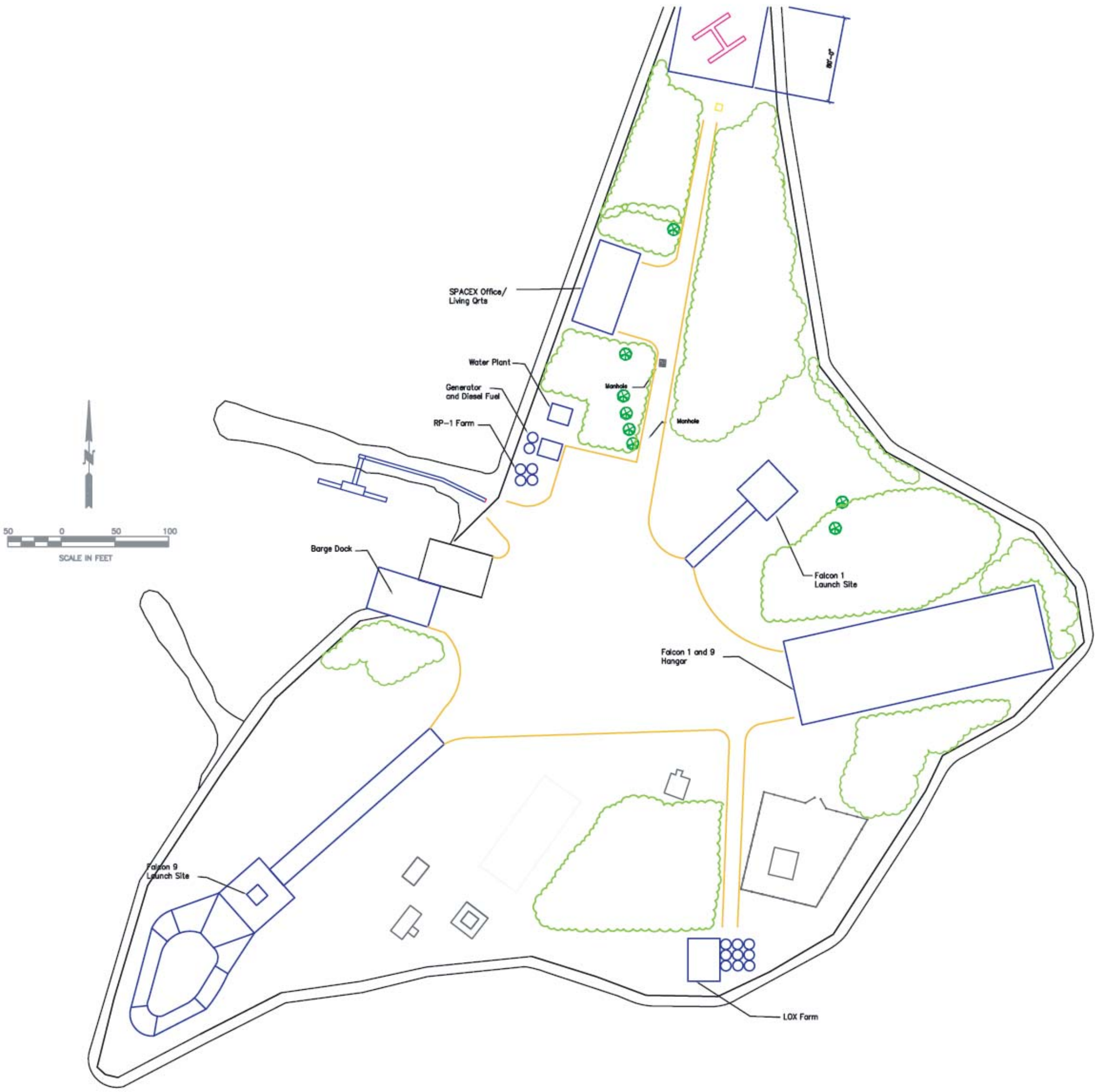
Figure 2-14

NORTH

Potential Sites for Payload Processing Facility

Kwajalein Islet

Figure 2-15



EXPLANATION

LOX - Liquid Oxygen

- Tree
- Vegetation
- Proposed Paved Area
- Proposed Facilities

NORTH

Alternative Siting Location for Falcon 9

Omelek Islet

Figure 2-16

2.3.2 USAKA ALTERNATIVE SITES CONSIDERED

Major changes are proposed to the existing Omelek launch site, and as such, other sites in the Kwajalein Atoll were evaluated as alternatives to Omelek. The following sites were considered and dismissed for the reasons discussed below.

2.3.2.1 Meck Islet

Meck currently supports a launch site used primarily by the Missile Defense Agency. The island has a number of facilities and infrastructure that could support launch of the Falcon vehicles. Because this island is dedicated to DoD missile defense missions, a reliable flight rate from Meck was not considered viable at this time. Additionally, a number of changes to existing facilities would be required to support Falcon missions, which would in turn affect the use of the island for the critical DoD missions. For these reasons, Meck was not considered practical for Falcon program launches.

2.3.2.2 Illeginni Islet

Illeginni is the only other islet in the Kwajalein Atoll large enough in size and far enough from populated areas to potentially support the Falcon 1 and 9 programs. However, Illeginni is still used as an impact zone for U.S. Air Force missile testing. Additionally, the harbor at Illeginni would require significant modification to support landing craft and barge deliveries for Falcon program equipment. Based on these facts, Illeginni was removed from consideration.

2.3.3 OTHER LAUNCH LOCATIONS CONSIDERED

The use of an equatorial site is important for very low inclination launches. The rotational speed of the Earth is greatest at the equator, and launch sites situated close to the equator can use this extra velocity to launch larger payloads into a given orbit with a given amount of fuel. At latitudes higher than the equator, payloads cannot be launched directly onto an orbital inclination that is less than the latitude of the launch site. Once a satellite is in orbit, orbital plane change maneuvers would be used to achieve the desired inclination. These plane change maneuvers consume the satellite's on-board fuel. The advantage of using launch sites close to the equator is that a satellite can be launched directly onto the desired orbit or as close to it as possible, thus reducing orbit plane change maneuvers and conserving on-board fuel. This ultimately increases the operational lifetime of the satellite. The geographical sites described below were considered and dismissed from further consideration as alternatives to USAKA/RTS.

2.3.3.1 Cape Canaveral, Florida

SpaceX may establish a launch site at Launch Complex 40 at Cape Canaveral, Florida. This site would augment but not replace operations at USAKA. This location at Cape Canaveral would support launches to inclinations supporting the International Space Station; however, use of Cape Canaveral for low inclination launches would require overflight of populated areas. Therefore, USAKA/RTS would remain critical for launch of payloads into very low inclination orbits.

2.3.3.2 Vandenberg Air Force Base, California

Vandenberg Air Force Base (AFB) launches a variety of missile systems from the west coast of the United States and is in close proximity to the SpaceX operations in El Segundo, California. However, the location of Vandenberg AFB would not support the majority of the SpaceX launch azimuths due to latitude and overflight of populated areas. Vandenberg AFB is being carried forward and evaluated in a separate environmental document for high inclination earth orbit launches. Vandenberg AFB is not suitable for low inclination eastern trajectory launches because overflight of populated areas would occur. This presents a safety risk not present at USAKA/RTS.

2.3.3.3 Alcantara Launch Facility, Brazil

The Alcantara Launch Center on the Atlantic coast of Sao Luis, Brazil, is used for launches of Satellite Launch Vehicle or Veiculo Lancador de Satelites space boosters, Sonda sounding rockets, meteorological rockets, and other science boosters. Brazilian scientists have launched hundreds of sounding rockets since the mid-1960s. Alcantara, also known as CLA, has a launch control center and blockhouse. Its position in relation to the equator is said to offer a launch advantage over Cape Canaveral. However, an accident in August 2003 destroyed some of the launch facilities (Space Today Online, 2003). Therefore, the Alcantara Launch Facility was not carried forward for further consideration.

2.3.3.4 Guiana Space Center, Kouru, French Guiana

The Guiana Space Center is the launch site for the European Ariane vehicles. The Guiana Space Center, also known as the Spaceport, is a strategically-located facility that provides the optimum operating conditions for Arianespace's commercial launches. Situated close to the equator at 5.3 degrees North latitude, the Spaceport is ideally situated for missions into geostationary orbit. Launching near the equator reduces the energy required for orbit plane change maneuvers. This saves fuel, enabling an increased operational lifetime for Ariane satellite payloads, and in turn, an improved return on investment for the spacecraft operators. The French Guiana coastline's shape allows for launches into all useful orbits from northward launches to –10.5 degrees, through eastward missions to +93.5 degrees (Arianespace, 2004). Because Arianespace is a direct competitor of SpaceX and would not allow SpaceX to use their launch facility, the Guiana Space Center was dismissed from further consideration as an alternative launch location.

2.3.4 CONDUCTING ONLY FALCON 1 LAUNCHES

SpaceX could continue to launch only Falcon 1 launch vehicles from Omelek. While this would require less construction and thus less vegetation/habitat removal, it would not meet SpaceX or USAKA satellite mission goals.

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3.0
AFFECTED ENVIRONMENT

3.0 AFFECTED ENVIRONMENT

This section describes the environmental characteristics that may be affected by the Proposed Action at Omelek. To provide a baseline point of reference for understanding any potential impacts, the affected environment is concisely described; any components of concern are described in greater detail. The EA evaluates the potential environmental impacts of conducting regular launch operations placing small and medium class payloads into orbit from Omelek using Falcon 1 and Falcon 9 launch vehicles. The EA also evaluates related activities, such as safety issues associated with transporting, handling, and storage of Falcon missile components, which could have potential impacts on public health and safety or the environment.

Available reference materials, including EAs, environmental impact statements (EISs), and natural resources plans, were reviewed. Questions were directed to installation and facility personnel and private individuals. Site visits were also conducted where necessary to gather the baseline data presented below.

Environmental Resources

Thirteen broad areas of environmental consideration were originally considered to provide a context for understanding the potential effects of the Proposed Action and to provide a basis for assessing the severity of potential impacts. These areas included air quality, airspace, biological resources, cultural resources, environmental justice, geology and soils, hazardous materials and waste, health and safety, infrastructure, land use, noise, socioeconomics, and water resources. These areas were analyzed as applicable for the proposed location or activity.

Only a few existing base personnel would be involved, and only 30 SpaceX personnel would require lodging on Kwajalein. Up to eight SpaceX personnel would live temporarily on Omelek in the SpaceX office facility, as required. Because there would be little or no effect to off-base populations, disproportionate impacts would not occur to any minority or low-income populations under Executive Order 12898 (Environmental Justice) or environmental health and safety risks that may disproportionately affect children under Executive Order 13045 (Federal Actions to Address Protection of Children from Environmental Health and Safety Risks).

For purposes of this analysis, open ocean refers to those ocean areas beyond U.S. and RMI territorial limits. Open ocean areas are subject to Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*. A limited number of resources could potentially be affected in open ocean areas by the Proposed Action, including airspace, biological resources, and health and safety. Noise and water impacts are relevant only with respect to the potential for effects on biological resources.

Environmental Setting

Kwajalein Atoll is located in the western chain of the RMI in the West Central Pacific Ocean. USAKA/RTS leases all or part of 11 islets in the Atoll, including Omelek. Omelek is a 4-hectare (10-acre) islet located about halfway between Kwajalein and Roi-Namur islets.

3.1 U.S. ARMY KWAJALEIN ATOLL, OMELEK ISLET

3.1.1 AIR QUALITY

Air quality in a given location is described by the concentrations of various pollutants in the atmosphere, expressed in units of parts per million, or micrograms per cubic meter ($\mu g/m^3$). Pollutant concentrations are determined by the type and amount of pollutants emitted into the atmosphere; the physical characteristics, including size and topography; and meteorological conditions related to prevailing climate.

Air quality at Omelek is defined with respect to compliance with ambient air quality standards set in the *Environmental Standards and Procedures for U.S. Army Kwajalein Atoll (USAKA) Activities in the Republic of the Marshall Islands, 10th Edition* (U.S. Army Space and Missile Defense Command, 2006b). Table 3-1 lists these standards. Table 3-2 lists threshold limits for the same pollutants from new stationary sources at USAKA. In the event that these levels are exceeded, a DEP would be required for the new stationary source.

3.1.1.1 Region of Influence

The region of influence for ozone may extend much further downwind than the region of influence for inert pollutants; however, as the project area has no heavy industry and very few automobiles, tropospheric ozone and its precursors are not of concern. For the air quality analysis, the region of influence for project operational activities includes Omelek.

3.1.1.2 Affected Environment

3.1.1.2.1 Climate

While available climatological information is specific to the island of Kwajalein, the other USAKA islets, including Omelek, have very similar climates. The average monthly temperatures on Kwajalein range from 27 to 29°C (80 to 85°F), depending on the season. The average annual precipitation is 256 centimeters (101 inches), 75 percent of which is recorded from mid-May to mid-December (the rainy season). During this time, light, easterly winds and frequent moderate to heavy showers prevail. During the drier season, light showers of short duration occur, and cloud cover is at a minimum. The relative humidity is uniformly high throughout the year, with values almost always between 70 and 85 percent. (U.S. Army Space and Strategic Defense Command, 1995)

Northeasterly trade winds ranging from 14.5 to 26 kilometers (9 to 16 miles) per hour are dominant during most of the year. The summer months can bring relatively calm conditions. Typhoons occasionally occur at Kwajalein Atoll; however, the atoll is considered to be outside the main areas of typhoon occurrence in the Western Pacific. (U.S. Army Kwajalein Atoll, 2006)

Table 3-1. USAKA Ambient Air Quality Standards

Pollutant	Averaging Period	USAKA Ambient Standard	USAKA Increment Degradation Standard ($\mu g/m^3$)
Carbon Monoxide	8-hour	8 mg/m^3 (7.2 ppm)	2,500
	1-hour	32 mg/m^3 (28 ppm)	10,000
Nitrogen Dioxide	Annual (1)	80 $\mu g/m^3$ (0.0424 ppm)	25
Ozone	8-hour (2)	128 $\mu g/m^3$ (0.064 ppm) (1)	40
Sulfur Oxides	Annual (1)	64 $\mu g/m^3$ (0.024 ppm)	20
	24-hour	292 $\mu g/m^3$ (0.112 ppm)	91
	3-hour	1,040 $\mu g/m^3$ (0.4 ppm)	325
Lead	Quarterly (1)	1.2 $\mu g/m^3$	0.375
PM-2.5	Annual (3)	12 $\mu g/m^3$	3.8
	24-hour (4)	52 $\mu g/m^3$	16.3
PM-10	Annual (arithmetic mean)	40 $\mu g/m^3$	12.5
	24-hour (5)	120 $\mu g/m^3$	37.5
PM-2.5	Annual (arithmetic mean)	12 $\mu g/m^3$	3.8
	24-hour (5)	52$\mu g/m^3$	16.3

Source: U.S. Army Space and Missile Defense Command, 2006b Table 3-1.6.6
$\mu g/m^3$ = micrograms per cubic meter
mg/m^3 = milligrams per cubic meter
PM-2.5 = particulate matter equal to or less than 2.5 microns in size
PM-10 = particulate matter equal to or less than 10 microns in size (also called respirable particulate and suspended particulate)
ppm = parts per million

Table 3-2. USAKA Air Pollutant Thresholds for Major Stationary Sources

Pollutant	Threshold
Carbon monoxide	90.7 metric tons (100 tons) per year
Nitrogen oxides	36.3 metric tons (40 tons) per year
Sulfur dioxide	36.3 metric tons (40 tons) per year
Ozone	36.3 metric tons (40 tons) per year of volatile organic compounds
Particulate matter	22.7 metric tons (25 tons) per year of PM emissions
	13.6 metric tons (15 tons) per year of PM-10 emissions

Source: U.S. Army Space and Missile Defense Command, 2006b, Table 3-1.5.2

3.1.1.2.2 Regional Air Quality

No ambient air quality data are known to exist for Omelek. However, since there are only extremely minor sources of air pollution such as occasional helicopter landings, strong persistent trade winds, and lack of topographic features to inhibit dispersion, the ambient air quality at Omelek is expected to be in compliance with the maximum pollution levels established in the UES.

3.1.1.2.3 Existing Emission Sources

The only existing major stationary air emission source at Omelek is the operation of two 400-kilovolt generators used to power the SpaceX launch activities and a 50-kW generator that provides power between launches (Table 3-3). The exhaust stack height (above ground level) is 3.2 meters (10.5 feet). Table 3-4 lists the potential emissions from the use of these generators per year.

Table 3-3. Omelek Major and Minor Stationary Sources of Air Pollution

	Type	Rating	Make/Model	Classification	Remarks
Generator	Genset	400 kVA	Whisperwatt	Major	(360 kW)
Generator	Genset	400 kVA	Whisperwatt	Major	(360 kW)
Generator	Genset	50 kW	-	Minor	

Table 3-4. Generator Emissions at Omelek*
Metric Tons (Tons) Per Year

	Volatile Organic Compounds	Oxides of Nitrogen	Carbon Monoxide	Oxides of Sulfur	PM-10
Generators	0.5 (.55)	6.13 (6.76)	1.32 (1.46)	0.4 (0.44)	0.44 (0.48)

Source: Calculations based on emission factors from U.S. Environmental Protection Agency, 2005, AP-42, Fifth Edition, Volume 1
*Note: Based on:
15 week/year mission operation for each 400-kilovolt generator @ 1,000 gallons/week diesel throughput
37 week/year non-mission operation (40 kW generator)@200 gallons/week diesel throughput

The generators are listed in the 2006 air permit for Kwajalein, also known as the DEP. The preliminary air quality analysis completed as part of the DEP indicated that compliance with the allowable incremental degradation standards (Table 3-1) may not be achieved with the current generators when all three units are concurrently operating. However, the primary ambient air quality standards are achieved. (Note: the units would only run concurrently in the event of a problem). The DEP did not define specific mitigation measures to be followed on Omelek because of the exceedances. However, the DEP requires USAKA to complete an analysis of generator configuration (including stack heights) and operational options that will achieve compliance with ambient air quality and incremental degradation standards; and USAKA is required to implement the preferred option identified in the above analysis by May 2009. (U.S. Army Kwajalein Atoll, 2006)

There are no monitoring data for power generator yearly throughput. However, according to SpaceX program requirement documentation, fuel consumption at the Power Plant on Omelek is approximately 757 liters (200 gallons) of diesel fuel per week during non-mission times and 3,785 liters (1,000 gallons) of diesel fuel per week during mission activities. Deliveries are made by fuel truck, to the island's 37,854-liter (10,000-gallon) diesel aboveground storage tank and supplemental tanks on Omelek as needed (Space Exploration Technologies, 2006; 2005).

Rocket launches are generally a smaller source of emissions. Currently, there are five Single Falcon 1 launches per year. Table 3-5 lists the anticipated annual emissions of criteria pollutants from five launches of the Falcon 1.

Table 3-5. Annual Falcon 1 Launch Emissions
Metric Tons (Tons) Per Year

	Volatile Organic Compounds	Oxides of Nitrogen	Carbon Monoxide	Oxides of Sulfur	PM-10
Five Falcon 1 Launches	0.0	0.0	432(476)	0.0	0.0

Source: Space Exploration Technologies Corporation, 2003.

3.1.2 AIRSPACE

Airspace, while generally viewed as being unlimited, is finite in nature. It can be defined dimensionally by height, depth, width, and period of use (time). The FAA is charged with the overall management of airspace and has established criteria and limits for use of various sections of this airspace in accordance with procedures of the International Civil Aviation Organization (ICAO).

3.1.2.1 Region of Influence

The region of influence for airspace at USAKA/RTS includes the airspace over and surrounding the proposed launch site on Omelek, the launch hazard area, debris containment corridor, potential regional radiation hazard areas, and airspace over and surrounding Kwajalein, and Meck.

3.1.2.2 Affected Environment

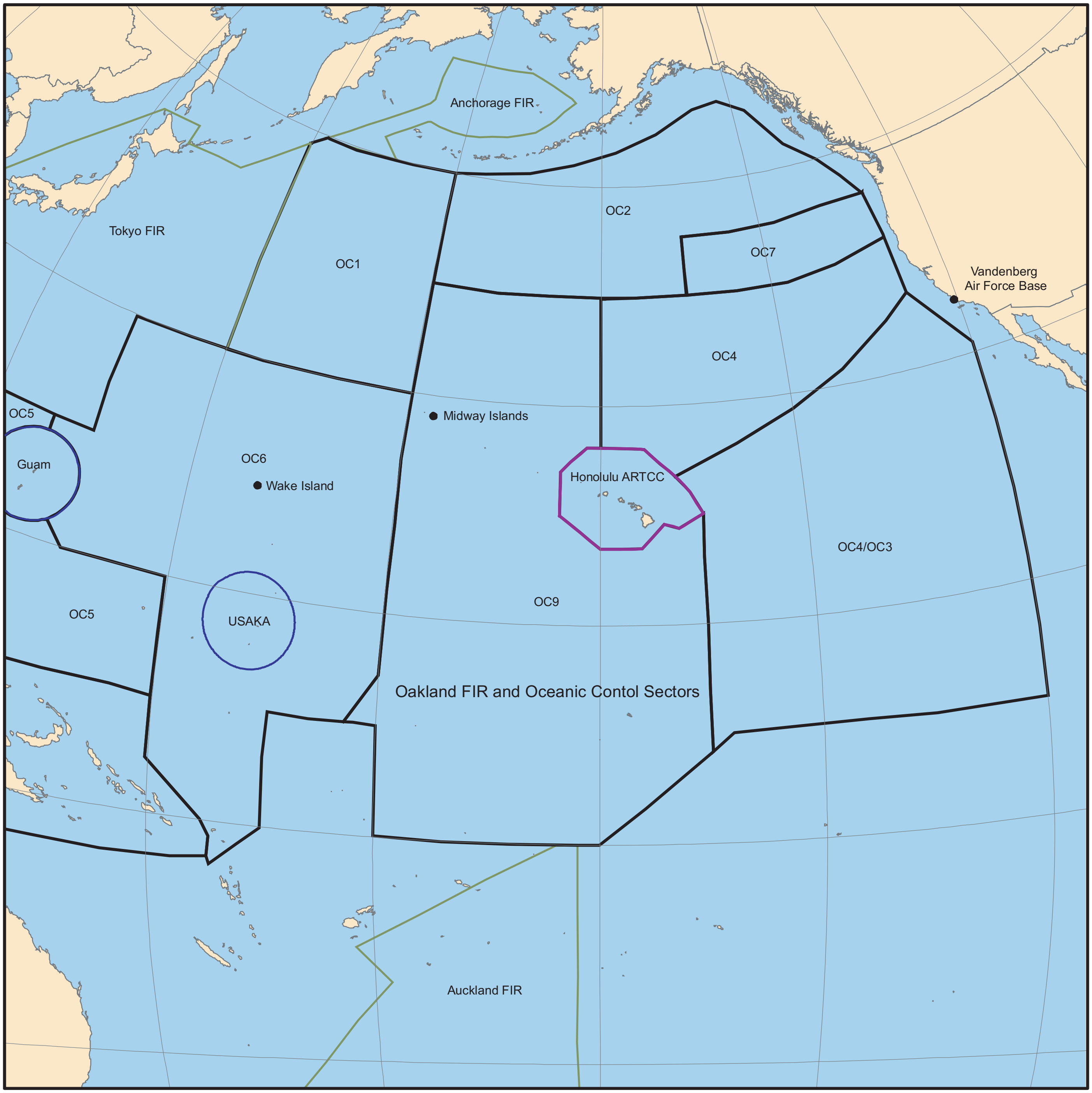
3.1.2.2.1 Controlled and Uncontrolled Airspace

USAKA/RTS is located in international airspace. Therefore, the procedures of the ICAO outlined in ICAO Document 4444, *Rules of the Air and Air Traffic Services*, are followed (International Civil Aviation Organization, 1996; 1997). ICAO Document 4444 is the equivalent air traffic control manual to the FAA Handbook 7110.65, *Air Traffic Control*. The ICAO is not an active air traffic control agency and has no authority to allow aircraft into a particular sovereign nation's Flight Information Region or Air Defense Identification Zone and does not set international boundaries for air traffic control purposes. The ICAO is a specialized agency of the United Nations whose objective is to develop the principles and techniques of international air navigation and to foster planning and development of international civil air transportation.

The FAA acts as the U.S. agent for aeronautical information to the ICAO, and air traffic in the region of influence is managed by the Oakland Air Route Traffic Control Center (ARTCC) in its Oceanic Control-6 Sector, the boundaries of which are shown in Figure 3-1.

3.1.2.2.2 Special Use Airspace

There is no special use airspace in the region of influence.



EXPLANATION

- Radar Control Area
- Flight Information Region (FIR)
- Oakland FIR and Oceanic Control (OC) Sector
- Honolulu Air Route Traffic Control Center Area
- Land

Note:
USAKA = U.S. Army Kwajalein Atoll
ARTCC = Air Route Traffic Control Center

NORTH

0 300 600 1,200 Nautical Miles

Airspace Managed by Oakland and Honolulu Air Route Traffic Control Centers

Pacific Ocean

Figure 3-1

3.1.2.2.3 En Route Airways and Jet Routes

Although relatively remote from the majority of jet routes that cross the Pacific, USAKA/RTS and vicinity have two jet routes above Kwajalein, R-584 and A-222 (Figure 3-2). An accounting of the number of flights using each jet route is not maintained.

Although not depicted on either the North Pacific Route Chart Southwest Area or Composite, there are low altitude, propeller driven aircraft carrying commercial traffic between the various islands of the RMI, particularly between the Marshall Islands International Airport at Majuro and Bucholz Army Airfield on Kwajalein.

3.1.2.2.4 Airports/Airfields

Bucholz Army Airfield has had a reported maximum of 1,674 operations per month, an average of over 55 per day. Many of the 55 flights per day were aircraft and helicopter flights to other USAKA islands. Currently flight activity through Bucholz Army Airfield is about 25 flights per day (Sims, 2004c). Dyess Army Airfield on Roi-Namur provides service to a variety of aircraft and helicopters.

3.1.3 BIOLOGICAL RESOURCES

Native or naturalized vegetation, wildlife, and the habitats in which they occur are collectively referred to as biological resources. For the purpose of discussion, biological resources have been divided into the areas of vegetation, wildlife, threatened and endangered species, and environmentally sensitive habitat.

3.1.3.1 Region of Influence

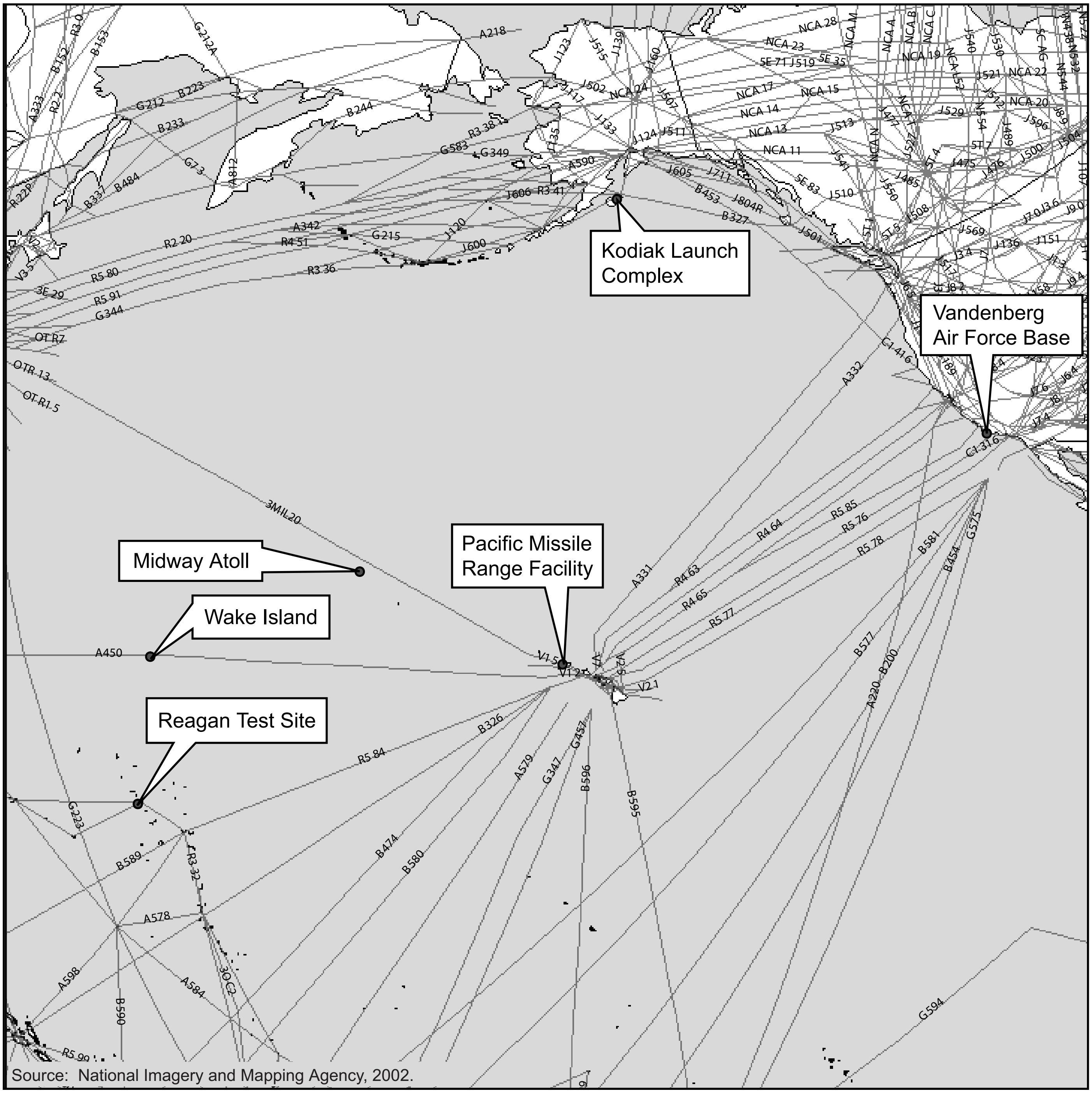
The region of influence for biology includes Omelek and the surrounding waters that may be affected by the proposed activities. Areas of Kwajalein and Meck that may be affected by construction and other project-related activities are also included in the region of influence. Figure 3-3 shows the biological resources of Omelek and the surrounding reef flat.

3.1.3.2 Affected Environment

3.1.3.2.1 Omelek

Vegetation

Omelek is a highly developed islet currently being used for Falcon 1 launches. Approximately two-thirds of Omelek has been cleared, and this area is dominated by non-native grasses and weeds. The remaining habitat contains three separate patches of mixed broadleaf forest: eastern patch, northern patch, and southern patch. The vegetation around the helipad is mowed to about 10 centimeters (4 inches). The rest of the relatively open interior of the island is mostly free of woody plants and is overgrown in areas with a dense mat dominated by beach pea and beggar’s tick (U.S. Department of the Army Space and Missile Defense Command, 2004a; 2006). Native *Scaevola sericea* shrubs, also known as saltbush, are slowly invading areas of Omelek (Sims, 2004b). *Pisonia grandis*, a stocky tree common to the Marshall Islands, can be found on Omelek, as well.



EXPLANATION

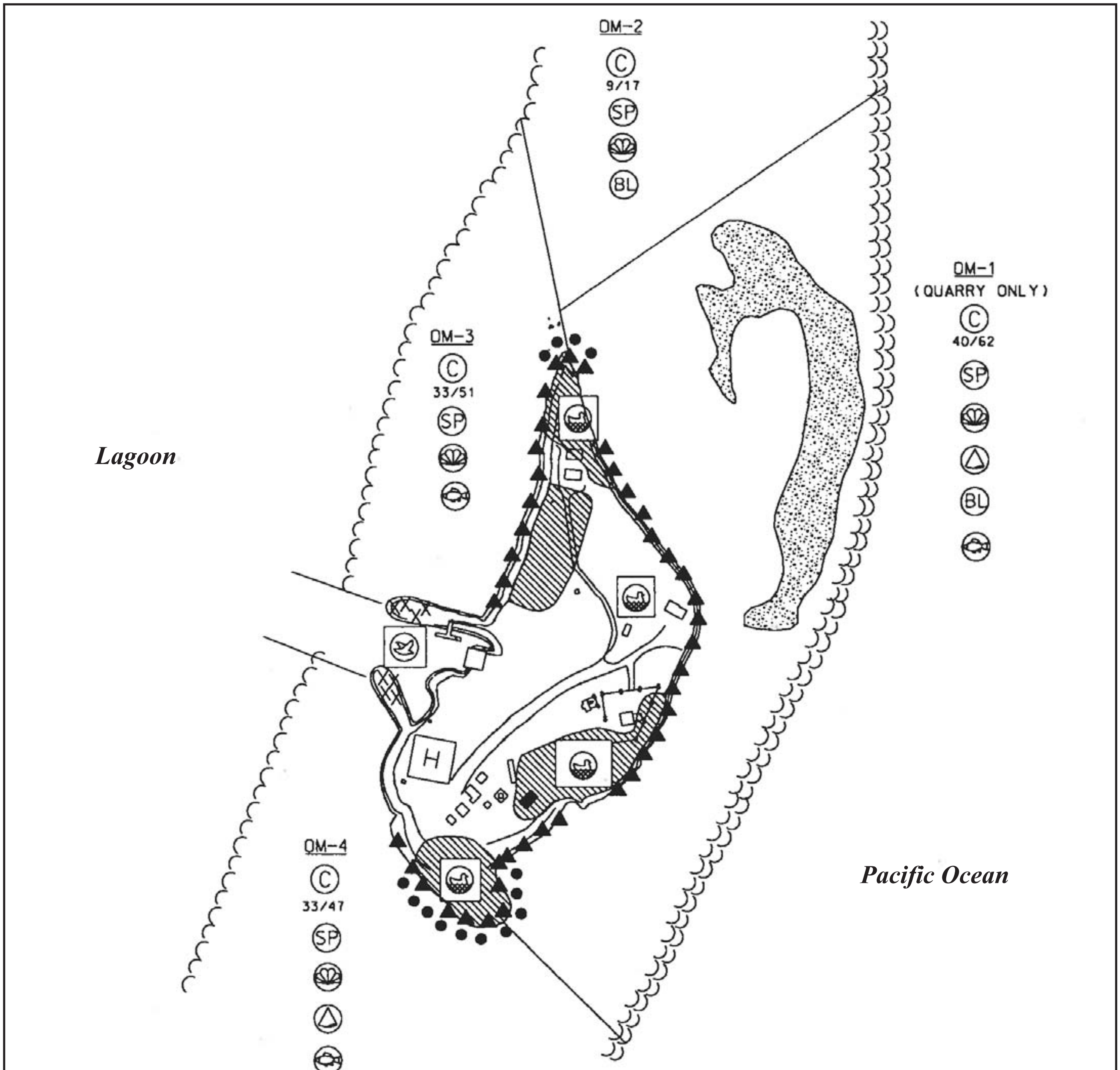
—— High Altitude Jet Routes

High Altitude Jet Routes

Pacific Ocean

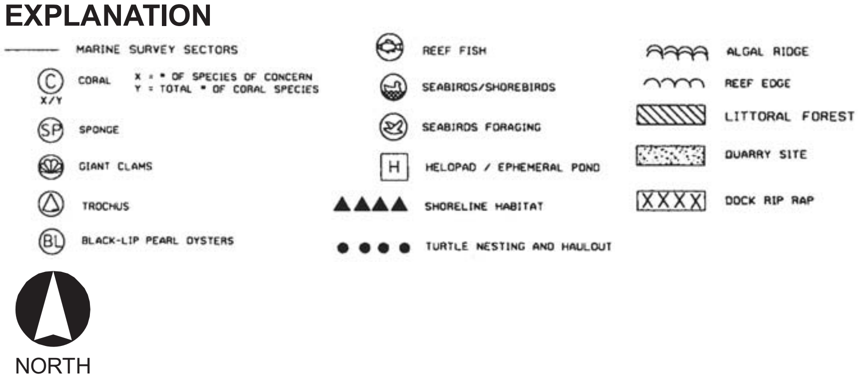
Figure 3-2

NORTH



Source: U.S. Department of the Army Space and Missile Defense Command, 2006

EXPLANATION



Biological Resources of Omelek Islet

Omelek, Kwajalein Atoll

Figure 3-3

Threatened and Endangered Plant Species

No threatened or endangered vegetation species have been identified on Omelek.

Wildlife

The native forest patches on Omelek provide nesting, roosting, and resting habitat for a variety of seabirds (Figure 3-3); *Pisonia* in particular is typically a favored nesting or rookery tree for sea birds, including the black noddy (United Nations University, 1993). Black and brown noddies and white terns are arboreal, although brown noddies may roost and nest on the ground. Several white terns and a brown noddy were observed perched in trees during the 2004 inventory. No nesting seabirds have been observed during the USAKA biological surveys. The island supported relatively little bird activity during the 2002 inventory. Black and brown noddies and black-naped terns have been observed foraging offshore. Black-naped terns have been observed occasionally at the north and south tips of the island where principal roosting habitat occurs. Open areas also provide habitat for black-naped terns. A pair of black-naped terns may have been nesting on the roof of a building east of the helicopter pad in 2004. The reef heron, Pacific golden plover, gray-tailed and wandering tattlers, ruddy turnstone, and whimbrel have also been observed foraging on the island. A bristle-thighed curlew and one red-footed booby were observed in 2002. An unusual migratory bird, the long-tailed cuckoo, was seen in 2004 flying across the interior of the islet to the northern forested area. (U.S. Army Corps of Engineers, undated; U.S. Department of the Army Space and Missile Defense Command, 2002; 2004a; 2006; U.S. Fish and Wildlife Service, 2004; Appendix C)

No introduced vertebrates were observed on Omelek during the latest survey, although it is assumed that rats are present (U.S. Department of the Army Space and Missile Defense Command, 2006). Reptiles on the island include the azure-tailed skink and island gecko. Hermit crabs are abundant on Omelek and purple, yellowish-white, and large red-brown land crabs have been observed. (U.S. Department of the Army Space and Missile Defense Command, 2004a; 2006)

Recent surveys indicate the presence of big-headed and crazy ants and Formosan termites on Omelek, (U.S. Department of the Army Space and Missile Defense Command, 2002; 2004a; U.S. Fish and Wildlife Service, 2004). Long-legged ants, an exotic species common on several nearby islands, were not observed on Omelek. (Sims, 2004a; U.S. Department of the Army Space and Missile Defense Command, 2002) Pink hibiscus mealy bugs have also been reported (U.S. Fish and Wildlife Service, 2004).

Giant clams, black-lipped pearl oyster, coral, sponges, and top shell snails are species of concern that have been observed in the vicinity of Omelek. A wide variety of reef fish have been recorded in the waters surrounding Omelek. (U.S. Department of the Army Space and Missile Defense Command, 2004a; 2006)

Threatened and Endangered Wildlife Species

Potential habitat for sea turtles on Omelek includes sandy beaches along the southern and northern tips of the island and the area of the lagoon shoreline from the northern tip of the island south to the north jetty, but no evidence of nesting has been observed. (U.S. Army Corps of Engineers, undated; U.S. Department of the Army Space and Missile Defense Command, 2002; 2006)

Environmentally Sensitive Habitat

Marine and terrestrial habitats on Omelek that are considered of significant biological importance include: (marine) the lagoon area facing the reef slope and reef flat; the interisland reef flat; lagoon floor; ocean area facing the reef slope and reef flat; quarry pits; and intertidal zone, and (terrestrial) mixed broadleaf forest areas; seabird colonies; and shorebird sites (U.S. Army Space and Missile Defense Command, 2006b).

Although the harbor area has been dredged, the lagoon-facing reef flat on either side of the jetties provides good quality marine habitat with high to moderate coral diversity and giant clams (Figure 3-3). The large quarried area on the ocean side also exhibits a diversity of marine life; coral diversity has remained high. Both areas had been affected by storm damage prior to the 2004 inventory. (U.S. Department of the Army Space and Missile Defense Command, 2006)

An abundance of corals are in the area, but some areas show signs of stress, while still others have areas of dead coral, particularly off the north point on the lagoon side (Sims, 2004b).

3.1.3.2.2 Kwajalein

Vegetation

Much of Kwajalein has been cleared and paved, including the large runway occupying the entire center (southern) portion of the island. Non-native grasses and weeds dominate the open areas and are maintained by mowing. A small amount of herbaceous strand still exists in some places along the coastline, and patches of littoral shrubland are present. The island has been enlarged over the years with dredged landfill since the 1930s and consequently exhibits vegetation characteristic of heavily disturbed areas. (U.S. Army Space and Missile Defense Command, 2002; U.S. Department of the Army Space and Missile Defense Command, 2006)

Threatened and Endangered Plant Species

No threatened or endangered vegetation species have been identified on Kwajalein.

Wildlife

Kwajalein has the greatest diversity of birds of all the USAKA islets. Most of these birds have been observed in the managed vegetation around the airport runway and adjacent catchment areas. Shorebirds use the shoreline and exposed reef flat during low tide, but also use the golf course grounds, airport runway, and mowed lawns. Birds commonly observed include black noddies, great crested terns, brown noddies, and white terns. Since 1996, white terns have been the only species observed nesting on the islet. However, in 2002 black-naped terns were observed nesting on the concrete pier structures at the harbor fuel loading docks. A broken black-naped egg was found in 2004. Common greenshanks were also observed on the islet for the first time. (U.S. Department of the Army Space and Missile Defense Command, 2004a; 2006)

Dogs, cats, and black rats are present on the islet. A wide variety of reef fish have been recorded in the water surrounding the islet. (U.S. Department of the Army Space and Missile Defense Command, 2006)

Threatened and Endangered Wildlife Species

Sea turtles frequently enter the lagoon and are commonly seen in the harbors at Kwajalein, Roi-Namur, and in the waters surrounding Meck. Green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) sea turtles have been observed on and offshore of Kwajalein. (U.S. Army Space and Strategic Defense Command, 1995) Suitable sea turtle nesting habitat was not observed on Kwajalein during the 2004 inventory (U.S. Department of the Army Space and Missile Defense Command, 2006).

Other threatened and endangered marine species that may possibly occur in and around USAKA/RTS include the blue whale (*Balaenoptera musculus*), finback whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), hawksbill sea turtle, and olive ridley sea turtle (*Lepidochelys olivacea*). Although whales are generally widely distributed, open water species, sperm whales and other whales are frequently sighted off Illeginni (Sims, 2004c).

Environmentally Sensitive Habitat

Extensive dredge and fill activities since the 1930s have degraded the marine habitat surrounding Kwajalein, particularly on the lagoon side. A remnant of the original reef flat is located just north of Echo Pier, outside the harbor. (U.S. Army Space and Missile Defense Command, 2001)

3.1.3.2.3 Meck

Vegetation

Much of Meck has been cleared and paved. Non-native grasses and weeds dominate the open areas and are maintained by mowing. A few native trees still exist on the northern end of the island within the region of influence. The island has been enlarged with dredged fill material. (U.S. Army Strategic Defense, 1989b; U.S. Army Space and Strategic Defense Command, 1993; 1995)

Threatened and Endangered Plant Species

No threatened or endangered vegetation species have been identified on Meck.

Wildlife

Seabirds have been observed nesting along the eastern perimeter of the runway. Habitat for seabird roosting exists to the southwest of the launch site in the fill area at the edge of the region of influence. Black-naped terns were observed roosting on the southeastern tip of the island and in active colonies on the east side of the helicopter pad during the 1998 inventory (U.S. Department of the Army Space and Missile Defense Command, 2002). A breeding colony of black-naped terns is located on the eastern side of the helicopter pad. Seven nests were observed in 2004. The exposed reef flats on the eastern side of the islet are used by foraging shorebirds. Other birds observed recently include golden plovers, ruddy turnstones, and bar-tailed godwits. (U.S. Department of the Army Space and Missile Defense Command, 2006)

Three species of ants were observed in 2004. A wide variety of reef fish have been recorded. (U.S. Department of the Army Space and Missile Defense Command, 2006)

Threatened and Endangered Wildlife Species

Sea turtles frequently enter the lagoon and are commonly seen in the waters surrounding Meck (U.S. Army Space and Strategic Defense Command, 1995; U.S. Department of the Army Space and Missile Defense Command, 2006).

Environmentally Sensitive Habitat

Extensive dredging and the deposition of fill on the lagoon and reef flat have greatly altered the marine environment of Meck. Most of the islet is surrounded by riprap intended for shoreline protection, which is of limited use to foraging shorebirds. These foraging shorebirds use the exposed reef flats on the eastern side of the islet. Giant clams are found on the reef. (U.S. Department of the Army Space and Missile Defense Command, 2006)

3.1.4 CULTURAL RESOURCES

According to the UES, cultural resources are material remains of human activity that are significant in the history, prehistory, architecture, or archaeology of the RMI. They include prehistoric resources and historic resources.

3.1.4.1 Region of Influence

The region of influence for cultural resources includes areas on Omelek, Kwajalein, and Meck that would be disturbed by proposed activities.

3.1.4.2 Affected Environment

The cultural history of the Marshall Islands can be divided into three gross periods: the prehistoric (circa BC/AD to 1816), the historic traditional period (1817 to 1914), and the historic period (1914 to present).

3.1.4.2.1 Omelek

Prehistoric and Historic Archaeological Resources

Omelek has been heavily disturbed by prior construction and operational activities. Although most of the island has been graded and modified, there are three small remnants of mixed broadleaf (littoral) forest (Figure 3-3) that may contain preserved cultural resources. Archaeological surveys conducted in 1988 indicated the presence possibly of a traditional Marshallese cemetery in the northern forested area, but no human remains have been identified. The features located within this forested area include coral slabs, two of which are situated nearly vertical within the site. Additional archaeological investigation in 1994 relocated this site, and additional subsurface testing was performed. Small fragments of charcoal and burned coral were identified, but did not provide definitive evidence as to the possible purpose of the site. Vertical coral slabs, sometimes cited as definitive evidence of Marshallese cemeteries, also occur naturally. The lack of burial shafts associated with the vertical slabs, noted in the 1994 testing of the site, suggest these slabs represent natural phenomena. The area where these vertical slabs were found has not been recommended for nomination to the RMI National Register/List of Historic Places due to lack of evidence for cultural occupation and lack of oral traditions associated with the phenomena. (Kwajalein Range Services, 2007)

Native Populations/Traditional Resources

Traditional Marshallese resources can include landscape features (rocks, trees, plants, stretches of shoreline and other natural features), archaeological sites, oral historical sites associated with the culture, oral traditions, history, religion, or heritage of the Marshallese (Kwajalein Range Services, 2007). Traditional sites are subject to the same regulations, and afforded the same protection, as other types of historic properties. By their nature, traditional resources sites often overlap with (or are components of) archaeological sites. As such, some of the recorded and unrecorded sites identified within the region of influence could also be considered traditional sites or contain traditional resources elements.

Traditional resources within the region of influence are expected to be associated with the Marshallese culture, as such sites, some of which have been identified on Arno and Majuro atolls, are known to occur in the Marshall Islands.

A comprehensive survey of the traditional cultural resources sites of the Kwajalein Atoll, most particularly the 11 islands controlled by USAKA, was conducted by Carucci in 1995. Numerous oral histories were obtained and a series of maps prepared. The author noted that Kwajalein's oral history is neither monolithic nor unchanging, but "with ebbs and flows, and altered contours and perspectives, that are constantly reshaped to the representational requirements of the current day" (U.S. Army Kwajalein Atoll, 2006). Carucci outlined that prehistoric Marshallese society was in constant change, but the influence of European feudalism has brought substantial change to local and social order. The support by Europeans, Japanese, and Americans, and their selective reinforcement of certain Marshallese chiefs, created largely uncontested positions. Segments of this fairly recent history seem to be somewhat useful in outlining traditional cultural resource sites throughout Kwajalein Atoll. Carucci further states that, because of limitations of time and transportation, he often relied only on one or two informants. Specific locations pointed out by various consultants "varied by as much as one thousand feet." (U.S. Army Kwajalein Atoll, 2006)

Historic Buildings and Structures

No historic World War II or significant Cold War features have been identified on Omelek (U.S. Army Space and Missile Defense Command, 2001).

All of the buildings and structures on Omelek prior to SpaceX activity were constructed between 1962 and 1990; among them are meteorological rocket launch pads and associated facilities; they are associated with the Cold War historic context and have been recently evaluated as to eligibility for inclusion in the RMI National Register. The buildings were determined not to be eligible for listing. (Kwajalein Range Services, 2007; U.S. Army Kwajalein Atoll, 2006; U.S. Army Space and Missile Defense Command, 2004a)

3.1.4.2.2 Kwajalein

Prehistoric and Historic Archaeological Resources

Major alterations of the size and contour of Kwajalein since the early 1940s have resulted in the burial of most archaeological resources beneath deposits of fill of varying depths. The average elevation has been increased by at least 30 centimeters (11.8 inches) and the islet has increased in area 26 percent (83 hectares [205 acres] of fill). Studies have consistently revealed that there is a post-World War II layer of fill covering most of the island's surface (of varying depths) and that the probability of intact subsurface prehistoric and historic sites (within the original boundary of the island) is high. These changes are primarily the result of dredging and filling; but the demands of mission-related construction, developing island infrastructure, and ongoing maintenance have also profoundly impacted the cultural resource base. There remain only six historic structures on island dating prior to 1944 that are in their original location, all the Traditional Marshallese landscape features have been destroyed or buried, and with the changes in shoreline, buildings, and non-culturally associated landscape features it becomes very difficult for older Marshallese to pin-point the former locations of cemeteries, houses, or religious sites. (Kwajalein Range Services, 2007)

Archaeological monitoring, surveys, and investigations on Kwajalein Island have identified subsurface prehistoric resources in dispersed areas within the boundaries of the pre-1944 island. The sites and features identified thus far have included: single-component resource extraction sites; a multi-component site with possible residential occupation(s); earth ovens (an "um," seven+); and parts of two cemeteries (Kwajalein Range Services, 2007). The artifacts associated with these sites and features have included: shell adzes and preforms, jewelry, and fishhooks. Floral and faunal resources associated with these sites have included animal bone, shell, and some possible carbonized plant material. (Kwajalein Range Services, 2007)

Historically, Kwajalein represented a permanent dwelling islet. Archaeological data, the atoll settlement pattern, Marshallese oral traditions, and historic data indicate that Kwajalein was probably the first island in the Atoll settled by humans and for much of the prehistoric and traditional historic periods it had a lagoon-side residential settlement pattern. Due to major alterations to the islet by Japanese and later by Americans, most traditionally used and frequented sites remain buried under various fill layers. Marshallese oral traditions maintain, prior to 1930, that there were at least six former Marshallese cemeteries (two of which have been located archaeologically), three chiefly residences, and the location of a flower tree represented sacred sites due to their importance in religious belief and traditional power structure. Other special locations were set aside for chants, dancing, tattooing, and medical and magical purposes. (Kwajalein Range Services, 2007)

World War II surface and subsurface features identified on Kwajalein are numerous and include gun mounts/emplacements for varying caliber weapons, pillboxes, concrete air raid shelters and ammunition bunkers, concrete piers, footings, foundations, and pads, personnel and communications trenches and anti-tank ditches, expended and unexpended ordnance, and foundations of numerous World War II buildings and structures (U.S. Army Space and Missile Defense Command, 2002).

Historic Buildings and Structures

The majority of the buildings and structures on Kwajalein were constructed between 1945 and 1992. Existing Japanese structures were built between 1940 and 1944. Facilities constructed before 1946 (including the Japanese structures) are associated with the World War II historic context and considered part of the Kwajalein Battlefield National Historic Landmark. In September 1996, a survey of Cold War era properties at USAKA was completed and several buildings and structures were determined to be eligible for listing on the U.S. National Register under a Missile Defense Cold War context. Since that time, however, it has been determined that the U.S. National Register criteria will not be applied to properties at USAKA, because the RMI Historic Preservation Office does not recognize the Missile Defense Cold War context as significant. Thus, there are no Cold War era properties at USAKA that are eligible for the RMI

National Register. (Kwajalein Range Services, 2007; U.S. Army Space and Missile Defense Command, 2002)

3.1.4.2.3 Meck

Prehistoric and Historic Archaeological Resources

The entire surface of Meck has been disturbed by grading and construction for missile launch facilities. In addition, as a result of land filling, the island has increased in size by approximately 6 to 22 hectares (14 to 55 acres). Archaeological survey and testing of the entire island in both 1988 and 1994 failed to identify any prehistoric or historic archaeological sites or World War II features. (U.S. Army Space and Missile Defense Command, 2002)

Now buried under fill layers, Meck once served as an island where initiation ceremonies took place. Meck is also said to have served as the ancient residence location of the Rimeik clan. Historically, Meck served as an islet of residence and a prime intermediate destination for intra-atoll voyages. (U.S. Army Space and Missile Defense Command, 2002)

Historic Buildings and Structures

The majority of the buildings and structures on Meck were constructed between 1967 and 1991; as such, they are associated with the Cold War historic context. The RMI Historic Preservation Office does not recognize the Missile Defense Cold War context as significant. Thus, there are no Cold War era properties at USAKA that are eligible for the RMI National Register of Historic Places. (Kwajalein Range Services, 2007) The southern half of the island houses facilities related to power generation, maintenance, supply, and waterfront and air operations. The central and northern half of the island consists of research and development operations and launch complexes, including missile and payload assembly buildings. (U.S. Army Space and Missile Defense Command, 2002)

3.1.5 GEOLOGY AND SOILS

Geology and soils include those aspects of the natural environment related to the earth, which may be affected by the Proposed Action. These features include physiography, geologic units and their structure, the presence/availability of mineral resources, soil condition and capabilities, and the potential for natural hazards.

3.1.5.1 Region of Influence

The region of influence is anticipated to be the proposed locations on Omelek and Kwajalein that may be subject to soil compaction (from construction activities) and erosion, as well as soil areas within the launch hazard area that have the potential to be subject to contamination from launch exhaust emissions and/or potential contamination from unburned fuel in the event of a terminated launch.

3.1.5.2 Affected Environment

Paleontological Resources

Paleontological resources consist of the physical remains of extinct life forms or species that may have living relatives. These physical remains include fossilized remains of plants and animals, casts or molds of the same, or trace fossils such as impressions, burrows, and tracks.

Geological studies indicate that the reefs and atolls of the Marshall Islands formed 70 to 80 million years ago; however, the natural processes from which atolls are built (U.S. Army Space and Strategic Defense Command, 1993) preclude the occurrence of paleontological remains.

Geology

The islands and reefs that collectively outline and form the Kwajalein Atoll are typical of other mid-Pacific Ocean atolls in that each was created as a result of prehistoric volcanic islands surfacing above the sea then gradually subsiding below the sea due to deflation of the underlying magma chamber. As the volcanoes subsided below the average sea level, the surrounding ring-shaped coral reefs remained, forming a centralized lagoon. (U.S. Army Space and Strategic Defense Command, 1995)

As a result of similar atoll building processes, Omelek and other land bodies within the mid-Pacific Ocean region have similar geological foundations primarily composed of layers of reef rock. Reef rock is made up entirely of the remains of the previous generations of marine organisms (reef corals, algae, mollusks, echinoderms) that secrete external skeletons of calcium and magnesium carbonate. (U.S. Army Kwajalein Atoll, Marshall Islands, 2004; U.S. Army Space and Strategic Defense Command, 1995)

Soils

USAKA's soils are poor and considered to be low in fertility and almost exclusively composed of calcium carbonate from the accumulation of reef debris and oceanic sediments. Consequently, soils are extremely deficient in major soil constituents such as nitrogen, potash, and phosphorous. Major physical factors which characterize USAKA's soil include coarse soil particles, minimal amounts of organic matter, and alkaline soil pH. In addition, water-holding capacity of the soil is poor due to the generally coarse grained-sands. (U.S. Army Kwajalein Atoll, Marshall Islands, 2004; U.S. Army Space and Missile Defense Command, 2002)

3.1.6 HAZARDOUS MATERIALS AND WASTE

In general, hazardous substances (materials) and wastes are defined as those substances that, because of their quantity, concentration, or physical, chemical, or infectious characteristics, would present substantial danger to public health and welfare or to the environment when released into the environment.

As defined by the Department of Transportation, a hazardous material is a substance or material that is capable of posing an unreasonable risk to health, safety, or property when transported in commerce and has been so designated. Hazardous waste is further defined as any solid waste not specifically excluded which meets specified concentrations of chemical constituents or has certain toxicity, ignitability, corrosivity, or reactivity characteristics.

Regulations governing hazardous material and hazardous waste management at USAKA/RTS are specified in UES Section 3-6. The UES classify all materials as either general-use, hazardous, petroleum products, or prohibited.

3.1.6.1 Region of Influence

The region of influence for potential impacts related to hazardous materials/wastes would be limited to areas of the atoll to be used for missile launch (Omelek) and related operations, and in areas where hazardous materials are stored and handled (Kwajalein, Meck, and Omelek).

3.1.6.2 Affected Environment

3.1.6.2.1 Omelek

Hazardous Materials Management

The use of hazardous materials at USAKA/RTS (including Omelek, Kwajalein, and Meck) is limited primarily to materials used in facility infrastructure support and flight operations, with some additional quantities of hazardous materials used by various test operations. Hazardous materials used in infrastructure support activities include various cleaning solvents (chlorinated and non-chlorinated), paints, cleaning fluids, pesticides, motor fuels and other petroleum products, and other materials. These substances are shipped to USAKA/RTS by ship or by air. Upon arrival at USAKA/RTS, hazardous materials to be used are distributed, as needed, to various satellite supply facilities, from which they are distributed to the individual users. Distribution is coordinated through the base supply system; however, the issue of such materials requires prior authorization by the USAKA/RTS Environmental Office to prevent unapproved uses of hazardous materials.

An activity-specific Hazardous Materials Procedure must be submitted to the Commander, USAKA/RTS for approval within 15 days of receipt of any hazardous material or before use, whichever comes first. Hazardous materials to be used by organizations on the test range and its facilities are under the direct control of the user organization, which is responsible for ensuring that these materials are stored and used in accordance with local and federal requirements. The use of all hazardous materials is subject to ongoing inspection by USAKA/RTS environmental compliance and safety offices to ensure the safe use of all materials. The majority of these materials are consumed in operational processes.

Aircraft flight operations conducted at USAKA/RTS involve the use of various grades of jet propellant, which are refined petroleum products (kerosenes). Fuels are stored in aboveground storage tanks located on several islands at USAKA/RTS. Fuels are transported to USAKA/RTS in accordance with the UES. Significant quantities of waste fuels are not normally generated since fuels are used up in power generation, flight operations, marine vessels, and vehicle and equipment usage.

Hazardous Waste Management

Hazardous waste treatment or disposal is not allowed at USAKA/RTS under the UES. Hazardous waste, whether generated by USAKA/RTS activities or range users, is collected at individual work sites in waste containers. These containers are labeled in accordance with the waste which they contain and are dated the day that the first waste is collected in the container. Containers are kept at the point of generation accumulation site until full or until a specified time limit is reached. Once full (250 liters [55 gallons]), containers are collected from the generation point within 72 hours and are prepared for transport to the USAKA/RTS Hazardous Waste 90-Day Storage Facility (Building 1521), located on Kwajalein. Each of the point of generation accumulation sites is designed to handle hazardous waste and provide the ability to contain any accidental spills of material, including spills of full containers, until appropriate cleanup can be completed. (U.S. Army Space and Missile Defense Command, 2006b)

At the 90-Day Storage Facility any sampling of waste is performed (for waste from uncharacterized waste streams), and waste is prepared for final off-island shipment for disposal. Hazardous wastes are shipped off-island within 90 days of arrival for treatment and disposal in the continental United States (U.S. Army Space and Missile Defense Command, 2006b). The barge departs Kwajalein approximately every 2 weeks.

In accordance with the UES, USAKA/RTS has prepared the KEEP for responding to releases of oil, hazardous materials, pollutants, and contaminants to the environment. The KEEP is a contingency plan similar to a spill prevention, control, and countermeasure plan, but it incorporates response provisions of a National Contingency Plan. The hazardous materials management plan is incorporated into the KEEP. SpaceX has prepared a Spill Prevention Control and Countermeasures Plan to address their activities on Omelek.

Pollution prevention, recycling, and waste minimization activities are performed in accordance with the UES and established contractor procedures in place at USAKA/RTS. The Installation Restoration Program is not applicable to USAKA/RTS, since it is located in a foreign country. Remedial action is performed as needed, in accordance with the UES.

Liquid Propellants and Other Toxic Fuels

Existing procedures ensure safe handling of liquid propellants and other toxic materials.

3.1.6.2.2 Kwajalein and Meck

Hazardous Materials Management

As discussed above, the use of hazardous materials at USAKA/RTS is limited primarily to materials used in facility infrastructure support and flight operations, with some additional quantities of hazardous materials used by various test operations. Hazardous materials at Kwajalein are handled in accordance with the UES, federal, DoD, U.S. Army, and U.S. Air Force hazardous materials management requirements.

Hazardous Waste Management

Hazardous waste generated on Kwajalein is handled in accordance with the procedures specified in the UES as discussed above.

Liquid Propellants and Other Toxic Fuels

Existing procedures ensure safe handling of liquid propellants and other toxic materials.

3.1.7 HEALTH AND SAFETY

Health and safety includes consideration of any activities, occurrences, or operations that have the potential to affect one or more of the following:

The well-being, safety, or health of workers—Workers are considered to be persons directly involved with the operation producing the effect or who are physically present at the operational site.

The well-being, safety, or health of members of the public—Members of the public are considered to be persons not physically present at the location of the operation, including workers at nearby locations who are not involved in the operation and the off-base population. Also included within this category are hazards to equipment and structures.

3.1.7.1 Region of Influence

The region of influence for potential impacts to worker health and safety at USAKA/RTS includes the areas where missile components would be stored and handled (Omelek, Meck, and Kwajalein) and where launch (Omelek) and post-launch activities would occur. The worker population of concern for the Proposed Action includes all of USAKA/RTS, but would predominantly consist of the personnel directly involved with Falcon launch program operations.

The region of influence for potential impact to public health and safety encompasses all 11 islands of Kwajalein Atoll and other nearby atolls that could be affected by the proposed activities including pre-launch transport of missile components, missile launch, and missile flight. A launch failure could potentially involve an explosion, missile debris, release of toxic materials into the air or water, high noise levels, and/or fire. The population of concern for the Proposed Action consists of the community living on the various atolls and low-lying islands that compose the RMI and any Marshallese people fishing from Gellinam and Eniwetak.

3.1.7.2 Affected Environment

3.1.7.2.1 Regional Safety

The Kwajalein Hospital is the primary health care facility for USAKA/RTS. The approximate 16-bed hospital has a dental clinic and provides emergency treatment, surgical, obstetric, general medical and diagnostic services for the community and range personnel. One medical technician staffs a dispensary located on Roi-Namur. A first aid station on Meck is also staffed by a medical technician. The hospital, dispensary, and first aid station are contractor operated and staffed. Video consultations with Tripler Army Medical Center in Honolulu, Hawaii provide access to medical specialists for those patients requiring supplemental evaluation. Medical specialists such as optometrists schedule periodic visits to Kwajalein. Other health facilities in the RMI include a private clinic on Majuro and a public hospital on Ebeye.

3.1.7.2.2 Omelek, Kwajalein, and Meck

Range Safety

Missions on USAKA/RTS are conducted with the approval of the USAKA/RTS Commander. A specific procedure is established to ensure that such approval is granted only when the safety of all proposed tests has been adequately addressed.

Range safety is accomplished by compliance with USAKA/RTS regulations and the use of established procedures and safety precautions to prevent injury to people and minimize damage to property. Range safety applies to preparation, testing, and execution of programs on

USAKA/RTS. Other range safety objectives are the successful completion of mission objectives.

All program operations must receive the approval of the Safety Office. This is accomplished by the user through presentation of the proposed program to the Safety Office. All safety analyses, Standard Operating Procedures, and other safety documentation applicable to those operations affecting USAKA/RTS must be provided, along with an overview of mission objectives, support requirements, and schedule. The Safety Office evaluates this information and ensures that all USAKA/RTS safety requirements, as specified in the Safety Manual and supporting regulations, are followed. (U.S. Army Space and Strategic Defense Command, 1995)

Ground Safety

Ground safety is the protection of range personnel and the public from injury when conducting potentially hazardous operations and handling hazardous materials. Several of the islands are affected by building construction, the storage and assembly of explosives and rocket propellants, and the operation of heavy equipment. Kwajalein, Meck, and Omelek are, or in the past have been, sites for assembling and launching missiles.

Explosives are used at USAKA/RTS for missile flight programs and for destruction of unexploded ordnance, fireworks, small arms rounds, and flares. Small amounts of explosives are used in missile launches for stage separation and flight termination systems, which destroy in-flight missiles that show abnormal flight characteristics. Explosives are stored on Kwajalein, Roi-Namur, and Meck.

Launch facilities consist of structures used for the assembly and launch of missiles that contain experimental payloads. The primary structures are missile and payload assembly buildings, launch control buildings, and launch pads. The site plans of launch facilities are reviewed and approved by the DoD Explosives Safety Board before construction begins. These structures are currently spaced according to explosive safety quantity-distance criteria defined in Army Regulation 385-64, *U.S. Army Explosives Safety Program*, and other regulations. Launches on smaller islands may be done remotely, when building separation is insufficient to protect personnel. The number of personnel working at launch facilities is limited during missile assembly and other potentially hazardous operations.

The ground safety plans for programs at USAKA/RTS contain emergency procedures for response to potential accident scenarios. For example, the emergency procedures for a missile launch program include the response to misfire and hangfire conditions, an explosion or fire on the launch pad, and the impact of an errant missile flight. Fire protection is provided by fire suppression systems in most operations buildings, and by continuously staffed fire stations, on Kwajalein, Roi-Namur, and Meck islands. No fire station is located on Omelek (U.S. Army Kwajalein Atoll, Marshall Islands, 2004).

Flight Safety

Flight safety provides protection to USAKA/RTS personnel, inhabitants of the Marshall Islands, and ships and aircraft operating in areas potentially affected by these missions. Specific procedures are required for the preparation and execution of missions involving aircraft, missile launches, and reentry payloads. These procedures include regulations, directives, and flight safety plans for individual missions. The area affected by aircraft and missile operations varies according to the type of mission.

Flight safety activities include the preparation of a flight safety plan that includes evaluating risks to inhabitants and property near the flight, calculating trajectory and debris areas, and specifying range clearance and notification procedures.

Notification is made to inhabitants near the flight path, and international air and sea traffic in the caution area designated for specific missions. Notices to Mariners (NOTMARs) and Notices to Airmen (NOTAMs) are transmitted to appropriate authorities to clear caution areas of this traffic and to inform the public of impending missions. The warning messages contain information describing the time and area affected and safe alternate routes. RMI is informed in advance of launches and reentry payload missions.

In missions that involve the potential for reentry debris near inhabited islands, precautions are taken to protect personnel. In Mid-Atoll hazard areas, where an island has a high probability of impact by debris, personnel are evacuated. In caution areas, where the chance of debris impact is low, precautions may consist of evacuating or sheltering non-mission-essential personnel. Sheltering is required for reentry vehicle missions impacting the Mid-Atoll Corridor in Kwajalein Atoll. The Mid-Atoll Corridor is declared a caution area when it contains a point of impact.

Instrumentation is used for range safety by tracking incoming reentry vehicles and terminating missile flights in order to prevent an impact on inhabited islands. The Kwajalein Range Safety System links the USAKA/RTS radar system to a range safety center on Kwajalein. A missile and payload can be tracked during the entire flight by the range safety center. Missiles launched from USAKA/RTS are equipped with flight termination systems that allow destruction of the missile if the flight deviates significantly from planned criteria or otherwise poses a threat to the public. For example, a flight would be terminated if the missile path intersects a protection circle, an artificial boundary around inhabited atolls and islands in the Marshall Islands.

3.1.8 INFRASTRUCTURE

Infrastructure addresses transportation routes and those facilities and systems that provide water, wastewater treatment, collection and disposal of solid waste, and power. This section addresses infrastructure for Omelek, Kwajalein, and Meck.

3.1.8.1 Region of Influence

The region of influence for infrastructure includes any on-island utility systems or structures, as well as any modes of transportation. The latter can encompass areas leading to the islands.

3.1.8.2 Affected Environment

3.1.8.2.1 Omelek

Transportation

Omelek does not have any paved roads, and it does not house any motor vehicles. Roads on Omelek are predominately unformed tracks (U.S. Army Space and Missile Defense Command, 2004a). The Omelek harbor is periodically dredged and is therefore capable of accepting marine transport. There is a pier and marine ramp available at the harbor. (U.S. Army Kwajalein Atoll, Marshall Islands, 2004) The Omelek pier is built into the embayment that is formed by a natural projection of the island and a constructed breakwater. This dock is used by personnel and receives limited cargo delivery. The power boats ferry personnel and material to and from Omelek. Omelek has a 900-square meter (10,000-square foot) helipad, and is serviced by UH-1H helicopters. (U.S. Army Kwajalein Atoll, Marshall Islands, 2004; U.S. Army Space and Missile Defense Command, 2004a)

Utilities

Water

Omelek does not have an active, developed potable water system (U.S. Army Space and Strategic Defense Command, 1995). When needed, bottled or potable water for drinking, food preparation, hand-washing and bathing is shipped from Kwajalein and stored on the island. Freshwater is used for pad cleanup, deluge spray, and firefighting. The water for the deluge system is supplied from a pressurized water tank that is filled with water from the water system. The deluge system uses ocean water that has been desalinated in a reverse osmosis system and stored in a 37,854-liter (10,000-gallon) tank. The reverse osmosis system also provides water for other non-potable uses. The water is used for industrial purposes only.

Wastewater

The existing site restrooms on Omelek were refurbished and are in use as intended. Waste water is diverted to the existing site septic/leach field system. Salt water from the island lens well pump provides flushing water. Fresh water for cleaning equipment and facilities and flushing toilets is supplied from a reverse osmosis system that was approved for the proof-of-principle launches. This system produces 4,542.5 liters (1,200 gallons) per day and discharges brine waste into the harbor area.

Solid Waste

The minimal quantities of solid waste generated on Omelek are collected and transported to Kwajalein for disposal (U.S. Army Space and Strategic Defense Command, 1993). Additionally, construction solid waste is generated frequently as new facilities are built and as existing facilities are upgraded or demolished. Solid waste is managed in accordance with the UES (UES Sections 3-6.5.5 through 3-6.5.7) (U.S. Army Space and Missile Defense Command, 2004a).

Electricity

A network of communication lines and underground electrical lines are found on Omelek, as are an associated generator building and communications equipment shed (U.S. Army Kwajalein Atoll, Marshall Islands, 2004). The generator building is a small facility in the south end of the island that distributes island power. Generators are located outside the facility and connected to an automatic transfer switch inside the facility. This switch transfers power generation from one generator to the other if a problem occurs. Power lines are routed from this facility to facilities around the island, primarily via existing underground conduits. The facility currently uses two 400-kVA (360 kW) portable generators which were previously approved for operations in the Proof-of-Principle Space Launches from Omelek Island EA. A 50-kW generator provides power during sustainment periods between missions.

3.1.8.2.2 Kwajalein

Transportation

There are approximately 21 kilometers (13 miles) of paved roads and 11 kilometers (6.5 miles) of unpaved roads on Kwajalein (U.S. Army Space and Strategic Defense Command, 1993). No private vehicles are permitted, and bicycles are the standard means of transportation on Kwajalein. Free bus service provides transportation to and from work sites, and vans transport groceries from the market to homes. Government vehicles, including golf carts, vans, and trucks are used primarily for business and maintenance purposes. Vehicles can also be rented for personal use for a nominal fee (U.S. Army Space and Missile Defense Command, 2007a).

Marine transport facilities are concentrated at Kwajalein, which serves as a base for receiving cargo and fuel to USAKA. Passenger fleets, consisting of two catamaran ferries, a land craft with passenger modules that can carry up to 190 passengers, and a personnel boat that can carry up to 73 passengers, are also located at Kwajalein (U.S. Army Space and Missile Defense Command, 2002). RTS marine assets include a variety of landing craft and utility vessels suitable for intra-atoll and inter-atoll mission support transportation (U.S. Army Space and Missile Defense Command, 2007b).

Travelers to Kwajalein must have a site point of contact or site sponsor established with a full understanding of the nature of the mission and rationale for the visit prior to a request being submitted (U.S. Army Space and Missile Defense Command, 2006a). Kwajalein also has air transportation capabilities and houses the Bucholz AAF which serves as a refueling point for a wide variety of military and civilian aircraft. Aircraft ranging from Learjets to military C-5 transports use Kwajalein as an en route stop (U.S. Army Space and Missile Defense Command, 2002).

Utilities

Water

Drinking water on Kwajalein is supplied by a conventional package filter drinking water system for potable water production. The capacity of the system is 1.7 million liters (450,000 gallons) per day. In 2005, water consumption on Kwajalein was approximately 1.1 million liters (300,000 gallons) per day (U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site, 2005b). The conventional filtration system (drinking water) is supplemented by a reverse osmosis treatment system. There are seven different fields which provide supplemental water (U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site, 2005a). Three portable reverse osmosis water purifying units are used to process the lens well water to reduce suspended and dissolved solids content before treatment. Drinking water quality is produced to meet the standards of the UES. These standards are essentially the same as the Environmental Protection Agency standards for public systems that serve a population of 10,000 people. (U.S. Army Space and Missile Defense Command, 2002)

Raw water is provided primarily by a rainwater catchment system along the runway. During dry seasons, additional water is provided by pumping the freshwater lens that forms an unconfined surficial aquifer beneath the island surface. (U.S. Army Space and Missile Defense Command, 2002)

Wastewater Treatment

Wastewater on Kwajalein is reclaimed by conventional secondary treatment followed by chemical (chlorine) disinfection. The reclaimed water is then used for non-potable applications, such as flushing toilets and vehicle washing. The non-potable water is the result of secondary treatment plus filtration and chlorination. Excess water is discharged in accordance with the UES toilet facilities and sewage disposal provisions or requirements. (U.S. Army Space and Missile Defense Command, 2002)

Solid Waste

USAKA/RTS has a developed solid-waste management plan to govern its solid-waste disposal operations, lessen the impacts on the local RMI environment, and preclude adverse environmental impacts to personnel and mission readiness (Defense Environmental Network and Information eXchange, 1997). The Kwajalein landfill occupies 5.3 hectares (13 acres) on the west edge of the island. In 2005, approximately 9,072 metric tons (10,000 tons) of solid waste was generated annually (24,948 kilograms [55,000 pounds] per day); 30 percent from residential areas, 60 percent commercial and industrial areas, 10 percent construction debris, and less than one percent of medical waste. (U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site, 2005b) Construction solid waste, which is generated as new facilities are built and as existing facilities are upgraded or demolished, is managed in accordance with the UES (UES Sections 3-6.5.5 through 3-6.5.7) (U.S. Army Space and Missile Defense Command, 2004a). Solid waste is collected and taken to the landfill/incinerator facility for processing. Source separation is practiced to facilitate processing. Combustibles are incinerated at the facility, and the inert materials are removed for disposal at an adjacent landfill. Metals are shipped to Honolulu to be recycled. Glass, tires, and plant matter, including wood, remain on Kwajalein for recycling. Glass is pulverized, tires are shredded and used as fuel in incinerators, and plant matter is chipped and composted. Some food waste on Kwajalein is used for composting. Glass, concrete rubble, and similar materials are processed for reuse as construction (including shoreline protection) and fill material at USAKA. (U.S. Army Space and Missile Defense Command, 2002)

Electricity

Electrical power on Kwajalein is provided by power plants run by diesel generators. The power plant maintains six diesel generators with a total output of 25,200 kW. (U.S. Army Kwajalein Atoll, 2006) Power distribution is conventional with underground high-voltage transmission lines and aboveground “user voltage” (110-220 volt alternating current) distribution lines. Kwajalein Power Plant is a system of 17 distribution feeders, 8 of which are “shed feeders,” which route power throughout the island. When a generator fails, the shed feeders located on certain non-mission-critical blocks, primarily in the residential sections, cut power to those areas so that the other main mission-critical feeders maintain power. In fiscal year 2002 Kwajalein residents used, on average, about 9,490 kW per hour. (Kwajalein, 2002)

3.1.8.2.3 Meck

Transportation

Meck has about 2 kilometers (1 mile) of paved road, a concrete pier that accepts both personnel and cargo, and a runway that no longer accepts fixed-wing aircraft but is capable of accepting helicopter transportation. Meck is also serviced by regularly scheduled ferryboat and UH-1 helicopter runs. There is also an existing concrete landing ramp and a barge pier, which ensure access to the island by maritime craft or tactical sealift assets. This site is approved to support launcher and generator operations. (U.S. Army Space and Missile Defense Command, 2002)

Utilities

Water

A new water treatment plant was put into operation during September 2001. The Meck water treatment plant is only operational during the normal 8 hours/day, 4 days/week, work schedule. During mission times, population and demand increase to approximately 28,390.5 to 37,854 liters (7,500 to 10,000 gallons) per day. Usually an average of 18,927 liters (5,000 gallons) per day is produced. (U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site, 2005a) This plant is a package plant and maintains a capacity of 545,099 liters (144,000 gallons) per day. (U.S. Army Space and Missile Defense Command, 2002) The water produced at Meck meets UES.

Raw fresh water is gathered from a rainwater catchment area located on the former runway and from the roof of the Meck Island Control Building. The drinking water supply is sometimes supplemented, during times of low rainfall, with treated water barged from the Kwajalein Water Treatment Plant. Both rainwater and the barged water are sent from the catchment areas to raw water storage. Raw water storage consists of one 1.8 million-liter (500,000-gallon) tank and two 946,350-liter (250,000-gallon) tanks. (U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site, 2005a)

Wastewater

Wastewater on Meck is collected and pumped to a septic system on the island. Residual sludge is collected from the septic tank as needed and periodically sent to Kwajalein for composting. (U.S. Army Space and Missile Defense Command, 2002)

Solid Waste

The small amount of solid waste generated on Meck is collected and taken to the landfill/incinerator facility for processing. The Meck landfill occupies 0.08 hectare (0.2 acre) on the southern tip of the island, adjacent to the shoreline. It is located approximately (150 feet) from an inactive runway and approximately 213 meters (700 feet) from the helipad. In 2005, the Meck solid waste disposal operations managed less than 181 metric tons (200 tons) of solid waste a year (453 kilograms [1,000 pounds] per day) comprised primarily of office and light food service wastes. (U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site, 2005b) Source separation is practiced to facilitate processing. Combustibles are incinerated at the facility, and the inert materials are removed for disposal at an adjacent landfill. As discussed above in Section 3.1.8.1, metals are shipped to Honolulu, and glass, tires, and plant matter are sent to Kwajalein for recycling. (U.S. Army Space and Missile Defense Command, 2002)

Electricity

Power on Meck is provided by diesel generators. The power plant maintains five diesel generators with a total output of 2,750 kW. Standby diesel generators are maintained at numerous locations in case of a power shortage. (U.S. Army Kwajalein Atoll, 2006)

3.1.9 LAND USE

Land Use addresses existing land use patterns on the islands which are being considered for the proposed action. This section addresses land use for Omelek, Kwajalein, and Meck.

3.1.9.1 Region of Influence

The regions of influence for land use analysis are the islets, Omelek, Kwajalein, and Meck.

3.1.9.2 Affected Environment

3.1.9.2.1 Omelek

Omelek is a 4-hectare (10-acre) islet located about halfway between Kwajalein and Roi-Namur. The islet is used for missile research and is under U.S. Army management (U.S. Army Space and Missile Defense Command, 2004a). Up to eight SpaceX personnel would live temporarily on Omelek in the SpaceX office facility, as required. The remaining SpaceX personnel are on the island only during designated work hours and return to Kwajalein for lodging. There are no recreational activities associated with Omelek.

3.1.9.2.2 Kwajalein

Kwajalein is the headquarters of USAKA and has a land area of 303 hectares (748 acres). It is extensively developed with housing and community facilities toward the eastern end of the island; air operations, supply, and utilities near the center of the island; and research, development, and communications operations toward the western end of the island. The land uses on Kwajalein include administration and flight operations, family housing, research and development operations, communications operations, supply (which includes high explosives magazine, petroleum, oils, and lubricants, and disposal), community support and unaccompanied personnel housing, outdoor recreation, utilities, maintenance, sanitary landfill, and waterfront operations. (U.S. Army Space and Strategic Defense Command, 1995)

Recreational opportunities at Kwajalein are many and varied. Activities available include swimming (three white coral sand beaches—Emon Beach, Coral Sands Beach, and Camp Hamilton), picnic pavilions, windsurfing, water skiing, scuba diving and snorkeling. There is also a golf course, bowling alley, hobby shop, movie theater, and the Corlett Recreation Center that provides a gym for indoor basketball, volleyball, youth soccer, racquetball/handball courts, and conference rooms for club meetings. (U.S. Army Space and Missile Defense Command, 2007a)

3.1.9.2.3 Meck

Meck has a land area of 22 hectares (55 acres), is part of the RTS, and is currently home to a launch site for anti-ballistic missiles. Facilities related to power generation, maintenance, and supply, waterfront and air operations, and limited community support are located on the southern half of the island. The rest of the island is used for research and development operations that include missile launch complexes (U.S. Army Space and Strategic Defense Command, 1993). Meck is not inhabited, and workers are on the island only during work hours and return to Kwajalein for lodging. There are no recreational activities associated with Meck.

3.1.10 NOISE

Under 29 CFR 1910.95, *Occupational Noise Exposure*, employers are required to monitor employees whose exposure to hazardous noise could equal or exceed an 8-hour time weighted average of 85 A-weighted decibels (dBA).

3.1.10.1 Region of Influence

The region of influence for noise analysis is the area within the maximum sound level = 85 decibel (dB) contours generated by proof-of-principle launches and activities. As a conservative method, the region of influence for Omelek is a circular area with a 12-kilometer (7.5-mile) radius, centered on the proposed launch site.

3.1.10.2 Affected Environment

3.1.10.2.1 Omelek

The primary sources of man-made noises on Omelek include helicopter operations and infrequent launching of meteorological rockets and satellites. Since Omelek has been developed as a launch support facility and has no inhabitants occupied in unrelated activities, aside from personnel no noise-sensitive receptors have been identified. The nearest inhabited island to Omelek is Gugeegue, which is approximately 21 kilometers (13 miles) away and considered to be outside of the region of influence.

3.1.11 SOCIOECONOMICS

Socioeconomics describes a community by examining its social and economic characteristics. Several demographic variables are analyzed in order to characterize the community, including population size, the means and amount of employment, and income creation. In addition, socioeconomics analyzes the fiscal condition of local government and the allocation of the assets of the community, such as its schools, housing, public services, and healthcare facilities. (U.S. Army Space and Missile Defense Command, 2002) The U.S. Government, which makes payments to the RMI for the use of USAKA/RTS, is the largest employer of Marshallese on the Kwajalein Atoll and also provides aid to the RMI government (Defense Environmental Network and Information eXchange, 1997). This section addresses socioeconomic characteristics for Omelek, Kwajalein, and Meck.

3.1.11.1 Region of Influence

The regions of influence for socioeconomic analysis are the islets of Omelek, Kwajalein, Meck, Ebeye, and Majuro.

3.1.11.2 Affected Environment

3.1.11.2.1 Omelek

Omelek is uninhabited (no resident population) and possesses no socioeconomic characteristics. However, three to six Marshallese are employed part-time or as-needed in support of ground and facility maintenance on Omelek, and one full-time Marshallese is employed full-time as technical support on the island. (Chinnery, 2007)

Subsistence Fishing

Access to Omelek Islet is restricted to USAKA personnel, USAKA contractors, SpaceX personnel, and those with written permission from the USAKA Commander. Marshallese individuals can obtain written permission from USAKA to stay temporarily on Omelek while fishing from the adjacent island of Gellinam, unless Omelek is closed temporarily on orders of the USAKA Commander.

3.1.11.2.2 Kwajalein

Kwajalein is the largest of the nearly 100 islands that make up the Kwajalein Atoll; a coral reef formation shaped like a crescent loop enclosing the world's largest lagoon with a surface area of 1,100 square miles. Kwajalein Atoll is part of the RMI. The USAKA/RTS is a government-owned, contractor-operated installation consisting of a small number of government military and civilian personnel, plus a large population of contractors. Because the island is not open to the general public, visitors must either have official business or be the guest of a resident. (U.S. Army Corps of Engineers, 2003)

Population and Income

USAKA strictly regulates access to Kwajalein. The population fluctuates monthly depending on program activities, but totaled 2,440 in 2005. This number consisted of military, civil service, and contractor personnel and their dependents. (U.S. Army Space and Missile Defense Command, 2002 and USAKA/RTS Real Property Master Plan, 2005) Transient personnel are primarily housed in the Kwajalein Lodge (U.S. Army Space and Strategic Defense Command, 1994). Currently, Kwajalein can accommodate 134 transient personnel (U.S. Army Space and Missile Defense Command, 2002).

Housing

There are 1,211 quarters on Kwajalein, with a variety of housing arrangements for families, couples, and unaccompanied personnel. Quarters include “new” and “old” housing, fourplexes, trailers and bachelor quarters. (U.S. Army Space and Missile Defense Command, 2007d)

Employment

The U.S. Government is an important source of income for the RMI and is the largest employer of Marshallese on Kwajalein Atoll (Defense Environmental Network and Information eXchange, 1997).

Education

The Kwajalein Schools are located on Kwajalein Atoll in the RMI. Kwajalein is a U.S. military installation administered by the U.S. Army and is subject to military rules and regulations.

Kwajalein Range Services, a private corporation contracted to provide a variety of support services for the resident population, operates the schools. The schools serve approximately 400 dependent children of the U.S. citizens residing on Kwajalein. About 15 percent of the students are from military families, and the remainder comes from homes of civilian residents working on the Range (Employment, 2007). Kwajalein schools promote high academic standards, with strong emphasis on basic skills at the secondary school. School is in session for 180 days a year from mid-August to early June. Students live on Kwajalein as well as the neighboring island of Ebeye. The students who live on Ebeye ride a boat to and from Kwajalein (approximately 15-minute boat ride) every day. (U.S. Army Space and Missile Defense Command, 2007e)

3.1.11.2.3 Meck

Meck is uninhabited (no resident population) and possesses no socioeconomic characteristics. However, a few Marshallese may be employed periodically to support ground and facility maintenance on the island (Chinnery, 2007).

3.1.11.2.4 Ebeye

Ebeye is the second most populated island in the RMI. Ebeye has a total land mass of 0.36 square kilometer (0.14 square mile). (Paul and Graham, 2002) Ebeye lies 4 kilometers (2.5 miles) north of Kwajalein, and is separated from the latter by an unbroken reef. It is 1,618 meters (1,770 yards) long and 210 meters (230 yards) wide throughout most of its length. (Spennemann, 2005)

Population, Income, and Education

Nearly 10,000 Marshallese reside on Ebeye, many of whom work on the RTS. (Paul and Graham, 2002)

In the past two decades (1982-2002), the mean annual wage for Ebeye workers doubled. However, prices in the RMI (according to the RMI consumer price index, or CPI) also doubled during this period. This means that real wages for Ebeye employees have remained the same for 20 years. The mean wage of Ebeye workers in 2002 was $10,758. (Paul and Graham, 2002)

Between 1967 and 2002, the percentage of adults (25 years and over) with an elementary education nearly tripled. Although only about one-third of Ebeye adults completed at least elementary school in 1967, close to 90 percent were elementary educated in 2002. About 4 in 10 adults on Ebeye were high-school educated in 2002. (Paul and Graham, 2002)

Housing

According to the 2006 RMI Community and Socioeconomic Survey, households on Ebeye remain the most crowded in the RMI, with an average of nine persons each. Ebeye had by far the highest percentage of persons living in multiple unit households, many of which share common sanitation facilities. The majority of Ebeye's household structures (buildings) were owned by their residents, but at the same time the majority of household land was not owned by the residents but was occupied with permission from the owners or title holders. (Republic of the Marshall Islands, 2006)

Employment

In 2002 the U.S. Army and its various private contractors employed an estimated 1,200 Marshallese (Paul and Graham, 2002). The 2006 RMI Community and Socioeconomic Survey found a very low labor force participation rate in Ebeye, at around 44.3 percent (meaning that more than half working age persons were unemployed but not looking for work). Unemployment on Ebeye was estimated at 26.4 to 38.1 percent. The most common occupations among those employed were laborers, cleaners, and other service workers. Half of the employed persons worked on the USAKA base, with another 20 percent working in the private sector and 19 percent working for the government (local or national). (Republic of the Marshall Islands, 2006) Approximately three to six Marshallese from Ebeye are employed by SpaceX during a launch period to support facility maintenance on Omelek and at least one employed fulltime by SpaceX to provide technical support for facility maintenance on Omelek (Chinnery, 2007).

3.1.11.2.5 Majuro

With a land area of 9.6 square kilometers (3.75 square miles), Majuro is the nation's capital for the Marshall Islands. Majuro also is the site of most public, commercial, and industrial development.

Population, Income, and Education

By 1999 the population of Majuro had reached 34,578 (U.S. Army Space and Missile Defense Command, 2006c). During this same time frame the 2000 census population for the entire Marshall Islands was 50,848 (U.S. Census Bureau, International Data Base, 2007). The population of Majuro in 1999 accounted for 68 percent of the Marshall Islands.

The 2006 RMI Community and Socioeconomic Survey indicated that Majuro's median household income was $14,737 and placed it second among all seven areas surveyed, behind Ebeye ($17,321). Additionally, 85 percent of Majuro households had earnings/salary income, but 12 percent of households had no workers at all (Republic of the Marshall Islands, 2006).

Majuro has elementary, middle, and several high schools, and a community college. The 2006 RMI survey revealed school attendance rate on Majuro Atoll at 90 percent. (Republic of the Marshall Islands, 2006 and Office of the United Nations High Commissioner for Human Rights, 1998)

Housing

Nearly half of Majuro's residents are located in a "downtown" administrative and commercial centre of 1.3 square kilometers (0.51 square mile). As most housing is single story, these figures represent a high ratio of people to floor space. (Office of the United Nations High Commissioner for Human Rights, 1998) A high internal migration exists as people move from the rural islands and atolls to Majuro and other urbanized areas in search of jobs, better health, and improved education. Thus, overcrowding results and shortages in housing (as well as availability of other essential services) take place. (U.S. Department of the Interior, Office of Insular Affairs, 1999) A 2006 survey by the RMI indicated that Majuro's home ownership rate was 87 percent, and the majority of households made no payments on their residence buildings, while 15 percent made mortgage payments (Republic of the Marshall Islands, 2006).

Employment

The 2006 RMI Community and Socioeconomic Survey indicated unemployment on Majuro, estimated at 31 percent in 1999, remains high, with an estimated range for 2006 of 25 to 39 percent. The top-five most commonly held jobs on Majuro were teachers (including principals), laborers, bookkeepers/cashiers, bricklayers/carpenters/construction, and protective service workers (policemen and security guards). Additionally, about 40 percent of employed persons worked in the public sector. (Republic of the Marshall Islands, 2006)

3.1.12 WATER RESOURCES

This section describes the existing water resource conditions at the proposed sites. Water resources include surface water, groundwater, water quality, and flood hazard areas. Generally, coral atolls lack surface water bodies or defined drainage channels due to extreme high porosity and permeability of the soils and surface sediments. With the exception of man-made impervious surfaces, abundant amounts of rainwater rapidly infiltrate directly into the ground (U.S. Army Space and Strategic Defense Command, 1995).

3.1.12.1 Region of Influence

The region of influence for water resources includes those surface and groundwater bodies that could potentially be affected by program activities.

3.1.12.2 Affected Environment

3.1.12.2.1 Omelek

Surface Water

Omelek's tropical marine climate is characterized by a relatively high annual rainfall. With the exception of transient shallow pools of rainwater, no surface water bodies exist on the island due to the extreme high porosity and permeability of the soils and surface sediments. (U.S. Army Space and Missile Defense Command, 2002)

Groundwater

As rainwater percolates down through the highly porous and permeable atoll surface, it collects as a lens of fresh groundwater that floats atop marine waters in the subsurface rock strata (U.S. Army Strategic Defense Command, 1989a; b). Omelek contains some groundwater, but the amount that may be available for potable water consumption has not been investigated. Potable water requirements are provided by Kwajalein and transported to Omelek to supply individual program requirements.

Water Quality

Freshwater quality in the region of influence is generally satisfactory. However, water quality is a constant concern because of the uncertainty of rainwater supply and the limited amount of freshwater in the groundwater lens.

Marine water quality around USAKA/RTS islands has generally been described as satisfactory. According to the UES (U.S. Army Space and Missile Defense Command, 2006b), stringent provisions are provided for surface waters as well as general and specific use categories and water quality standards. Discharges to surface waters are required to meet operational and effluent limits established through DEPs and water quality management planning.

Flood Hazard Areas

No flood hazard areas have been identified within the region of influence.

3.1.12.2.2 Kwajalein

Potable water sources on Kwajalein are supplied by both groundwater wells and captured rainwater in catchment areas located adjacent to the airfield's runway. Water capture during periods of drought can be less than one-third of the daily demand. Groundwater occurs on Kwajalein as a lens of fresh to brackish water floating on deeper marine waters in the subsurface rock layers. Seasonal infiltration of rainwater recharges the aquifer. The fresh groundwater storage capacity has been estimated at about 1,060 million liters (279 million gallons), with fluctuations of greater than 20 percent in response to recharge or pumping. Raw water is stored in twelve 4-million-liter (1-million-gallon) aboveground storage tanks. (U.S. Army Space and Strategic Defense Command, 1995; U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site, 2005a)

3.1.12.2.3 Meck

The amount of fresh groundwater that may be available on Meck for potable water consumption has not been investigated. Potable water requirements are provided by a rainwater catchment area adjacent to the airfield runway. Two 950,000-liter (250,000-gallon) tanks and one 2-million liter (500,000-gallon) tank store raw water. (U.S. Army Space and Strategic Defense Command, 1995; U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site, 2005a)

3.2 OPEN OCEAN

For purposes of this analysis, open ocean refers to those ocean areas beyond U.S. and RMI territorial limits as described for each launch alternative. Open ocean areas are subject to Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*. A limited number of resources would potentially be impacted by the Proposed or Alternative Action, including airspace, biological resources, health and safety, transportation, and water resources.

3.2.1 AIRSPACE

A general description of airspace is provided in the first paragraph of section 3.1.2.

3.2.1.1 Region of Influence

The region of influence is defined as those portions of the international airspace over the open Pacific Ocean that would potentially be affected by the Proposed Action.

3.2.1.2 Affected Environment

The affected airspace in the open ocean region of influence is described below in terms of its principal attributes, namely controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and air traffic control. There are no military training routes in the region of influence.

Controlled and Uncontrolled Airspace

Because the airspace over the open ocean beyond the territorial limits of the United States and the RMI is in international airspace, the procedures of the ICAO are followed. The FAA acts as the U.S. agent for aeronautical information to the ICAO, and air traffic in the region of influence is managed by the Honolulu and Oakland ARTCCs.

Special Use Airspace

There is no special use airspace in the ocean area region of influence.

En Route Airways and Jet Routes

The ocean area airspace use region of influence has several en route high altitude jet routes (A331, A332, A450, R463, R464, R465, R 584, Corridor V 506, and Corridor G 10), which pass through the region of influence. Most of the ocean area airspace use region of influence is well removed from the jet routes that currently crisscross the North Pacific Ocean (Figure 3-2).

As an alternative to aircraft flying above 8,839 meters (29,000 feet) following published, preferred instrument flight rules routes, the FAA is gradually permitting aircraft to select their own routes. This Free Flight program is an innovative concept designed to enhance the safety and efficiency of the National Airspace System. The concept moves the National Airspace System from a centralized command-and-control system between pilots and air traffic controllers to a distributed system that allows pilots, whenever practical, to choose their own route and file a flight plan that follows the most efficient and economical route. (Federal Aviation Administration, 1996)

Free Flight is already underway, and the plan for full implementation will occur as procedures are modified, and technologies become available and are acquired by users and service providers. This incremental approach balances the needs of the aviation community and the expected resources of both the FAA and the users. Advanced satellite voice and data communications are being used to provide faster and more reliable transmission to enable reductions in vertical, lateral, and longitudinal separation, more direct flights and tracks, and faster altitude clearances (Federal Aviation Administration, 1996). With full implementation of this program, the amount of airspace in the region of influence that is likely to be clear of traffic will decrease as pilots, whenever practical, choose their own route and file a flight plan that follows the most efficient and economical route, rather than following the published jet routes.

Air Traffic Control

Control of oceanic air traffic from/to the United States is carried out from oceanic centers in Anchorage, Oakland, and New York. The Oakland Oceanic Flight Information Region is the world's largest, covering approximately 48.4 million square kilometers (18.7 million square miles) and handling over 560 flights per day. Traffic between the Continental United States and

Hawaii flies on the Central East Pacific Composite Route System. (Federal Aviation Administration, 2000)

3.2.2 BIOLOGICAL RESOURCES

Marine biology of the open ocean area consists of the animal and plant life that lives in and just above the surface waters of the sea and its fringes, the salient physical and chemical properties of the ocean, biological diversity, and the characteristics of its different ecosystems or communities.

3.2.2.1 Region of Influence

The open ocean area region of influence includes those areas below the potential Falcon flight corridors and the first stage, fairing, and second stage drop areas in the central North Pacific Ocean. The average depth of the ocean area region of influence is 3,932 meters (12,900 feet).

3.2.2.2 Affected Environment

The general composition of the ocean includes water, sodium chloride, dissolved gases, minerals, and nutrients. These characteristics determine and direct the interactions between the seawater and its inhabitants. The most important physical and chemical properties are salinity, density, temperature, pH, and dissolved gases. For oceanic waters, the salinity is approximately 35 parts of salt per 1,000 parts of seawater.

Most organisms have a distinct range of temperatures in which they may thrive. A greater number of species live within the moderate temperature zones, with fewer species tolerant of extremes in temperature.

Surface seawater often has a pH between 8.1 and 8.3 (slightly basic), but generally is very stable with a neutral pH. The amount of oxygen present in seawater will vary with the rate of production by plants, consumption by animals and plants, bacterial decomposition, and surface interactions with the atmosphere. Most organisms require oxygen for their life processes. Carbon dioxide is a gas required by plants for photosynthetic production of new organic matter. Carbon dioxide is 60 times more concentrated in seawater than it is in the atmosphere.

Ocean Zones

Classification of the Pacific Ocean zones is based on depth and proximity to land. Using this methodology, there are four major divisions or zones in the ocean: the littoral zone, the coastal zone, the offshore zone, and the pelagic zone. Spanning across all zones is the benthic environment, or sea floor. This section discusses the pelagic zone and the benthic environment.

The pelagic zone is commonly referred to as the open ocean. The organisms that inhabit the open ocean typically do not come near land, continental shelves, or the seabed. Approximately 2 percent of marine species live in the open ocean.

The bottom of the sea floor is known as the benthic area. It comprises 98 percent of the species of animals and plants in the ocean. Less than 1 percent of benthic species live in the deep ocean below 2,000 meters (6,562 feet).

Biological Diversity

Marine life ranges from microscopic one-celled organisms to the world's largest animal, the blue whale. Marine plants and plant-like organisms can live only in the sunlit surface waters of the ocean, the photic zone, which extends to only about 101 meters (330 feet) below the surface. Beyond the photic zone, the light is insufficient to support plants and plant-like organisms. Animals, however, live throughout the ocean from the surface to the greatest depths.

The organisms living in pelagic communities may be drifters (plankton) or swimmers (nekton). The plankton consists of plant-like organisms and animals that drift with the ocean currents, with little ability to move through the water on their own. The nekton consists of animals that can swim freely in the ocean, such as fish, squids, and marine mammals. Benthic communities in the vicinity of Omelek are made up of marine organisms, such as kelp, sea grass, giant clams, top-shell snails, black-lipped pearl oysters, sponges, coral, sea cucumbers, sea stars, and crabs that live on or near the sea floor (U.S. Army Space and Missile Defense Command, 2004a).

Threatened and Endangered Species

Species identified as threatened or endangered that exist in the ocean area region of influence, listed in section 3.1.3, include the sei whale, blue whale, finback whale, humpback whale, sperm whale, loggerhead sea turtle, green sea turtle, leatherback sea turtle, hawksbill sea turtle, and olive ridley sea turtle.

Noise

Baseline or ambient noise levels on the ocean surface—not including localized noise attributed to shipping—is a function of local and regional wind speeds. Studies of ambient noise of the ocean have found that the sea surface is the predominant source of noise, and that the source is associated with the breaking of waves. Wave breaking is further correlated to wind speed, resulting in a relationship between noise level and wind speed. (Federal Aviation Administration, July 2001)

Ambient noise in relation to underwater noise is also the existing background noise of the environment. Ambient noise strongly affects the distances to which animal and specific man-made sounds and other sounds of interest can be detected by marine mammals (Richardson et al., 1995). Common sources of background noise for large bodies of water are tidal currents and waves; wind and rain over the water surface; water turbulence and infrasonic noise; biological sources (e.g., marine mammals); and human-made sounds (e.g., ships, boats, low-flying aircraft). The ambient noise levels from natural sources typically vary by as much as 20 dB or more (Richardson et al., 1995) according to numerous factors including wind and sea conditions, seasonal biological cycles, and other physical conditions. Noise levels from natural sources can be as loud as 120 dB (re: 1 micropascal [μPa] at 1 meter [3.2 feet]) in major storms. (U.S. Department of the Air Force, 1998)

Noise associated with human sources varies with the characteristics of the specific noise source. The primary human-made noise source within the region of influence is expected to be associated with ship and vessel traffic. This source may include transiting commercial tankers and container ships, commercial fishing boats, and military surface vessels and aircraft. Vessel noise is primarily associated with propeller and propulsion machinery. In general, noise levels increase with vessel size, speed, and load. Noise levels from large ships can reach levels of 180-190 dB (re 1 μPa at 1 meter [3.2 feet]), whereas smaller vessels range from approximately 100-160 dB (re 1 μPa at 1 meter [3.2 feet]) (U.S. Department of the Air Force, 1998). At distances greater than 1 meter (3.2 feet), noise levels received diminish rapidly with increasing distance (Richardson et al., 1995).

Water Resources

A general description of water resources is provided in the first paragraph of section 3.1.12.

Water quality in the open ocean is excellent, with high water clarity, low concentrations of suspended matter, dissolved oxygen concentrations at or near saturation, and low concentrations of contaminants such as trace metals and hydrocarbons. A description of the open ocean's physical and chemical properties, including salinity, density, temperature, pH, and dissolved gases, is given above.

3.2.3 HEALTH AND SAFETY

A general description of health and safety is provided in the beginning paragraphs of section 3.1.7.

3.2.3.1 Region of Influence

The open ocean region of influence consists of all areas beneath the proposed flight track where there is the potential for impact of missile components during planned activities or abnormal flight termination and the broad ocean area where the missile's first stage and missile debris would impact.

3.2.3.2 Affected Environment

The affected health and safety environment for the open ocean is described below in terms of its principal attributes, namely range control procedures and verification of ocean area clearance procedures.

Range Control is charged with surveillance, clearance, and real-time range safety. The Range Control Officer using USAKA/RTS assets is solely responsible for determining range status and setting "RED" (no firing) and "GREEN" (range is clear and support units are ready to begin the event) range firing conditions. USAKA/RTS uses Range Commanders Council (RCC) 321-02, *Common Risk Criteria for National Test Ranges*. RCC 321-02 sets requirements for minimally-acceptable risk criteria to occupational and non-occupational personnel, test facilities, and nonmilitary assets during range operations. Under RCC 321-02, individuals of the general public shall not be exposed to a probability of fatality greater than 1 in 10 million for any single mission and 1 in 1 million on an annual basis.

Flight Safety provides protection to USAKA personnel, inhabitants of RMI, and ships and aircraft operating in areas potentially affected by mission activities. Specific procedures, including regulations, directives, and flight safety plans, are required for the preparation and execution of missions involving aircraft, missile launches, and reentry payloads. USAKA controls all flight corridor operations as part of USAKA/RTS. All operations are thus conducted in accordance with safety procedures, which are consistent with those implemented for USAKA/RTS. There is no special use airspace over USAKA/RTS.

4.0
ENVIRONMENTAL CONSEQUENCES

4.0 ENVIRONMENTAL CONSEQUENCES

This chapter describes the potential environmental consequences of the proposed activities by comparing these activities with the potentially affected environment components provided in Chapter 3.0. Sections 4.1 through 4.2 provide discussions of the potential environmental consequences of these activities. The amount of detail presented in each section is proportional to the potential for impacts. Sections 4.3 through 4.5 provide discussion of the following with regard to proposed program activities: environmental effects of the No-action Alternative; Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (Executive Order 12898); and Federal Actions to Address Protection of Children from Environmental Health Risks and Safety Risks (Executive Order 13045, As Amended By Executive Order 13229).

To help define the affected environment and determine the significance of program-related effects, written, personal, electronic, and telephone contacts were made with applicable agencies and installations. Chapter 7 provides a list of those contacted, and Appendix B provides copies of applicable agency correspondence.

4.1 U.S. ARMY KWAJALEIN ATOLL

4.1.1 AIR QUALITY

4.1.1.1 Site Preparation Activities

4.1.1.1.1 Omelek, Kwajalein, and Meck

An increase in air emissions associated with construction of the improvements proposed in Section 2.1.5 would be negligible and therefore was not evaluated. While proposed SpaceX activities would continue to use existing facilities as authorized in the Proof-of-Principle Space Launches from Omelek Island EA, additional facilities are proposed for construction and relocation. Section 2.1.5 details the proposed new construction, upgrades, and facility relocation. Specific types of equipment that would be used during construction are not known at this time. Excavation and grading would normally involve the use of bulldozers, scrapers, backhoes, and trucks, depending on the area disturbed. The construction of buildings would likely involve the use of pile drivers, concrete mixers, pumps, saws, hammers, cranes, and forklifts. Proposed construction at Omelek and Kwajalein might cause temporary generation of fugitive dust and diesel exhaust emissions. Additionally, volatile organic compounds (VOCs) might be released from paints, solvents, or cleansers. Specific amounts of each pollutant generated depend on the square footage built, the number of vehicles involved, and the length of time the construction would take place. These emissions are not anticipated to cause exceedances of the UES. Additionally, implementation of standard dust suppression methods (frequent watering) and a vehicle maintenance program (proper tuning and preventive maintenance of vehicles) would minimize fugitive dust emissions and vehicle exhaust emissions, respectively, and would help to maintain the area's current air quality. Due to the exclusion of the public from the immediate vicinity of construction, the public would not be exposed to emissions. Once construction is completed, air quality would return to its former level.

As described in the Proof-of-Principle Space Launches from Omelek Island EA, launch preparation activities would also include the arrival of SpaceX equipment by a commercial cargo carrier and a landing craft, as well as the transportation of launch personnel. Emissions produced during these activities would be temporary and localized and are not anticipated to affect regional air quality.

In addition, two dress rehearsals are proposed in the launch preparation schedule. Included in a dress rehearsal could be fully fueling the launch vehicle and, under some circumstances, static fire tests. Static fire tests would require fully fueling the launch vehicle and firing the first stage engine for approximately 5 seconds. The engine would then be shut down, the fuel removed, and the vehicle returned to storage. Static fire testing would only be required during initial launches of the Falcon 1 and Falcon 9 launches. Once the Falcon Program is operational, the static tests would no longer be necessary. Anticipated emissions would be temporary and localized and are not anticipated to affect regional air quality.

4.1.1.2 Operational Activities

4.1.1.2.1 Omelek

The two existing 400-kilovolt diesel generators used on Omelek for power would be upgraded to two 1,000-kilovolt diesel generators. Both 1,000-kVA generators would supply power on the island during launch activities. A possible scenario for usage of the generators would be to have each generator run 22 days per launch. A 100-kVA generator will take the place of the 50-kW generator currently in use. This smaller 100-kVA generator would be used during sustainment periods, 5 months per year, when no launches would occur. Table 4-1 lists these stationary sources of air pollution for the proposed action.

Table 4-1. Proposed Major and Minor Stationary Sources of Air Pollution

Source	Type	Rating	Make/Model	Classification	Remarks
Generator	--	1,000 kVA	--	Major	(>600 kW)
Generator	--	1,000 kVA	--	Major	(>600 kW)
Generator	--	100 kVA	--	Minor	(<600 kW)

Table 4-2 lists the possible exhaust emissions associated with the two proposed 1,000-kilovolt and one 100-kVA generators. These levels of emissions are considerably below the threshold levels listed in Table 3-2 and are not anticipated to impact the regional air quality or exceed the USAKA ambient air standard listed in Table 3-1, when all 3 units are operating concurrently. However, the ambient air quality standards are achieved. It can be assumed that compliance with the allowable incremental degradation standards will also not be achieved with the proposed generators. According to the current air quality DEP, within 2 years of its effective date (September 21, 2006), USAKA will complete an analysis of generator configuration (including stack height) and operational options that will achieve compliance with both standards. Implementation would occur within 3 years of the effective date of the DEP.

Table 4-2. Potential Generator Emissions*
Metric Tons (Tons) Per Year

	Volatile Organic Compounds	Oxides of Nitrogen	Carbon Monoxide	Oxides of Sulfur	PM-10
Generators	0.29 (0.32)	7.13 (7.86)	1.81 (1.99)	0.17 (0.19)	0.17 (0.21)

Source: U.S. Environmental Protection Agency, 2005, AP-42, Fifth Edition, Volume 1

*Note: Based on:
31 weeks/year mission operation for each 1,000-kilovolt generator using a total of 1,000 gallons of diesel/week
21 weeks/year non-mission operation (100-kW generator) using 200 gallons of diesel/week

A LOX plant is planned for installation on Kwajalein that would produce up to 6.4 metric tons (7 tons) per day of LOX, and may produce LN2 as a by-product. The LOX plant would not be in operation between missions. The possible LN2 by-product would be used to cool the loading and handling LOX equipment. The plant would be operated using the existing power supply on Kwajalein that is already subject to the DEP. It is not likely that any other element of the LOX plants would meet the thresholds for major stationary source defined in Chapter 3.0, Table 3-2.

LOX fueling operations at Omelek would be similar to that described in the Proof-of-Principle Space Launches from Omelek Island EA, and would involve pumping LOX through aboveground lines between the LOX plant and the launch vehicle. Any emissions of LOX during the fueling process would be negligible and would not have a negative impact to the surrounding air quality. In the event of a spill, the LOX and LN2 would be allowed to evaporate and would not impact the surrounding regional air quality.

Kerosene for either the Falcon 1 or the Falcon 9 launch vehicle would be stored in bulk containers in a concrete containment system. Permanent aboveground lines would connect both the LOX areas and the kerosene storage area to the Falcon 1 and 9 launch pads. Spills would be contained and cleaned up in accordance with the procedures identified in the KEEP and site specific emergency plan or spill prevention plan and are anticipated to have no contribution to the overall emissions generated during flight test activities.

Each launch event is considered to be a discrete event that generates short-term impacts to the local air quality. The Falcon 9 system launches would begin in 2008 after site preparation is complete. An average of six Falcon 1 launches per year is planned for the next 10 years, and up to four Falcon 9 launches per year starting after 2008. Long-term effects resulting from launches are not expected because the launches would be infrequent and the resulting emissions would be rapidly dispersed and diluted by winds. Table 4-3 lists the anticipated emissions of criteria pollutants from the proposed Falcon 1 and Falcon 9 launches. These levels are below the threshold levels listed in Table 3-2 and are not anticipated to impact the regional air quality or exceed the ambient air quality standards listed in Table 3-1. Falcon 1 and Falcon 9 launches would also emit hydrogen, carbon dioxide, and water; however, these emissions are not regulated and would not cause an impact to the regional air quality.

Table 4-3. Falcon 1 and Falcon 9 Launch Emissions*
Metric Tons (Tons) Per Year

	Volatile Organic Compounds	Oxides of Nitrogen	Carbon Monoxide	Oxides of Sulfur	PM-10
Six Falcon 1 Launches	0.0	0.0	518.4 (571.4)	0.0	0.0
Four Falcon 9 Launches	0.0	0.0	3,110.4 (3,428.6)	0.0	0.0

Source: Space Exploration Technologies Corporation, 2003.
*Based on Falcon 9 having 9 times the emission factor for Falcon 1 because the same engine is used for both missiles.

4.1.1.2.2 Kwajalein/Meck

Falcon launch program activities on Kwajalein and Meck would be related to launch control and oversight, which are not expected to impact air quality.

4.1.1.3 Post Flight Activities

Post flight activities would include the removal of equipment and assets brought to Omelek. The removal could result in small localized of fugitive dust, which would have a negligible impact to air quality.

4.1.1.4 Cumulative Impacts

Due to the limited industrialization of Omelek and the surrounding environment, the potential cumulative impacts to air quality due to the proposed construction and launch activities would not be substantial. There are currently no other activities planned at Omelek. The Proposed Action activities would not occur at the same time as other regional programs such as Ground-Based Midcourse or Minuteman III. Missile launches are short-term, discrete events, thus allowing time between launches for emission products to be dispersed. The increased size and use of the power station may not comply with the allowable UES incremental degradation standards. There are operational options that would achieve compliance with ambient air quality and incremental degradation standards. SpaceX is considering the addition of a wind-based power generator for use between missions when power needs are reduced. Other operational options could include limiting the fuel consumption per year or increasing the stack heights of the generators. If one or a combination of these options was implemented, it is not likely that the Proposed Action at Omelek would result in cumulative impacts to the regional air quality.

4.1.2 AIRSPACE

Assessment of potential impacts to airspace is based on the following: if proposed activities have the potential to result in an obstruction to air navigation; modification to or new requirements for special use airspace; changes to existing air routes; or additional restricted access to regional airfields and airports.

4.1.2.1 Site Preparation Activities

4.1.2.1.1 Omelek, Kwajalein, Meck

Although site preparation activities (i.e., equipment delivery) could involve flights in and out of Bucholz Army Airfield on Kwajalein, they would not restrict access to, nor affect the use of, existing airfields and airports in the region of influence. Operation at the airfield would continue unobstructed. Similarly, the existing airfield or airport arrival and departure traffic flows would not be affected. No modification to or new requirements for special use airspace would be required. No changes to existing air routes or additional restricted access to regional airfields and airports are anticipated. All arriving and departing aircraft and all participating military aircraft are under the control of the Bucholz Army Airfield Control Tower; thus, there would be no airfield conflicts in the region of influence, and no effect.

4.1.2.2 Operational Activities

4.1.2.2.1 Omelek

Omelek is located under international airspace and, therefore, has no formal airspace restrictions governing it. Commercial and private aircraft would be notified in advance of Falcon launch activities by USAKA/RTS as part of their routine operations through NOTAMs by the FAA.

To satisfy airspace safety requirements in accordance with Army Regulation 385-62, *Regulations for Firing Guided Missiles and Heavy Rockets for Training, Target Practice, And Combat*, the responsible commander would coordinate with the Administrator, FAA, through the appropriate U.S. Army airspace representative as required by Army Regulation 95-2, *Air Traffic Control, Airspace, Airfields, Flight Activities, and Navigational Aids*. Provision would be made for surveillance of the affected airspace in accordance with Army Regulation 385-62. In addition, safety regulations dictate that launch operations would be suspended when it is known or suspected that any unauthorized aircraft have entered any part of the airspace above the launch hazard zone until the unauthorized entrant has been removed or a thorough check of the suspected area has been performed. No new special use airspace would be required. NOTAMs would be issued to advise avoidance of the tracking radar areas during activation of the USAKA Range, particularly in the vicinity of Kwajalein or Roi-Namur when their radars are transmitting.

Although Omelek is approximately 35 kilometers (22 miles) north of Bucholz Army Airfield, some of the desired azimuths shown on Figure 2-4 could impact standard flight patterns for military aircraft coming to Kwajalein from Hawaii. SpaceX would coordinate Falcon launches with the USAKA/RTS Commander, which would include scheduling to avoid airspace conflicts.

4.1.2.2.2 Kwajalein/Meck

USAKA/RTS is located under international airspace and, therefore, has no formal airspace restrictions governing it. Commercial and private aircraft would be notified in advance of Falcon launch activities by USAKA/RTS as part of their routine operations through NOTAMs by the FAA.

4.1.2.3 Post Flight Activities

4.1.2.3.1 Omelek, Kwajalein, Meck

Flights required as part of the post flight activities would not restrict access to, nor affect the use of, existing airfields in the region of influence. Operations at the airfields would not be obstructed. Existing airfield or airport arrival and departure traffic flows would also not be affected, and access to the airfield would not be curtailed. All arriving and departing aircraft and all participating military aircraft are under the control of the Bucholz Army Airfield Control Tower; thus, there would be no airfield conflicts in the region of influence, and no impact.

4.1.2.4 Cumulative Impacts

Missile launches are short-term, discrete events and are actively managed by USAKA/RTS range safety. The Proposed Action would not occur at the same time as other regional programs such as Ground-Based Midcourse Defense or Minuteman III. No other projects in the region of influence have been identified that would have the potential for cumulative impacts to airspace. The use of the required scheduling and coordination process for international airspace, and adherence to applicable DoD directives and U.S. Army regulations concerning issuance of NOTAMs and selection of missile firing areas and trajectories, lessens the potential for significant incremental, additive, cumulative impacts.

4.1.3 BIOLOGICAL RESOURCES

4.1.3.1 Site Preparation Activities

4.1.3.1.1 Omelek

Vegetation

Site preparation for the Proposed Action would result in the removal of existing non-forested areas and some mature forest, primarily *Pisonia* trees (Table 4-4), or approximately an additional 9.6 percent of the total acreage of Omelek and approximately 19 percent of the current vegetation (Appendix C). In order to accomplish the Falcon 1 and 9 launches, trees and other vegetation would need to be removed from a portion of the north point of the island. In addition, vegetation would need to be removed from the south point and along the west coast, currently low scrub. These areas could be re-planted with palm trees and other vegetation that may help stabilize the coastline. Any replanting would be conducted in coordination with USAKA and other appropriate agencies. Some trees would also need to be removed from around the Falcon 1 launch site for long-term use, and from the area of the Falcon 9 hangar. Clearance for the proposed launch pad and associated infrastructure would be primarily placed in areas of grass and forb (broad-leaved herb other than grass) vegetation which are currently maintained at a low level by mowing or other mechanical control and, as such, already significantly disturbed. Pier refurbishment would not expand the existing pier footprint and is thus not anticipated to result in impacts to adjacent biological resources.

Prior to their arrival on Omelek, SpaceX personnel would be briefed on the need to respect and protect sensitive island resources, including the remaining native forest, and to avoid harassment of sensitive species. Personnel would be instructed to stay on existing roads and paths where possible. Onsite supervisors would ensure that personnel comply with the briefing objectives.

Table 4-4. Impacts to Vegetation

Facility/Activity	Area of Impact Square Meters (Square Feet)	Habitat Type
Office Trailer	46.5 (500)	Littoral shrub vegetation (*e.g.*, *Tournefortia argentea* and *Scaevola taccada*)
New Helicopter Pad	557 (6,000)	Littoral forest (*e.g.*, *Tournefortia*, *Pisonia grandis*, *Guettarda speciosa*, *Terminalia samoensis*, *Cocos nucifera*)
	372 (4,000)	Littoral shrub vegetation
Falcon 9 Launch Site (pad, containment berm, runway ramp)	372 (4,000)	Littoral forest (*e.g.*, *Tournefortia*, *Pisonia grandis*, *Guettarda speciosa*, *Terminalia samoensis*, *Cocos nucifera*)
	1,115 (12,000)	Littoral shrub vegetation
Falcon 9 Hangar	93 (1,000)	Littoral shrub vegetation (*e.g.*, *Tournefortia argentea* and *Scaevola taccada*)
RP-1 Fuel/Storage/Containment	357.7 (3,850)	Littoral shrub vegetation (*e.g.*, *Tournefortia argentea* and *Scaevola taccada*)
Liquid oxygen/helium/nitrogen Containment Site	46.5 (500)	Littoral shrub vegetation (*e.g.*, *Tournefortia argentea* and *Scaevola taccada*)
Falcon 1 Launch Pad (South Side) Vegetation Removal	464.5 (5,000)	Littoral forest (*e.g.*, *Tournefortia*, *Pisonia grandis*, *Guettarda speciosa*, *Terminalia samoensis*, *Cocos nucifera*)
Falcon 1 Launch Pad (North Side) Vegetation Removal	464.5 (5,000)	Littoral shrub vegetation (*e.g.*, *Tournefortia argentea* and *Scaevola taccada*)
Paving Unimproved Paths	4,180.5 (45,000)	--
Harbor Modifications (Pilings, Dock)	0.6-meter (2-foot) diameter x 4 pilings 37.2 (400)	Sand habitat Shoreline and Shallow Coral Reef Habitat
Rainwater Runoff (diverted into harbor)	6.8 million liters (1.8 million gallons) per year	Shallow coral reef habitat

Source: U.S. Fish and Wildlife Service, 2007 (Appendix C)

Threatened and Endangered Plant Species

No threatened or endangered vegetation has been identified in the project areas.

Wildlife

Personnel would be instructed to avoid areas designated as avian nesting or roosting habitat by USAKA/RTS in coordination with the Pacific Islands Fish and Wildlife Service office and to avoid all contact with any nest that may be encountered. Emergency lighting would be shielded and pointed down to minimize the potential for impacts to migratory birds and sea turtles.

Immediately prior to their shipment to Omelek, prefabricated buildings and all other materials would be inspected by a certified pest control inspector and, if necessary, treated for the removal of pests (e.g., rats, mice, and ants) and other non-native organisms to prevent their potential spread and introduction to other USAKA islands.

The effects of noise on wildlife vary from serious to no effect in different species and situations. Behavioral responses to noise also vary from startling to retreat from favorable habitat, due partly to the fact that wildlife can be very sensitive to sounds in some situations and very insensitive to the same sounds in other situations (Larkin, 1996).

Construction noise and the increased presence of personnel could temporarily affect wildlife within the area. Construction ground disturbance and equipment noise-related impacts could include loss of habitat, displacement of wildlife, and short-term disruption of daily/seasonal behavior. Typical noise levels at 15 meters (50 feet) from construction equipment range from 70 to 98 dBA. The combination of increased noise levels and human activity would likely displace some birds that forage, feed, or roost within this 15-meter (50-foot) radius. Although construction activities could cause flushing (birds suddenly flying up), this is a common reaction to sudden natural sounds that only slightly increases the energy expenditure of individual birds, and while some might potentially leave the immediate area permanently, others may likely become accustomed to the increased noise and human presence. As discussed above, actions would be taken to minimize disturbance to sensitive resources, such as posting signs designating sensitive areas on the northern part of the island, and providing personnel with information on the need to protect and avoid harassment of sensitive species.

The removal of at least 3,887 square meters (41,850 square feet) of vegetation would result in the more or less permanent removal of some habitat available for nesting seabirds or foraging shorebirds on Omelek. As stated above, this would be approximately an additional 9.6 percent of the total area of Omelek. Continuation of habitat enhancement projects on Eniwetak Islet would be used to offset the vegetation removal.

Sedimentation from installing pilings and a concrete barge dock 3 meters (10 feet) into the harbor could temporarily degrade water quality in the vicinity due to short-term turbidity. Effects to reef fish in the region of influence and to benthic species such as crabs from turbidity would be temporary. The area has been previously dredged. Best Management Practices such as silt curtains and operational controls to reduce turbidity would be used if required. Installation of the pilings and the barge dock would be conducted in accordance with guidelines provided in the Routine Maintenance Dredging and Filling DEP. Turbidity would be minimized and all debris would be removed. Discharges to surface waters would be required to meet established operational and effluent limits and water quality management planning.

Work would be delayed if threatened and endangered species (such as sea turtles) are observed in the area until any such species observed has moved out of harm's way or leaves the area (U.S. Army Kwajalein Atoll/Ronald Reagan Ballistic Missile Defense Test Site, 2003). Since organisms that have colonized the harbor are likely uniquely adapted to this low energy environment and may only survive in a similar environment, such as another harbor or similar low energy area, any relocation of benthic organisms would be coordinated well in advance of removal with USAKA, the U.S. Fish and Wildlife Service, and National Marine Fisheries Service to ensure a higher probability of survival.

Shoreline reinforcement would be accomplished by placing large rocks and debris along the shoreline as needed in accordance with guidelines provided in the Routine Maintenance Dredging and Filling DEP.

Threatened and Endangered Wildlife Species

Personnel would be instructed to avoid all contact with sea turtles or turtle nests that might occur within the area. If turtle nests are discovered, then SpaceX personnel would contact USAKA Environmental, who would consult with the appropriate UES agencies (i.e., U.S. Fish and Wildlife Service and National Marine Fisheries Service) prior to the launch. No site preparation activities would take place offshore, and thus marine mammals would not be affected.

Environmentally Sensitive Habitat

Harbor improvements at Omelek should cause no localized impact to the coral near the existing jetty. The potential impact from the addition of pilings would be mitigated through careful site planning and construction practices.

4.1.3.1.2 Kwajalein

Vegetation

The new facilities would be constructed on the man-made northwestern portion of Kwajalein in areas of grass and forb vegetation, which are currently maintained at a low level by mowing or other mechanical control and, as such, already significantly disturbed. No native vegetation would be affected.

Threatened and Endangered Plant Species

No threatened or endangered vegetation has been identified on Kwajalein.

Wildlife

Construction noise and the increased presence of personnel could affect wildlife within the area. Construction ground disturbance and equipment noise-related impacts would include loss of habitat, displacement of wildlife, and short-term disruption of daily/seasonal behavior. The combination of increased noise levels and human activity would likely displace some seabirds that forage, feed, or roost within a 15-meter (50-foot) radius. While some wildlife may potentially leave the immediate area permanently, others may likely become accustomed to the increased noise and human presence.

Threatened and Endangered Wildlife Species

Personnel would be instructed to avoid all contact with sea turtles or turtle nests that might occur within the area. No site preparation activities would take place offshore, and thus marine mammals would not be affected.

4.1.3.1.3 Meck

An existing facility would be used on Meck, with no construction required.

4.1.3.2 Operational Activities

4.1.3.2.1 Omelek

Vegetation

Launch exhaust products would include hydrogen, carbon dioxide, carbon monoxide, and water. The exact size of the expected blast burn or scorch area for the Falcon 9 has not been determined, but sufficient open space should be created at the launch sites proposed to absorb ground impacts from a nominal launch, without substantially affecting the remaining mature forest trees, such as *Pisonia.*

Threatened and Endangered Plant Species

No threatened or endangered vegetation has been identified in the project areas.

Wildlife

Disturbance to wildlife from the launches would be brief and is not expected to have a lasting impact nor a measurable negative effect on migratory bird populations. Studies indicate that birds may flush during sharp, loud noises but return to normal behavior within a short time. Wildlife that remain in the area would quickly resume feeding and other normal behavior patterns after a launch is completed. Birds driven from preferred feeding areas by disturbances from aircraft or explosions usually return soon after the disturbance stops, as long as the disturbance is not severe or repeated (Federal Aviation Administration, 1996). No evidence has indicated that serious injuries to wildlife have resulted from prior launches in the region, and no long-term adverse effects are anticipated. The brief noise peaks that would be produced by the Falcon are comparable to levels produced by close-range thunder (120 dB to 140 dB peak). The Falcon launches are not anticipated to result in direct effects to nesting, resting, or roosting birds other than the temporary disturbance during the launch itself.

The exhaust plume produced by the Falcon launch vehicle would consist mainly of steam and carbon dioxide. The carbon dioxide, when mixed with the deluge water, would create carbonic acid, which would then break down into bicarbonate and hydrogen ions and create a mild acid.

In the event of a catastrophic launch anomaly, hazardous material and waste would be removed in accordance with the UES. A Restoration Plan would be developed to address terrestrial and marine resources in coordination with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service.

Threatened and Endangered Wildlife Species

Within 2 hours of the launch, SpaceX personnel would survey the shoreline within 100 meters (328 feet) on both sides of the launch site to determine if sea turtles are present in the water or hauled out at this area. If turtles are observed in the area, then SpaceX would consult with USAKA Environmental before continuing with launch activities. Reasonable measures could be taken to return animals to the water prior to launch. If the survey indicates that the sand level covers the rocky outcrop near the launch pad along the shore line, then a fence may be required in accordance with the requirements of the Proof-of-Principle Space Launches from Omelek Island EA if turtles are observed in the area. The survey would be documented and mitigation efforts would be kept on site readily available for inspection. If turtle nests are discovered, then SpaceX personnel would contact USAKA Environmental, who would consult with the appropriate UES agencies to ensure the sea turtle nest is protected to the satisfaction of the U.S. Fish and Wildlife Service.

4.1.3.2.2 Kwajalein/Meck

Falcon launch program activities on Kwajalein and Meck would be related to launch control and oversight, which are not expected to impact any biological resources.

4.1.3.3 Post Flight Activities

4.1.3.3.1 Omelek

A back-out crew, located at Meck for both mission abort operations and also post-flight operations, would arrive and depart Meck via boat transport. After launch and approval by ground safety, this crew would approach Omelek and begin post-launch procedures. SpaceX personnel would clean up the launch site. Limited noise and a small increase in fugitive dust would be produced during these activities.

After each launch, the remaining deluge water would be collected, containerized, and tested if required. This water would be pumped into drums and removed from Omelek if found to be contaminated. Contaminated or non-contaminated water would not be discharged directly into the ocean. These actions would prevent impacts to seawater surrounding Omelek.

SpaceX would remove all hazardous and non-hazardous waste from Omelek and dispose of it in accordance with USAKA/RTS regulations and UES requirements.

4.1.3.3.2 Kwajalein/Meck

Falcon post-launch activities on Kwajalein and Meck would be related to oversight and storage of hazardous materials.

4.1.3.4 Cumulative Impacts

The construction planned for Omelek would result in cumulative impacts to biological resources, mainly through the loss of some habitat for foraging and roosting migratory sea and shorebirds. Habitat enhancement projects on Eniwetak would continue in order to offset this loss. If SpaceX later decides to no longer use Omelek for the Falcon Program, they would return the islet to its current condition (to the extent practicable) in coordination with USAKA/RTS. This action could include removal of some or all of the new roads and paved areas, removal of some or all of any new facilities, and re-foresting selected areas with regional vegetation that would provide nesting, roosting, and resting habitat for seabirds. It is unlikely that the Proposed Action in conjunction with currently planned activities at USAKA/RTS would result in cumulative impacts to the island's biological resources from emissions, noise, or other effects arising from program actions. The Proposed Action activities would not occur at the same time as other regional programs such as Ground-Based Midcourse Defense or Minuteman III. No other activities on Omelek are anticipated which, when combined with proposed SpaceX activities, would result in cumulative impacts. Personnel would be instructed on the avoidance of sensitive habitat and species. Missile launches are short-term, discrete events. No significant cumulative impacts to biological resources have been identified as a result of prior or current launch-related activities in the region of influence.

4.1.4 CULTURAL RESOURCES

Ground-disturbing activities at Omelek would be planned so that archaeologically sensitive areas such as those areas in the northern portion of the islet that contain old broadleaf forest would be avoided to the extent possible. If the proposed facilities cannot be located to avoid these areas, archaeological monitoring with systematic sampling as necessary would accompany construction of any facilities.

4.1.4.1 Site Preparation Activities

4.1.4.1.1 Omelek

Clearance for the proposed launch pad and associated infrastructure would be primarily placed in areas of grass and forb vegetation, which are currently maintained at a low level by mowing or other mechanical control and, as such, are already significantly disturbed. All of the buildings and structures on Omelek prior to SpaceX activity were constructed between 1962 and 1990 and have been recently determined not to be eligible for listing. (Kwajalein Range Services, 2007; U.S. Army Kwajalein Atoll, 2006; U.S. Army Space and Missile Defense Command, 2004) The layout of buildings and infrastructure would avoid known culturally sensitive areas. To minimize disturbance to cultural resources, appropriate measures would be taken, such as installing signage to designate sensitive areas and educating facility personnel on protecting sensitive island resources.

4.1.4.1.2 Kwajalein

The two new facilities that may be constructed on Kwajalein as part of Phase 2 would be constructed on the man-made northwestern portion of Kwajalein and thus would pose no threat to sub-surface archaeological resources.

4.1.4.1.3 Meck

An existing storage facility on Meck would be used and thus would pose no threat to sub-surface archaeological resources.

4.1.4.2 Operational Activities

4.1.4.2.1 Omelek

Personnel involved in launch and other operational activities would follow UES requirements in handling or avoiding any cultural resources uncovered during operational or monitoring activities. Impacts to cultural resources from routine operational activities would thus be avoided.

4.1.4.2.2 Kwajalein/Meck

Falcon launch program activities on Kwajalein and Meck would be related to launch control and oversight, which are not expected to impact any cultural resources.

4.1.4.3 Post Flight Activities

4.1.4.3.1 Omelek

Post flight clean-up and evacuation procedures would be handled so as to avoid removal, destruction, or damage to cultural resources.

4.1.4.3.2 Kwajalein/Meck

Falcon post-launch activities on Kwajalein and Meck would be related to oversight and storage of hazardous materials, which are not expected to impact any cultural resources.

4.1.4.4 Cumulative Impacts

No cumulative affects to cultural resources have been identified due to prior launch activities. No other activities on Omelek have been identified. Overall avoidance would minimize the potential for cumulative impacts concerning cultural resources. Personnel would be instructed of the sensitivity of cultural resources and to avoid any impacts to these resources. Also, ongoing consultation with the RMI Historic Preservation Officer through the USAKA/RTS Environmental Office would continue.

4.1.5 GEOLOGY AND SOILS

This section addresses potential impacts to geology and soils that could result from proposed activities. Since the geology and soils of the USAKA islands are similar, this resource is addressed as one location.

4.1.5.1 Site Preparation Activities

Site preparation activities and other necessary prelaunch activities are not expected to result in any adverse geological or soil impacts. Although site preparation activities would subject soils to wind, possible erosion would be minimal due to the short duration and limited to the immediate vicinity of the construction site. Proposed construction activities would be performed in accordance with the USAKA Stormwater Pollution Prevention Plan to minimize potential erosion and stormwater runoff. Best Management Practices, such as regular watering of excavated material as required, would furthermore reduce the potential for soil erosion. Shoreline reinforcement in some areas around Omelek would occur during Phase 2, although reinforcement of select areas may also occur in Phase 1. The areas that need reinforcement are shown in Figure 2-13. Reinforcement would be accomplished by placing large rocks and debris per standard practice, which would slow the dramatic shoreline erosion observed in areas along Omelek.

4.1.5.2 Operational Activities

Since the Falcon launch vehicles use LOX and kerosene propellants, the emission products (carbon monoxide, carbon dioxide, hydrogen, and water) lack hazardous materials and would consist primarily of steam. Thus, no impacts to geology and soils would occur as a result of launch emissions.

Potential soil contamination could occur in the event of an accidental fuel spill or premature flight termination that resulted in burning/unburned fuel coming in contact with soils. However, in the unlikely event of an accidental release of kerosene, emergency response personnel would comply with the UES, emergency response plan prepared by SpaceX, and the KEEP. Following these safety regulations and requirements would minimize the potential for accidental spills, as well as provide the means for mitigating or minimizing effects to soils and disposal of the recovered fuel if an accident were to occur. Therefore, the risk of accidental fuel spills during flight test activities would be considered temporary in duration.

4.1.5.3 Post Flight Activities

Post flight activities would include the usage of fresh water to douse fires and/or for initial cleanup on the pad. Fresh water would also be used to rinse the pad and launch stand prior to securing for storage. Any contaminated soil would be removed from Omelek by SpaceX and disposed of in accordance with USAKA/RTS regulations and the UES. Minimal soil compaction as a result of the removal of all mobile equipment/assets is anticipated.

4.1.5.4 Cumulative Impacts

Preparation of the launch site and adherence to established hazardous waste and spill prevention procedures and regulations minimize the potential for any impacts to the soils. No other activities on USAKA that could affect geology and soils of Omelek have been identified. Shoreline reinforcement would slow the dramatic shoreline erosion observed in areas along Omelek.

4.1.6 HAZARDOUS MATERIALS AND WASTE

This section addresses potential impacts that could result from the proposed storage and use of hazardous materials and the generation and disposal of hazardous waste associated with Falcon 1 and Falcon 9 launch operations from Omelek.

4.1.6.1 Site Preparation Activities

All hazardous materials used and waste generated during site preparation activities would be handled, transported, stored, treated, and disposed of off-site in accordance with a Hazardous Materials Contingency Plan and Hazardous Waste Management Plan to be prepared by SpaceX. These plans would follow regulations established in the UES and would follow the KEEP.

Construction activities associated with the Proposed Action would be centralized to the greatest extent possible at the selected project site and on specific construction laydown areas. Hazardous materials and waste management would be performed in accordance with ongoing USAKA/RTS procedures. All construction activities would follow the USAKA spill control plan.

Proposed construction activities are anticipated to use small quantities of hazardous materials, which would result in the generation of some hazardous and nonhazardous wastes. The hazardous materials that are anticipated to be used are common to construction activities and could include diesel fuel, anti-freeze, hydraulic fluid, lubricating oils, welding gases, and small amounts of paints, thinners, and adhesives. Hazardous materials management techniques would be used during the construction period to minimize (1) the amount of hazardous materials stored, (2) the threat of their accidental and unplanned release into the environment, and (3) the quantity of hazardous waste generated.

Falcon 1 and Falcon 9 missile components would be brought to Kwajalein as the initial arrival point at USAKA/RTS. Kwajalein and Meck would serve as the supply point for consumable materials to be employed during vehicle preflight assembly and check out operations. Some of the materials to be employed during vehicle preflight assembly are considered to be hazardous materials (e.g., cleaning solvents, motor fuels, and household pesticides). These materials would be stored on Kwajalein in appropriate warehouse facilities before issuance for use on Omelek. These materials are similar to hazardous materials already in use on Omelek for current SpaceX operations and represent only a small increase in the total amount of materials to be handled. The quantity of these materials that would be used represents a *de minimis* increase above those already in use and could, therefore, easily be accommodated by the current hazardous materials management systems.

Falcon 1 and Falcon 9 launch vehicles would arrive in two fully assembled stages at USAKA. Depending on the landing craft schedules, the vehicles would be transferred to Omelek or would be stored in an existing physically secured area on Kwajalein. The stages would be inspected, assembled, tested, and moved to the launch site. Both vehicles would be fueled on the pad, and kerosene and LOX would be loaded the day of the launch. The goal is to launch within 1 month of payload arrival at the launch site. Payload preparation activities would be conducted in parallel with most launch vehicle preparation activities. Payload activities include payload checkout, spacecraft propellant loading, and payload encapsulation in the fairing. Sections 2.1.1 and 2.1.2 detail the proposed propellants for the Falcon 1 and Falcon 9.

Hazardous materials used with payloads would be handled according to the UES and other applicable safety standards. The Falcon 1 would carry small payloads, consisting mostly of non-hazardous materials. Some payloads may use small amounts of liquid or solid propellants for on-orbit maneuvering. Falcon 9 payloads would almost always include some additional propellants on board, for either orbit maintenance or orbital insertion burns. The propellants would be used only after the payload separates from the Falcon launch vehicle. Propellants for payloads of both vehicles may include UDMH, MMH, NTO, pressurized gasses including helium and nitrogen, and some solid propellants such as ammonium perchlorate. Details of the proposed hypergolic fuels are provided in Section 2.1.3.1. A trained immediate response spill team would be established onsite and spills would be contained and cleaned up according to the procedures identified in the KEEP and a SpaceX-specific emergency plan. USAKA will ensure compliance.

In accordance with DoD Regulation 5200.2R, *Personal Security Program Regulation* and requirements of the UES, SpaceX personnel would perform pollution prevention, waste minimization, and recycling measures where applicable. Proposed construction activities would be performed in accordance with the USAKA Stormwater Pollution Prevention Plan to minimize potential erosion and stormwater runoff.

4.1.6.2 Operational Activities

Hazardous Materials Management

The use of hazardous materials during Falcon 1 and Falcon 9 launch operations would be limited to small amounts of solvent cleaners (e.g., acetone, isopropyl alcohol), and some handling and storage of motor vehicle and/or generator systems. These types of hazardous materials are similar to hazardous materials already in use at USAKA/RTS and would result in only a minor increase over current amounts. Use and management of hazardous materials associated with missile launch activities would continue to be performed in accordance with the requirements of the UES and the USAKA/RTS Range safety office. Personnel trained in the appropriate procedures to handle potentially hazardous materials would be on standby.

During normal flight operations there would be no hazardous materials issues associated with flight corridors. If an in-flight malfunction occurs, the range officers may initiate flight termination, resulting in missile debris being deposited beneath the flight path. The potential effects on the ocean environment from hazardous materials associated with missile debris are discussed in Section 4.2.3, Health and Safety – Open Ocean, and have been analyzed in previous NEPA documents, with the conclusion that impacts would be minimal.

Hazardous Waste Management

Hazardous waste management at USAKA/RTS is performed in accordance with the UES, which requires shipment of hazardous waste back to the continental United States for treatment and/or disposal. Personnel trained in the appropriate procedures to handle potentially hazardous waste, including spill containment and cleanup, would be on standby should a mishap occur. Such personnel involved in these operations would wear appropriate protective clothing, as necessary.

The types of hazardous wastes that would potentially be generated from Falcon 1 and Falcon 9 launches are similar to wastes already handled at USAKA/RTS. The quantity of hazardous waste that may be generated would represent a small increase over current conditions and would be collected in accordance with the UES. If the deluge water is determined to be hazardous waste, it would be containerized and removed from the islet.

SpaceX would assemble a PHT that would be responsible for responding to hazards and spills for all Falcon program propellants, including both launch vehicle propellants, such as LOX and kerosene, as well as payload related propellant, such as NTO and MMH. Emergency preparedness and response activities would be conducted according to the procedures identified in the KEEP and a SpaceX specific emergency plan. This team would be staffed and trained according to USAKA/RTS safety standards, and would include an incident commander, response technicians, hypergolic product expert, and decontamination team lead. The team would be equipped with personal protective equipment and remediation equipment and supplies relevant to the hazard, including cryogenic gloves for handling LOX, Self-Contained Atmospheric Protective Ensemble (SCAPE) equipment and leak detection instruments for hypergolic fluid spills, containers, shovels, and absorbent materials. The team would receive refresher training annually and must complete one training exercise every 6 months.

LOX and LN2 spills would be allowed to dissipate naturally because they are not toxic to the environment. Kerosene and diesel fuel spills, however, would be contained in concrete containment areas or temporarily bermed using portable rubber berm material, and cleaned up using suitable absorbent materials. Hypergolics and other toxic materials would be diluted using approved fluids and cleaned up using approved procedures. All hazardous spill materials would be loaded in drums and labeled appropriately per UES requirements. All hazardous waste would be disposed of in accordance with the UES in coordination with USAKA/RTS.

The transportation and storage of hypergolic payload fuels would be conducted in accordance with USAKA safety requirements and applicable safety regulations. These fuels would be stored in certified facilities with leak detection sensors and specially-designed ventilation systems.

4.1.6.3 Post Flight Activities

Post flight activities would include restoration actions and debris recovery, if necessary, on a case-by-case basis and would be in coordination with the procedures of the Facility Services Division of Hazardous Materials. SpaceX back-out personnel would assess the islet and use fresh water to douse fires if necessary. After each launch, the remaining deluge water is either containerized and disposed of according to UES requirements, or allowed to evaporate within the pad containment if test results indicate the water is not hazardous. The deluge water for the first Falcon 1 Proof-of-Principle launch was analyzed for contaminants; the results of all detected analytes are provided in Table 2-3. The only analyte that exceeded the UES Standards for Groundwater Quality was pH. The deluge water from the first Falcon 9 launch would be similarly analyzed to establish a baseline for proper disposition. The drainage system would remain open to allow rainwater to drain from the launch pad after the remaining deluge water is removed or evaporates.

All hazardous and non-hazardous waste from launch operations on Omelek would be disposed of in accordance with USAKA/RTS regulations and the UES. Equipment would be moved into the storage hangar or protected and left in place. Facilities at Omelek would be cleaned and prepared for storage within approximately 7 days after launch. After each mission, environmental monitors would walk around the islet to look for any observable effects of the launch to sensitive species and resources. Observable effects would be reported to applicable agencies through USAKA/RTS as required.

4.1.6.4 Cumulative Impacts

Adherence to the hazardous materials and waste management systems of USAKA/RTS would preclude the potential accumulation of hazardous materials or waste. The UES establishes emergency response procedures that would aid in the evaluation and cleanup of any hazardous materials released. SpaceX would have a trained immediate response spill team onsite; in addition, USAKA would ensure compliance of the response to all hazardous spills. Falcon 1 and Falcon 9 program actions are not expected to result in cumulative hazardous materials and hazardous waste impacts on USAKA/RTS. The Proposed Action activities would not occur at the same time as other regional programs. No other projects in the ROI have been identified that would have the potential for incremental, additive cumulative impacts to existing hazardous materials and waste management practices.

4.1.7 HEALTH AND SAFETY

An impact would be considered if it involved materials or operations that posed a potential public or occupational health hazard. The Proposed Action is not expected to substantially increase health and safety risk to either USAKA/RTS or SpaceX personnel or members of the public.

4.1.7.1 Site Preparation Activities

Proposed construction activities for the Falcon 1 and Falcon 9 Launch Vehicle Program would comply with all applicable UES and USAKA/RTS Range Safety Requirements. Missile components would initially be transported to Kwajalein. Kwajalein and Meck would also be used as the storage location for all consumable materials (e.g., solvents/cleaners, small parts, tools) that would be used during test flight pre-launch and launch operations. The primary hazard related to these storage operations would be the potential for explosion/fire of liquid fuel boosters and/or small explosive actuation devices (used in missile control and the Flight Termination System). At Kwajalein and Meck, as at all other USAKA/RTS locations, all operations involving explosives (including packaging and handling for movement) would require implementation of a written procedure, which has been approved by the USAKA/RTS Safety Office. These operations must be conducted under the supervision of an approved ordnance officer using explosive-certified personnel. All storage and handling of explosives is required to take place in facilities designed to handle explosives and which have been cited in accordance with the requirements of Kwajalein Missile Range Regulation 385-75, *Explosive Safety*. The regulation specifies the required explosive safety quantity-distances for each facility to ensure safety in the event of explosion, based upon the maximum quantity of explosive material permitted for the facility. This would serve to prevent propagation of explosions to nearby facilities where explosives are also stored.

The explosive devices and materials proposed for use as part of the Falcon 1 and Falcon 9 flight tests would be very similar to those currently stored and used at USAKA/RTS. The total weight of explosive ordnance on the Falcon vehicle is less than 20 grams (0.7 ounce). Storage operations would not entail any specialized procedures beyond those already in use. Storage facilities (magazines) are available at Kwajalein for proper storage of all explosive materials. Missile assembly buildings, launch pads, and operations buildings would be separated by distances specified in DoD and U.S. Army regulations. The types of facilities, as well as the quantity and type of propellant and other explosives stored, are used to determine the distance requirements for structure spacing.

The LOX and fuels must be isolated from each other and from the loaded Falcon launch vehicles. Figure 2-5 shows that a preliminary radius of 117 meters (385 feet) must be maintained around the LOX storage area, and a preliminary radius of 55 meters (180 feet) must be maintained around the kerosene storage area (Figure 2-5). Figure 2-6 depicts the preliminary explosive safety quantity-distance for the Falcon 9 launch vehicle, which represents the personnel exclusion zone during launches. A preliminary radius of 565 meters (1,855 feet) must be maintained around the Falcon 9 launch pad during launches (Figure 2-6).

The Marshallese individuals who have written permission from USAKA to stay temporarily on Omelek while fishing from the adjacent islet of Gellinam would be asked by the USAKA/RTS Commander to evacuate the launch hazard area once the Falcon missile has been brought to the islet. Islets of the atoll and access to the mid-Atoll corridor are routinely closed during launch events. Once the launch has been accomplished and the associated facilities secured, the Marshallese can resume their temporary habitation.

4.1.7.2 Operational Activities

Operation of the Falcon 1 and Falcon 9 Launch Vehicle Program would comply with all UES and USAKA/RTS Range Safety Requirements. Flight safety studies would be performed to ensure that launches would not compromise range safety requirements and that risk to personnel would be within RCC Standard 321 limits. Launches would not be permitted to occur without review and agreement by the Range Safety Officer. Protection circles, based on the payload, missile and launch azimuth, would be established for each launch. Access to Omelek would be limited to all but mission essential persons. Personnel would be evacuated from the islet prior to launch. The flight corridor would be over the islets and open ocean. At USAKA/RTS, thrusted stages that can potentially hazard populated areas must have a flight termination system.

The Omelek launch site can accommodate safe trajectories for almost any orbital inclination. Orbital inclination is the angle between the earth's geographical equatorial plane and the satellite's orbital plane. It basically describes how far north and south of the equator the satellite would go during its orbit. Figure 2-4 shows potential launch azimuths characterized by the flight safety approach taken to ensure public safety.

Launch azimuths within the areas labeled "Containment" would be planned so that missiles would not fly over populated islets. Missile trajectories would be designed so that if the missile malfunctions during the flight it would be destroyed and no debris from the missile would fall over a populated islet.

The sectors labeled "Risk Based" on Figure 2-4 represent launch azimuths in which it is difficult to design launch trajectories to avoid overflight of a populated islet. Within this sector, USAKA/RTS would require the launch customer to develop trajectories that minimize overflight of populated islets. Additionally, USAKA/RTS would perform a risk analysis based upon the trajectory; assess potential missile failure modes and the probabilities of these failures; and determine the population density of islets near the trajectory. Using this data, an analysis to determine the expected level of public risk associated with the mission would be performed. This risk estimate would be compared to acceptable risk criteria defined in RCC Standard 321-02, *Common Risk Criteria for National Test Ranges*. USAKA/RTS would allow the mission to proceed if the calculated mission risk is less than RCC-321 criteria. If the calculated mission risk is higher than the standard, then that mission trajectory would not be allowed.

The sector labeled "Not Allowed" on Figure 2-4 cannot be used for launch azimuths unless specifically approved by a range safety waiver. Waivers are granted only by the USASMDC National Range Commander, or his/her designated representative, and are granted only if mission objectives are considered sufficiently important; if the objective cannot be otherwise met; and if, in his/her judgment, the risk involved is reasonable and acceptable.

Both the Falcon 1 and Falcon 9 flight vehicles allow recovery of the spent first stage by use of a parachute attached to the front end of the first stage. The location of the stage's ocean impact would vary with each mission (two *representative* locations for a Falcon 1 mission are shown in Tables 2-1 and 2-2). A salvage ship would locate the floating first stage by pinpointing the transponder or light beacon that would signal the location. Approximately 30.3 liters (8 gallons) of LOX and 19 liters (5 gallons) of kerosene could remain in the expended first stage of Falcon 1, and approximately 303 liters (80 gallons) of LOX and 190 liters (50 gallons) of kerosene could remain on Falcon 9. The first stage would be recovered by USAKA/RTS or commercial recovery personnel and returned to Kwajalein. Residual kerosene would remain on-board until the vehicle arrives at the refurbishment facility. Residual LOX would generally boil-off before recovery operations begin, vaporizing before arriving at Kwajalein. SpaceX would transport the recovered booster to their facilities in El Segundo, California, for reconditioning and reuse.

In addition to standard payloads, the Falcon 9 vehicle may also carry a capsule (Dragon) as a payload that is being developed to deliver cargo to the ISS under contract with NASA. Prior to launch, the Dragon would be processed similarly to any other payload. After completion of its mission to deliver cargo to the ISS, the Dragon will re-enter the atmosphere on a pre-planned trajectory, soft-land in the ocean, and be recovered by a recovery vessel similar to the Falcon 9 first stage. All materials brought down from the station will be delivered to NASA unless directed otherwise. Recovery zones are currently being planned; however, locations in the Gulf of Mexico, the coast of California, and the Kwajalein Atoll are being considered.

The second stage would enter orbit with the payload. The second stage of Falcon 1 would eventually reenter the atmosphere, burning up on reentry; it is unlikely that debris would reach the earth. The Falcon 9 second stage could be recovered if so designed. In this event, the stage would reenter the atmosphere upon a pre-programmed trajectory and would impact a predetermined position. Recovery of the second stage would be similar to recovery of the first stage.

A catastrophic failure of the Falcon 9 on the launch pad represents the worst case scenario. Should this occur, a number of possible outcomes could result, the most likely being a fire on the launch pad. A water fire extinguishing system designed to manage vehicle engine fires would be used. An explosion on the launch pad would likely spread debris across Omelek Islet. Damage to facilities and vegetation across the islet would likely result if an explosion occurred on the pad. In the event of an in-flight anomaly, the vehicle would either break-up in flight or fall into the water intact. In the worst case scenario, the vehicle would land on the reef.

Use of existing sensors would continue in accordance with ongoing activities at USAKA/RTS. For communication link equipment, associated radiofrequency (RF) emissions are considered to be of sufficiently low power so that there is no exposure hazard. The hazards associated with the use of tracking radars at USAKA/RTS were considered in the USAKA EIS (U.S. Army Space and Strategic Defense Command, 1993). The analysis considered potential program operational requirements and restrictions and USAKA-required safety procedures. It concluded that the required implementation of all operational safety procedures would preclude any potential for adverse worker or public exposure to RF radiation. Operation of these systems would not present a significant health and safety hazard.

In situations where Omelek must be evacuated, SpaceX will ensure that private marine transport capable of evacuating all personnel on islet will be available for use. Personnel will turn off master power and move to Meck, where further instructions may be provided. Some emergency lighting will be provided around the dock area to facilitate an evacuation at night.

4.1.7.3 Post Flight Activities

The back-out crew (the same crew that completes the on-Omelek tasks 4 hours prior to launch) would be located at Meck for mission abort operations and post-flight operations. This crew would arrive and depart Meck by boat and would communicate with the launch organization at Meck. After launch and approval by ground safety, the crew would approach Omelek and begin post-launch procedures. Equipment would be moved into the storage hangar or protected and left in place. No impacts to personnel or public health and safety are anticipated.

4.1.7.4 Cumulative Impacts

USAKA/RTS is a restricted access area dedicated to research, test, and training military activities. Safety standards are high at USAKA/RTS and would serve to keep any cumulative safety impacts attributable to all USAKA/RTS operations within acceptable standards to both workers and the public. The Proposed Action activities would not occur at the same time as other regional programs such as Ground-Based Midcourse Defense or Minuteman III. No other projects in the ROI have been identified that would have the potential for incremental, additive cumulative impacts to health and safety.

4.1.8 INFRASTRUCTURE

This section discusses the potential environmental consequences of the proposed actions on the infrastructure of Omelek, Kwajalein, and Meck.

4.1.8.1 Site Preparation Activities

4.1.8.1.1 Omelek

Transportation—Construction

New facilities and upgrades are proposed for Omelek under Phase 1 (Helipad) and Phase 2 (Paved Path Area, Harbor Modification):

The new helipad would allow access to Omelek by helicopter for emergency use and for occasional transportation to and from the island. Relocating the helipad to the southeast side would reduce the potential of impacting the approach and departure path when other new facilities are added.

The unimproved paths used to access the island would be paved to provide safe, reliable transportation routes. Roads would generally measure 6 meters (20 feet) wide and would support the weight of the Falcon 9 vehicle. Some areas of general paving would be constructed to provide adequate turning radii for large vehicle transporters and parking locations for island motor vehicles. Road design would also include an evaluation of rainwater drainage on Omelek, and rainwater control channels or conduit would be installed during paving construction.

Harbor modifications are also planned for Phase 2. To facilitate access to Omelek by cargo barges in addition to the currently used landing craft vessels, a series of pilings would be installed on the south side of the harbor.

Utilities

Power and communications are already distributed to key areas on Omelek via existing underground conduit. New facilities and upgrades are proposed for Omelek under Phase 1 and Phase 2 construction. Power, communications, water, and sewage would be routed through new underground conduits to and from the facilities. The new storage area located to the east on Omelek would store kerosene and diesel fuel in aboveground tanks or standardized containers, located within a concrete containment area. The storage and containment area could store enough fuel for at least three Falcon 9 launches (up to 378,541 liters [100,000 gallons]). Water from the reverse osmosis system would be stored in this area; however, it would not be located within the containment area.

Water

All new facilities and upgrades on Omelek would be routed through new underground water conduits. Water from the proposed new osmosis system would be stored in the proposed new Kerosene Propellant, Diesel Fluid, and Water Storage Area. In Phase 2, a reverse osmosis unit would be installed to generate approximately 11,356 liters (3,000 gallons) of water per day to support the deluge system and other non-potable uses. Other water uses including rinsing, washing, bathing, laundry, and cooking are prohibited. If at a later date the system is to be used for potable water applications, it would have to meet requirements of the UES, such as chlorination and monitoring. A DEP would also have to be developed and approved prior to any potable use of the water from the reverse osmosis unit.

Wastewater Treatment

Sewage from all new facilities and upgrades on Omelek would flow through new underground conduits. The toilets in the new facilities would be connected to the existing septic/leach system located on the southern end of the island.

Road design would also include an evaluation of rainwater drainage on Omelek, and rainwater control channels or conduit would be installed during paving construction. Rainwater run-off from paved areas on Omelek could be managed by allowing rainwater to collect in some low areas and diverting run-off via culverts to vegetated areas or to the harbor. SpaceX would like to use a combination of approaches: (1) allow run-off to drain naturally along the access road to the north and along the paved roads to the east towards vegetated areas and (2) construct surface or underground culverts to divert water from the central and southern portions of the island to the harbor.

Solid Waste

Concrete debris from removed buildings would be used for shoreline reinforcement if deemed suitable by the USAKA Environmental Management Officer. Otherwise, small concrete debris would be used as fill in construction areas that require it. Remaining debris would be removed from Omelek and placed in the Kwajalein waste management areas. Additionally, construction solid waste generated as a result of the proposed action would be managed in accordance with the UES Sections 3-6.5.5 through 3-6.5.7.

Electricity

Power and communications are already distributed to key areas on Omelek via existing underground conduits. Additional trenching would be required in several areas to extend these services to the new facilities (Figure 2-12). During and after Phase 1 construction activities, island power would be supplied by portable generators located near the existing generator facility. One 400-kW generator would be used to support construction operations and launch operations.

Until Phase 1 construction is complete, the 400-kW generator is expected to provide site power 60 percent of the time. Under Phase 2 construction, two 1,000-kVA generators would supply power on the island during launch activities. Power would be transported to the various areas either through existing or newly constructed conduits below ground, or via temporary above-ground cable trays.

SpaceX is considering the addition of a wind-based power generator for use between missions when power needs are reduced. The wind generator would likely be two commercial grade 50- to 100-kW generators. The system has yet to be designed or sized beyond the stated generation requirement. When implemented, the wind turbine would be mounted on the far eastern spur of the island near the generator building.

4.1.8.1.2 Kwajalein

There are two facilities that may be constructed on Kwajalein during Phase 2. The first would be a LOX production plant that would supply LOX for launches on Omelek. Additionally, this plant would store LOX on Kwajalein during production. If implemented, this plant would produce up to 6.4 metric tons (7 tons) per day when active and store up to 37,854 liters (10,000 gallons) on Kwajalein during production. An area of approximately 232 square meters (2,500 square feet) is needed to construct the facility, which most likely would be sited on the western, industrial side of Kwajalein. Tentatively, the facility would be located at Building 1500 in the existing LN2 facility.

The second facility is a Payload Processing Facility to supplement or replace the facility in the hangar on Omelek. Approximately 2,322.5 square meters (25,000 square feet) is needed to construct this facility (Figure 2-15). USAKA planning has two tentative locations for this facility on Kwajalein, shown in Figure 2-16. These locations would also serve as alternative locations for the LOX production plant. In addition to normal processing activities, fueling of payloads would also occur in this facility; as such, hazardous materials would be present for short periods (up to 2 weeks). These materials would be stored in an approved facility on Meck Island when not in use. The processing facility would be equipped with special HVAC systems with scrubbers that would reduce or eliminate the potential for toxic emissions in the event of a spill. Additionally, construction solid waste generated as a result of the proposed action would be managed in accordance with the UES Sections 3-6.5.5 through 3-6.5.7.

4.1.8.1.3 Meck

There are no proposed site preparation requirements for Meck. Meck is currently an approved site to support launcher and generator operations.

4.1.8.2 Operational Activities

4.1.8.2.1 Omelek

Transportation

Both vehicles (Falcon 1 and Falcon 9) would arrive at USAKA in two stages, each fully assembled. Depending on the landing craft schedules, the vehicles would be transferred to Omelek or Kwajalein. The stages would be inspected, assembled, tested, and moved to the launch site. The Falcon 1 launch vehicle arrives at USAKA via government or commercial cargo carries and would be transferred to Omelek using a landing craft. Falcon 9 pre-launch activities would be very similar to those of Falcon 1. Once the Falcon 9 stages arrive separately via landing craft or barge, they would be placed in the Falcon 9 processing hangar on Omelek. Additionally, prior to their use, propellants would be stored in a certified facility on Meck, and transported to Omelek for fueling the payload. Residual propellants would be returned to the Meck storage facility.

The kerosene would be delivered in 22,712-liter (6,000-gallon) tanker trailers that would be transported by barge to Omelek and either offloaded at the dock to the storage area through a pipeline (Figure 2-12) or moved from the barge to the storage area and offloaded there. Additionally, a payload in the form of a capsule is being developed to deliver cargo to the International Space Station under contract with NASA. Transportation logistics for the capsule will be addressed after development has been completed.

A salvage ship would locate the floating first stage by pinpointing the transponder or light beacon that would signal the location. The first stage would be recovered by USAKA/RTS or commercial recovery personnel and returned to Kwajalein. SpaceX would transport the recovered booster to their facilities in El Segundo, California, for reconditioning and reuse. The Falcon 9 second stage could be recovered if so designed. Recovery of the second stage would be similar to recovery of the first stage.

Utilities

Power and communications are already distributed to key areas on Omelek via existing underground conduit. Power, communications, water, and sewage would be routed through new underground conduits to and from the facilities. The new storage area located to the east on Omelek would store kerosene and diesel fuel in aboveground tanks or standardized containers, located within a concrete containment area. The storage and containment area could store enough fuel for at least three Falcon 9 launches (up to 378,541 liters, or 100,000 gallons). Water from the reverse osmosis system would be stored in this area; however, it would not be located within the containment area.

Water

Water from the proposed new reverse osmosis system would generate approximately 11,356 liters (3,000 gallons) of water per day to support the deluge system would be stored in the proposed new Kerosene Propellant, Diesel Fluid, and Water Storage Area. The reverse osmosis system will be used for industrial water applications only, unless its use as a source of potable water meets requirements of the UES, such as chlorination and monitoring, and is approved by USAKA.

After each launch, the remaining deluge water is either containerized and disposed of according to UES requirements, or allowed to evaporate within the pad containment if test results indicate the water is not hazardous. The drainage system would remain open to allow rainwater to drain from the launch pad after the remaining deluge water is removed or evaporates. The deluge water could be allowed to drain from the launch pad if no hazardous materials are identified. Additionally, SpaceX back-out personnel would assess the island and use fresh water to douse fires if necessary.

Wastewater Treatment

Wastewater treatment would be the same as that discussed in Section 4.1.8.1.1.

Solid Waste

Solid waste would be removed from Omelek and placed in the Kwajalein waste management areas.

Electricity

On launch day during Phase 1, two 400-kW generators would be active, with an automatic transfer switch system that would transition island power from one generator to the other in the event of a problem. During non-construction periods and between launch operations, Omelek would be placed in a caretaker mode and powered by a small 50-kW portable generator. Until Phase 1 construction is complete, the 400-kW generator is expected to provide site power 60 percent of the time. Under Phase 2, two 1,000-kVA generators would supply power on the island during launch activities. Power would be transported to the various areas either through existing or newly constructed conduits below ground, or via temporary above-ground cable trays. A smaller 100-kVA generator would be used during sustainment periods, 3 to 8 months per year, when no launches would occur.

4.1.8.3 Post Flight Activities

Under Phase 1, a Kerosene Propellant, Diesel Fluid, and Water Storage Area and a LOX, Helium and Nitrogen Storage Area are proposed for Omelek and under Phase 2 a storage facility is proposed for the indoor storage of motor vehicles, and launch site spares and equipment. This storage facility would store launch site spares and equipment, as well as provide an indoor storage location for motor vehicles on Omelek, which would significantly reduce corrosion problems. Power and communications would be routed to this new facility via new underground conduit in a trench that follows the new access road to this location, as shown in Figure 2-12.

4.1.8.4 Cumulative Impacts

No cumulative impacts are predicted as a result of Proposed Actions on Omelek. Sufficient infrastructure would be available and capable of supporting the 30 transient personnel associated with launch activities as well as construction/upgrades and launch activities proposed for Omelek. Power, communications, water, and sewage would be routed through new underground conduits to and from the facilities. Solid waste would be recycled for use on the island or transport to Kwajalein for disposal. Phase 1 and 2 construction would include generator facility with ample power to support proposed launch activities for both Falcon 1 and Falcon 9. The water generated through the reverse osmosis system would be used for industrial applications only, unless approved by USAKA as a potable source in accordance with the UES. Human consumption of the water generated through the reverse osmosis system for drinking water, rinsing, washing, bathing, laundry, and cooking is prohibited.

No adverse impacts to waterway transportation (landing craft/barge/etc.) are expected due to the transport of propellants to and from Meck. The demand on electrical, wastewater, solid waste and water systems to support the storage facility is expected to be within the current capacity of utility systems on Kwajalein and Meck.

4.1.9 LAND USE

SpaceX would continue to use many of the existing facilities as authorized in the Proof-of-Principle Space Launches from Omelek Island EA. Additionally, SpaceX proposes to construct several new facilities, relocate select facilities, and improve the general infrastructure to support Falcon 1 and Falcon 9 launch vehicle operations. The facility and infrastructure improvements would occur in two construction phases. Additionally, storage requirements are associated with the proposed activities. This section discusses how the Proposed Actions would affect land use on Omelek, Kwajalein, and Meck.

4.1.9.1 Site Preparation Activities

4.1.9.1.1 Omelek

As part of Phase 1 new construction/upgrades are proposed to support and sustain launch activities. Table 4-5 summarizes proposed Phase 1 construction/upgrades. Omelek would remain under U.S. Army management and would continue to be used for missile research. The Proposed Action is consistent with the mission of the island and would not conflict with any known land use plans, policies, or controls.

Replacement of Existing Trailer

The existing trailer used as offices for the Falcon 1 Proof-of-Principle launches would be moved as part of Phase 1 construction to accommodate the Falcon 9 hangar and the new LOX storage facility. The trailer would be moved to the west of the Falcon 1 Hangar, as shown in Figure 2-8.

Helipad

The helipad would be moved to the southeast side of the islet; it would allow access to Omelek by helicopter for emergency use and for occasional transportation to and from the island. Relocating the helipad to the southeast side reduces the potential of impacting the approach and departure path when other new facilities are added. The helipad would be constructed with concrete or asphalt under Phase 1; lights would be added to enable nighttime access for helicopters under Phase 2.

As part of Phase 2 new construction/upgrades are proposed to support and sustain launch activities. Table 4-6 summarizes proposed Phase 2 construction/upgrades.

Wind-based Power Generator

SpaceX is considering the addition of a wind-based power generator for use between missions when power needs are reduced. The wind generator would likely be two commercial grade 50- to 100-kW generators. The system has yet to be designed or sized beyond the stated generation requirement. When implemented, the wind turbine would be mounted on the far eastern spur of the island near the generator building.

Table 4-5. Phase 1 Construction/Upgrades on Omelek Islet

New Construction/Upgrades*	Description
Falcon 9 Hangar - Launch Vehicle Processing Hangar (Figure 2-11)	• Located on southern tip of islet • Will measure 73 meters (290 feet) long
LOX, Helium, and Nitrogen Storage Area (Figure 2-13)	• Concrete pad at least 12x18 meters (40x60 feet) • Will support up to 8 vertical storage tanks
Replacement of Existing Trailer (Figure 2-8)	• Relocate to the West of Falcon 1 hangar • Will not exceed 12x40 meters (39x131 feet) • Will accommodate increased number of personnel expected on Omelek
Helipad	• Moved to southeast side of islet • Allows emergency access to Omelek by helicopter
Falcon 9 Launch Pad and Stand with Runway (Figure 2-10)	• Pad would include an elevated stand or platform • Stand would measure ≈6x6 meters (20x20 feet) • Concrete runway 61x6 meters (200x20 feet)
Kerosene Propellant, Diesel Fluid and Water Storage Area (Figure 2-12)	• The storage and containment area would store enough fuel for at least three Falcon 9 launches
New Propellant Line Path (Figure 2-13)	• Lines would route LOX, helium, and nitrogen to both launch pads via over-ground lines • Short runs in surface level trenches would be constructed in areas that receive traffic
Vegetation Removal	• See Section 4.1.3 - Biological Resources
Trenching for Water, Communication, and Power Lines (Figure 2-12)	• Additional trenching would be required in several areas to extend these services to the new facilities

* All construction and launch activities of the Falcon 1 and 9 launch programs would comply with the UES and the USAKA/RTS Range Safety Requirements.

Table 4-6. Phase 2 Construction/Upgrades on Omelek Islet

New Construction/Upgrades*	Description
Generator Facility	• Would be relocated to the east side of the islet • House two 1,000-kVA generators • House one 100-kVA generator
Additional Trenching	• Would provide power to facilities without underground conduits
Wind-based Power Generator	• Would be used between missions to reduce power needs
Reverse Osmosis Unit	• Would generate ≈11,356 liters (3,000 gallons) of water/day to support deluge system
Storage Facility (Figure 2-12)	• Would be located at an existing ordnance storage facility site • Would store launch site spares and equipment • Would provide indoor storage for motor vehicles, which would significantly reduce corrosion problems
Paved Paths Areas	• Provide safe, reliable transportation routes • Include rainwater drainage control
Harbor Modification (Figure 2-9)	• Would facilitate access to Omelek by cargo
Shoreline Reinforcement (Figure 2-14)	• Would slow shoreline erosion

* All construction and launch activities of the Falcon 1 and 9 launch programs would comply with the UES and the USAKA/RTS Range Safety Requirements.

Paved Path Areas

During Phase 2, the unimproved paths used to access the islet would be paved to provide safe, reliable transportation routes. The paving material would be primarily concrete, but asphalt may be laid in some locations depending on cost and availability of equipment. Some areas of general paving would be constructed to provide adequate turning radii for large vehicle transporters and parking locations for island motor vehicles. Road design would also include an evaluation of rainwater drainage on Omelek, and rainwater control channels or conduit would be installed during paving construction.

4.1.9.1.2 Kwajalein

As part of Phase 2, new construction/upgrades are proposed to support and sustain launch activities. Tables 4-7 summarizes proposed Phase 2 construction/upgrades:

Table 4-7. Phase 2 Construction/Upgrades on Kwajalein Islet

New Construction/Upgrades*	Description
LOX Production Plant	• Located on industrial side (western) of Kwajalein • Would produce LOX daily when active • Would store LOX during production
Payload Processing Facility (Figure 2-16)	• Located on industrial side of Kwajalein • Alternative location for LOX Plant • Fueling of payloads

* All construction and launch activities of the Falcon 1 and 9 launch programs would comply with the UES and the USAKA/RTS Range Safety Requirements.

4.1.9.2 Operational Activities

4.1.9.2.1 Omelek

Falcon 1 and 9 launches are entirely consistent with the mission of the island and would not conflict with any land use plans, policies, or controls of USAKA. The establishment and activation of a launch hazard area (LHA) would require the temporary clearance of the adjoining Pacific Ocean in front of the launch site. Temporary clearance of this LHA should have no impacts on recreational or commercial use of these waters since the area off the island is not used frequently by commercial fishermen or for recreational use by residents of USAKA (all of whom work for the U.S. Government or U.S. Government contractors). As part of USAKA range safety practices, the Mid-atoll Corridor is maintained as a closed area. All boat traffic is prohibited for a period encompassing any flight test activity. (U.S. Army Space and Missile Defense Command, 2002)

4.1.9.2.2 Kwajalein

Launch control would be executed remotely from Kwajalein. A SpaceX facility is currently housed in Building 1500, from which SpaceX controls 26 stations. For Falcon 9, SpaceX would require up to 50 additional stations in an existing RTS facility to provide launch control support.

Communication with Omelek from Kwajalein is by fiber optic cable, and all required communications to Omelek pass through a redundant network system.

Construction and operation of proposed facilities and upgrades discussed above and in Section 2.1.5.3 would not change any existing land uses on Kwajalein. The proposed LOX Plant and Payload Processing Facility would be located on the industrial side of the island. Additionally, no negative cumulative impacts are expected from the remotely executed launch control which would originate from a current SpaceX facility on Kwajalein.

4.1.9.2.3 Meck

Propellants would be stored in an approved certified facility on Meck and residual propellants would be returned to the storage facility after each launch. Storage of hazardous material (propellants) on Meck would not change any existing land uses.

4.1.9.3 Cumulative Impact

Construction and operation of proposed facilities and upgrades discussed above would not change any existing land uses on Omelek or Kwajalein. Although Proposed Action when combined with current and proposed launch activities discussed in Section 2.1 would increase the total number of annual launches currently approved for Omelek, no cumulative impacts are expected. No negative cumulative impacts are expected from the potential temporary storage of launch vehicles on Omelek and the storage of propellants on Meck. The launch vehicles on Omelek would be stored in an existing physically-secured area and the propellants on Meck would be stored in an approved facility. Additionally, some proposed upgrades (i.e., Harbor Modification, Shoreline Reinforcement), could protect Omelek from further shoreline erosion.

4.1.10 NOISE

The area of concern for the Proposed Action is noise effects on launch personnel. Noise effects on wildlife are discussed in Section 4.1.3, Biological Resources.

4.1.10.1 Site Preparation Activities

4.1.10.1.1 Omelek/Kwajalein

Noise produced during site preparation activities such as construction, upgrades, and relocation of facilities would be minor and short-term, resulting in little to no effect on construction workers or launch personnel. The specific types of equipment that would be used during proposed construction are not known at this time. Excavation and grading would normally involve the use of bulldozers, scrapers, backhoes, and trucks. The construction of buildings would likely involve the use of pile drivers, concrete mixers, pumps, saws, hammers, cranes, and forklifts. Typical sound levels from construction equipment are listed in Table 4-8. Due to the exclusion of the public from the immediate vicinity of construction, the public would not be exposed to hazardous noise levels. To minimize noise level impacts, personnel or contractors involved in the proposed construction activities would be required to wear hearing protection in areas where noise levels would exceed limits set by OSHA.

Table 4-8. Typical Construction Noise Levels

Source	Noise level (peak [dB])	Distance from Source			
		15 meters (50 feet)	30.5 meters (100 feet)	61 meters (200 feet)	122 meters (400 feet)
Heavy Trucks	95	84-89	73-83	72-77	66-71
Dump Trucks	108	88	82	76	70
Concrete Mixer	105	85	79	73	67
Jackhammer	108	88	82	76	70
Scraper	93	80-89	74-82	68-77	60-71
Dozer	107	87-102	81-96	75-90	69-84
Generator	96	76	70	64	58
Crane	104	75-88	69-82	63-76	55-70
Loader	104	73-86	67-80	61-74	55-68
Grader	108	88-91	82-85	76-79	70-73
Dragline	105	85	79	73	67
Pile Driver	105	95	89	83	77
Fork Lift	100	95	89	83	77

Source: Golden et al., 1980

In addition, two dress rehearsals are proposed in the launch preparation schedule. Included in a dress rehearsal could be fully fueling the launch vehicle and, under some circumstances, static fire tests. Static fire tests would require fully fueling the launch vehicle and firing the first stage engine for approximately 5 seconds.

4.1.10.1.2 Meck

There are no proposed site preparation requirements for Meck.

4.1.10.2 Operational Activities

Noise levels for the Falcon 1 and Falcon 9 launch vehicles were modeled. Table 4-9 lists the modeled noise levels for the Falcon 1 and Falcon 9 vehicles within the 85-dB contour. These noise levels are not anticipated to impact SpaceX personnel as they would be evacuated from the islet prior to the launch.

Omelek has been developed as a launch support facility with no permanent inhabitants occupied in unrelated activities and there are no inhabited islets within 21 kilometers (13 miles); adverse impacts from launch activities are not anticipated.

4.1.10.3 Post Flight Activities

Noise generated during the removal of all mobile equipment and assets would have minimal impact to the noise environment on or off Omelek.

Table 4-9. Modeled Noise Levels for the Falcon 1 and Falcon 9 Launch Vehicles

	Distance from Launch Pad kilometers (miles)	Modeled Noise Levels
Falcon 1	1.6 (1.0)	113.3 dB
	4.8 (3.0)	96.7 dB
	8.0 (5.0)	85.2 dB
Falcon 9	0.30 (0.19)	141 dB
	0.76 (0.47)	133 dB
	1.52 (0.95)	127 dB
	3.05 (1.90)	121 dB

4.1.10.4 Cumulative Impacts

No noise sensitive noise receptors are in the vicinity; thus no noise impacts are expected. Construction activities on Omelek related to the upgrading existing facilities, relocating facilities, and construction of new facilities would cause a short-term temporary increase in the noise levels in the immediate vicinity of the construction activities. This effect would be localized, and is not anticipated to cause permanent noise level impacts. The Proposed Action activities would not occur at the same time as other regional programs such as Ground-based Midcourse Defense or Minuteman III. The sound levels generated by each launch would be a short, discrete event; the potential cumulative impacts to noise from the proposed launches would not be substantial.

4.1.11 SOCIOECONOMICS

Socioeconomic characteristics do not apply to Meck. Meck is uninhabited and personnel would be on the island only to perform duties associated with Pre-Launch and Post-Launch activities for the Falcon 1 and Falcon 9 operations.

4.1.11.1 Operational Activities/Post Flight Activities

4.1.11.1.1 Omelek

Access to Omelek Islet is restricted to USAKA personnel, USAKA contractors, SpaceX personnel, and those with written permission from the USAKA Commander. Marshallese individuals can obtain written permission from USAKA to stay temporarily on Omelek while fishing from the adjacent island of Gellinam, unless Omelek is closed temporarily on orders of the USAKA Commander.

4.1.11.1.2 Kwajalein

Approximately 30 people would be involved in both Falcon 1 and Falcon 9 launch activities. Up to 8 of the 30 SpaceX personnel would live temporarily on Omelek in the SpaceX office facility, as required. The remaining transient personnel would be lodged on Kwajalein and transported daily between the two islands. No additional facilities would be required to house personnel.

4.1.11.1.3 Meck

As stated in section 3.1.11.2.3, Meck is uninhabited (no resident population) and possesses no socioeconomic characteristics. However, a few Marshallese may be employed periodically to support ground and facility maintenance on the island.

4.1.11.1.4 Ebeye and Majuro

Launch procedures on Omelek could continue to employ a small number of Marshallese from Ebeye and possibly from Majuro in support of ground and facility maintenance and technical support on the island. Personal income of the potential Marshallese employed in support of the increase in launches from Omelek may increase; however, three to seven Marshallese employees would account for less than 1.0 percent of the total population of Ebeye and less that 0.01 percent of the total population of Majuro. There would be no impact on the permanent population size, employment characteristics, and the type of housing available on Ebeye or Majuro.

4.1.11.2 Cumulative Impact

Income generated at lodging and retail facilities may increase slightly from the 30 transient workers who could be on Kwajalein. This increase would be temporary and intermittent as it relates to the scheduled Falcon 1 and Falcon 9 launch operations. There would be no impact on the permanent population size, employment characteristics, and the type of housing available on the island. Socioeconomic characteristics do not apply to Omelek and Meck.

4.1.12 WATER RESOURCES

This section addresses the potential impacts to water resources due to proposed activities.

4.1.12.1 Site Preparation Activities

4.1.12.1.1 Omelek

Construction of the new Falcon 9 launch pad and the Payload Processing Facility would be confined within the immediate construction area in compliance with the UES and would thus not impact water resources. Proposed construction activities would be performed in accordance with the USAKA Stormwater Pollution Prevention Plan to minimize potential erosion and stormwater runoff. Installation of new pilings and the proposed concrete barge dock would produce short-term water quality degradation, or turbidity and sediment transport. Best Management Practices would be used to limit turbidity, such as silt curtains if required. Water resources could also be impacted by potential accidental spills of petroleum and other materials during construction activities. However, emergency response personnel would comply with the KEEP prepared by USAKA in accordance with the UES and standard operating procedures for spill prevention, control, and countermeasures would be used to minimize any impacts.

4.1.12.1.2 Kwajalein

Construction of the LOX production plant and Payload Processing Facility on the northwestern end of Kwajalein would not impact groundwater wells or catchment areas located adjacent to the airfield’s runway and approximately 1.6 kilometers (1 mile) away.

4.1.12.1.3 Meck

An existing storage facility on Meck would be used, and thus no construction would be required.

4.1.12.2 Operational Activities

4.1.12.2.1 Omelek

Since the Falcon launch vehicles use LOX and kerosene propellants, the exhaust plume produced during launch would consist mainly of steam and carbon dioxide. The carbon dioxide, when mixed with the deluge water, would create carbonic acid, which would then break down into bicarbonate and hydrogen ions and create a mild acid similar to a carbonated beverage. The steam produced is anticipated to have the same pH as rainwater; that, combined with the fact that most of the steam from the exhaust plume is expected to rapidly evaporate, should produce no long-term effects.

Although a potential impact to water resources could occur in the event of an accidental fuel spill or premature flight termination that resulted in fuel coming in contact with water resources, in the unlikely event of an accidental release of kerosene outside the containment areas, emergency response personnel would comply with the Hazardous Materials Contingency Plan and Hazardous Waste Management Plan prepared by SpaceX and the KEEP. Following these safety regulations and requirements would minimize the potential for accidental spills, as well as provide the means for mitigating or minimizing effects to water resources if an accident were to occur. The risk of accidental fuel spills during flight test activities would be considered temporary in duration.

Impacts to the waters surrounding Omelek due to stormwater runoff would be in compliance with the UES nonpoint source requirements and the USAKA Stormwater Pollution Prevention Plan. Designs incorporating sheetflow patterns or grooves to allow stormwater to disperse over larger areas should minimize the potential for effects.

4.1.12.2.2 Kwajalein

In the unlikely event of an accidental release of hazardous material at the Payload Processing Facility, emergency response personnel would comply with the Hazardous Materials Contingency Plan and Hazardous Waste Management Plan prepared by SpaceX and the KEEP.

4.1.12.2.3 Meck

In the unlikely event of an accidental release of hazardous material at the storage area, emergency response personnel would comply with the Hazardous Materials Contingency Plan and Hazardous Waste Management Plan prepared by SpaceX and the KEEP. The Meck catchment is protected, and controls are in place to prevent its contamination.

4.1.12.3 Post Flight Activities

At the conclusion of flight activities Falcon launch vehicle personnel would remove all temporary mobile equipment/assets as required. Fresh water would be used to douse fires and/or for initial cleanup on the pad. Fresh water would also be used to rinse the pad and launch stand prior to securing for storage. This water would be collected and tested for contaminants. No deluge or rinse water would be discharged back into the ocean. SpaceX would remove hazardous and nonhazardous waste from Omelek and dispose of it in accordance with USAKA/RTS regulations and the UES. After flight activities some hazardous and non-hazardous waste may remain on Omelek in accordance with current waste management procedures and the UES.

Kwajalein/Meck

Falcon program post flight activities on Kwajalein and Meck would be related to oversight and storage of hazardous materials, which are not expected to affect any water bodies due to proper handling and compliance with UES guidelines.

4.1.12.4 Cumulative Impacts

The small increase in the number of transient personnel at Kwajalein, Meck, and Omelek is expected to require little or no increase in groundwater withdrawal, depending on the amount of fresh water in storage and rainfall catchment during the period of program activity. No groundwater quality degradation would be expected. Missile hardware, debris, and propellants that would fall into the ocean are expected to have only a localized, short-term effect on water quality. Stormwater runoff would be in compliance with the UES nonpoint source requirements. The proposed activities would not occur at the same time as other regional programs such as Ground-Based Midcourse Defense or Minuteman III.

4.2 OPEN OCEAN

4.2.1 AIRSPACE—OPEN OCEAN (FLIGHT CORRIDOR)

Only the proposed flight operations have the potential for impacts to airspace use in the ocean environment. Typically, a launch vehicle would be at very high altitude passing through Flight Level (FL) 600 (approximately 18,290 meters [60,000 feet]) in just a matter of minutes after launch, and thus well above the airspace subject to the rules and regulations of the ICAO Convention. However, the designation and activation of booster drop areas in the launch corridor could have airspace use impacts.

Controlled and Uncontrolled Airspace

The airspace in the ROI outside territorial limits lies in international airspace and, consequently, is not part of the National Airspace System. Because the area is in international airspace, ICAO procedures are followed. The FAA acts as the U.S. agent for aeronautical information to the ICAO, and air traffic in the over-water ROI is managed by the Honolulu and Oakland ARTCCs.

After launch, typically the Falcon launch vehicle would be above FL 600 within minutes of the rocket motor firing. As such, all other local flight activities would occur at sufficient distance and altitude so that the missile would be little noticed. Because the airspace in the open ocean area around Kwajalein Atoll is not heavily used by commercial aircraft, the impacts to controlled/uncontrolled airspace would be minimal. The Proposed Action would not represent a direct special use airspace impact.

To satisfy airspace safety requirements in accordance with Army Regulation 385-62, the responsible commander would coordinate activities with the Administrator, FAA, through the appropriate U.S. Army airspace representative. Provision will be made for surveillance of the affected airspace and in addition, safety regulations dictate that launch operations would be suspended when it is known or suspected that any unauthorized aircraft have entered any part of the launch hazard area or first stage and fairing drop zones until the unauthorized entrant has been removed or a thorough check of the suspected area has been performed. NOTAMs would be issued to advise avoidance of the tracking radar areas during Falcon launch and flight operations. The second stage would go into a degrading orbit with the payload.

En Route Airways and Jet Routes

Because the airspace in the open ocean area around Kwajalein Atoll is not heavily used by commercial aircraft, and has few en route airways and jet routes crossing the North Pacific, the impacts to airways and jet routes that crisscross the Ocean Area airspace use ROI are expected to be minimal. Missile launches would be conducted in compliance with DoD Directive 4540.1 that specifies procedures for conducting missile and projectile firing, namely “firing areas shall be selected so that trajectories are clear of established oceanic air routes or areas of known surface or air activity.” As stated above, before conducting a missile launch, NOTAMs would be sent in accordance with U.S. Army regulations and the responsible commander would coordinate with the Administrator, FAA, through the appropriate U.S. Army airspace representative.

In addition to the reasons cited above, no adverse impacts to the ROI’s over-water airways and jet routes are identified because of the required coordination with the FAA. The procedures for scheduling each piece of airspace are performed in accordance with letters of agreements with the controlling FAA facility and the Oakland ARTCC. Schedules are provided to the FAA facility as agreed between the agencies involved. Aircraft transiting the Open Ocean ROI on one of the low-altitude airways and/or high-altitude jet routes that would be affected by launch activities would be notified of any necessary rerouting before departing their originating airport and would therefore be able to take on additional fuel before takeoff. Real-time airspace management involves the release of airspace to the FAA when the airspace is not in use or when extraordinary events occur that require drastic action, such as weather requiring additional airspace.

The FAA ARTCCs are responsible for air traffic flow control or management to transition air traffic. The ARTCCs provide separation services to aircraft operating on instrument flight rules flight plans and principally during the en route phases of the flight. They also provide traffic and weather advisories to airborne aircraft. By appropriately containing hazardous military activities within the over-water Warning Areas, non-participating traffic is advised or separated accordingly, thus avoiding substantial adverse impacts to the low altitude airways and high altitude jet routes in the region of influence.

Airports and Airfields

There are no airports or airfields in the Ocean Area airspace use region of influence. Consequently, there would be no impacts to airports and airfields.

The Falcon launch site, launch hazard area, and the water impact and debris containment areas inside the broad ocean area east of Kwajalein Atoll would be well north of Bucholz Army Airfield and its standard instrument approach and departure procedures. Some of the desired azimuths shown on Figure 2-4 could impact standard flight patterns for military aircraft coming to Kwajalein from Hawaii. SpaceX would coordinate Falcon launches with the USAKA/RTS Commander, which would include scheduling to avoid airspace conflicts. All arriving and departing aircraft are under the control of Bucholz Army Airfield Control Tower.

Cumulative Impacts

First stage and fairing impact would take place in international airspace. Operational activities would request clearance of various areas of airspace, and may cause rerouting or rescheduling of flights. However, most impacts would be in remote areas that would have little effect on air traffic. There is no airspace segregation method such as warning or restricted area to ensure that the area would be cleared of non-participating aircraft. The Proposed Action activities would not occur at the same time as other regional programs such as Ground-Based Midcourse Defense or Minuteman III. Falcon launches would be short-term, discrete events, however, and using the required scheduling process for international airspace would minimize the potential for cumulative impacts.

4.2.2 BIOLOGICAL RESOURCES—OPEN OCEAN (FLIGHT CORRIDOR)

Based on prior analysis done and the effects of past launch activities, the potential impacts of activities in the open ocean related to SpaceX flights on biological resources are expected to be minimal, as discussed below.

The proposed flight operations would have no discernible or measurable effect on the ocean's overall physical and chemical properties, and thus would have no impacts to the overall marine biology of the Ocean Area region of influence for USAKA/RTS. Moreover, the proposed flight operations would have no discernible effect on the biological diversity of either the pelagic or benthic marine environments. Although the proposed activities would take place in the open ocean, or pelagic zone, which is far removed from land and contains approximately 2 percent of marine species; the potential for impacts exists from the Falcon's first stage and fairing entering the ocean's surface.

Hazardous Materials Deposition

NASA conducted a thorough evaluation of the effects of missile systems that are deposited in seawater. It concluded that the release of hazardous materials aboard missiles into seawater would not be significant. Materials would be rapidly diluted and, except for the immediate vicinity of the debris, would not be found at concentrations identified as producing any adverse effects. In the event of an accidental fuel spill or premature flight termination resulting in fuel coming in contact with water resources, fuel would be rapidly buffered by the seawater thus preventing any significant adverse impacts. The Pacific Ocean depth in the vicinity of the launch area is thousands of meters (feet) deep, and any area affected by release of the propellant would be relatively small due to the size of the Falcon's motor or propellant relative to the quantity of seawater. Consequently, any impact from the fuel is expected to be minimal. In addition, an accident response team would be available to negate or minimize any adverse effects. The risk of accidental fuel spills during flight test activities would be considered minor and temporary in duration. (Federal Aviation Administration, 1996)

Debris

Debris impact and booster drops in the broad ocean area would not occur within the 322-kilometer (200-mile) limit of the Exclusive Economic Zone of affected islands. Hydrocarbon fuels such as kerosene that reach the ocean surface would spread quickly on the surface from the effects of gravity, wind, and waves. Most of the fuel would evaporate from the ocean surface within a few hours. The remainder would disperse in the water column and degrade. Release of the liquid fuel would have little, if any, impact on water quality. (Missile Defense Agency, 2004) Analysis in the Marine Mammal Technical Report, prepared in support of the Point Mugu Sea Range EIS, determined that there is a very low probability that a marine mammal would be killed by falling missile boosters or debris as a result of tests at the Point Mugu Sea Range (less than 0.0149 marine mammals exposed per year). Large pieces of falling debris from missiles have the potential to strike and injure or kill marine mammals. As a general guideline, pieces of debris with an impact kinetic energy of 15 joules (11 foot-pounds) or higher are hazardous to humans (Pacific Missile Range Facility, Barking Sands, 1998). Debris impact and booster drops in the open ocean area are not expected to adversely affect marine mammal species protected by the Marine Mammal Protection Act of 1972. The probability is rather low that migratory whales or sea turtles would be within the area to be impacted by falling debris and boosters. The potential for an object or objects dropping from the air to affect marine mammals or other marine biological resources is less than 10^{-6} (1 in 1 million). The probability of a spent missile landing on a cetacean or other marine mammal is remote. (Department of the Navy, Naval Air Warfare Center Weapons Division, 2002)

This probability calculation was based on the size of the area studied and the density of the marine mammal population in that area. The analysis concluded that the effect of missile debris and intact missiles coming down in the open ocean would be negligible. The range area at Point Mugu is smaller than the USAKA/RTS range area, and the density of marine mammals at Point Mugu is estimated to be larger than the density found at USAKA/RTS. It is thus reasonable to conclude that the probability of a marine mammal being injured or killed by missile or debris impact from SpaceX flights from Omelek is even more remote than at Point Mugu. (Department of the Navy, Naval Air Warfare Center Weapons Division, 2002; Pacific Missile Range Facility, Barking Sands, 1998)

The first stage may be attached to a parachute system and recovered. The second stage of the Falcon 9 could also be recovered if so designed. Entanglement of a marine mammal or sea turtle in a parachute and potential drowning would be very unlikely since the parachute would either have to land directly on an animal, or an animal would have to swim blindly into it before it is recovered or sinks to the ocean floor. The potential for a marine mammal or sea turtle to be in the same area and have physical contact with a parachute is remote. After completion of its mission to deliver cargo to the ISS, the Dragon would re-enter the atmosphere on a pre-planned trajectory, soft-land in the ocean, and be recovered by a recovery vessel. Impacts to marine species would be similar to those of the Falcon 9 first stage.

Shock Wave Impacts

In the unlikely event of an unsuccessful flight, the Falcon launch vehicle could hit the water with speeds of 91 to 914 meters (300 to 3,000 feet) per second. It is assumed that the shock wave from its impact with the water is similar to that produced by explosives. At close ranges, injuries to internal organs and tissues would likely result. However, the taking of, or injury to, any marine mammal by direct impact or shock wave impact would be extremely remote (less than 0.0006 marine mammals exposed per year). The splashdown of the Falcon launch vehicle is planned to occur in open ocean waters thousands of meters (feet) deep at considerable distance from the nearest land. (Pacific Missile Range Facility, Barking Sands, 1998)

Sonic Boom Overpressure Impacts

In addition to the noise of the rocket engine, sonic booms are possible. A sonic boom is a sound that resembles rolling thunder, produced by a shock wave that forms at the nose of a vehicle that is traveling faster than the speed of sound. Previous sonic boom modeling performed for Falcon launch vehicles at Vandenberg Air Force Base determined that sonic boom impacts would impact the Channel Islands, approximately 64 kilometers (40 miles) from the launch site, with maximum noise levels of 65 to 75 dBA. (Space Exploration Technologies Corporation, 2003)

The Falcon would propagate a unique sonic boom contour depending upon its mass, shape, velocity, and reentry angle, among other variables. The location of the possible impact point would vary depending upon the particular flight profile. It is therefore difficult to produce the specific location, extent, duration, or intensity of sonic boom impacts on marine life. These noise levels would be of very short duration.

The noise level thresholds of impact to marine life in general, and marine mammals in particular, are currently the subject of scientific analysis. There is the possibility that underwater noise levels resulting from sonic booms could affect some marine mammals or sea turtles in the open ocean. In addition, since different species of marine mammals have varying sensitivity to different sound frequencies and may be found at different locations and depths in the ocean, it is difficult to generalize sound impacts to marine mammals from missile impacts in the broad ocean area. However, sonic boom modeling has been performed for launches of the Falcon launch vehicle from Vandenberg Air Force Base, California (Space Exploration Technologies Corporation, 2003) and compared with sonic booms from a larger missile, the Atlas IIAS. Maximum dBA sonic boom levels predicted for the Falcon were less than those of the Atlas IIAS. The modeling performed determined that sonic boom noise levels would be approximately 65 to 75 dBA 64 kilometers (40 miles) from the launch site (Space Exploration Technologies Corporation, 2003). Falcon launches from Omelek would be over the open ocean and at an altitude of approximately 8 kilometers (5 miles) when it goes supersonic.

According to analysis provided in the Navy's Point Mugu Sea Range EIS, momentary startle or alert reactions in response to a single transient sound such as a sonic boom are not considered a significant adverse effect to whales. Humpback whales have often been observed behaving normally in the presence of strong noise pulses from sources such as distant explosions and seismic vessels. (Department of the Navy, Naval Air Warfare Center Weapons Division, 2002)

The *Final Supplemental Environmental Impact Statement for Proposed Actions at U.S. Army Kwajalein Atoll* determined that maximum short-term noise levels of less than 92 dBA would cause a nonsignificant impact in noise-sensitive areas (U.S. Army Space and Strategic Defense Command, 1993). Falcon launches from Omelek would be over the open ocean and at an altitude of approximately 8 kilometers (5 miles) when it goes supersonic. Again, these sonic booms noise levels would be similar to mild thunder. The resultant sonic boom should not adversely impact any of the surrounding islands at Kwajalein Atoll.

Prior to each launch from Omelek, sonic boom noise levels would be modeled using atmospheric conditions that would be representative of that launch. No evidence of injury, mortality, or abnormal activity to any marine mammals as a result of Atlas IIAS launches from Vandenberg Air Force Base has been observed. Based on these studies and the fact that Falcon launch vehicles would generate lower sonic boom noise levels than the Atlas IIAS, no significant impacts to marine mammals are expected.

Cumulative Impacts

No substantial impacts to the open ocean area and its wildlife have been identified from current and past missile launch activities. Prior analysis has not identified a significant potential for cumulative impacts. The Proposed Action activities would not occur at the same time as other regional programs such as Ground-Based Midcourse Defense or Minuteman III. The proposed Falcon launches would take place in the open ocean area; these would be discrete, short-term events and no adverse cumulative impacts are anticipated.

4.2.3 HEALTH AND SAFETY—OPEN OCEAN (FLIGHT CORRIDOR)

Every reasonable precaution would be taken during the planning and execution of SpaceX flight activities to prevent injury to human life or property. USAKA/RTS conducts missile flight safety, which includes overflights of the area around USAKA/RTS prior to any launch and analysis of missile performance capabilities and limitations, of hazards inherent in missile operations and destruct systems, and of the electronic characteristics of missiles and instrumentation. It also includes computation and review of trajectories and hazard area dimensions; review and approval of destruct systems proposals; and preparation of the Range Safety Approval and Range Safety Operational Plans required of all programs.

Impact zones in the open ocean area would be delineated. The location and dimensions of the impact zones would vary for each flight scenario of the Falcon 1 and Falcon 9. Impact zones for each flight would be determined by range safety personnel based on detailed launch planning and trajectory modeling. This planning and modeling would include analysis and identification of a flight corridor. Flights would be conducted when trajectory modeling verifies that flight vehicles and debris would be contained within predetermined areas, all of which would be over the open ocean and removed from land and populated areas.

Both the Falcon 1 and Falcon 9 allow for recovery of the first stage. The location of the stage's ocean impact would vary with each mission. The first stage would be recovered by USAKA/RTS or commercial recovery personnel and returned to Kwajalein. The second stage of the Falcon 1 would reenter the atmosphere, but would burn up upon reentry and it is highly unlikely that any debris would reach the ocean. The Falcon 9 second stage could be recovered if so designed. In this event, the stage would reenter the atmosphere on a pre-programmed trajectory and would impact a predetermined position. Recovery of the second stage would be similar to recovery of the first stage. Appropriate NOTMARs and NOTAMs would be issued before proceeding with a launch. Furthermore, prior warning of launch activities would enable commercial shipping to follow alternative routes away from test areas. After completion of its mission to deliver cargo to the ISS, the Dragon would re-enter the atmosphere on a pre-planned trajectory, soft-land in the ocean, and be recovered by a recovery vessel similar to the Falcon 9 first stage.

Cumulative Impacts

Each Falcon 1 and Falcon 9 launch would result in the impact of Falcon boosters into the open ocean, the first stage by parachute, second stage if designed for recovery, and the fairing by free-fall. The Proposed Action would result in a slight increase in flight activities in the open ocean area. As such, there could be a cumulative impact to health and safety in the open ocean area. However, the Proposed Action also requires the administration of NOTAMs and NOTMARs to warn aircraft and surface vessels of the potentially hazardous areas and allows them ample time to avoid the hazards. The Proposed Action activities would not occur at the same time as other regional programs such as Ground-Based Midcourse Defense or Minuteman III. As such, any cumulative health and safety impact in the open ocean area due to the Proposed Action would be minimal.

4.3 ENVIRONMENTAL EFFECTS OF THE NO-ACTION ALTERNATIVE

If the No-action Alternative is selected, no environmental consequences associated with the SpaceX Falcon 9 program are anticipated. Five Falcon 1 launches would continue from Omelek, or the islet could again be considered as a missile launch facility for other programs as analyzed in prior EISs and EAs.

4.4 FEDERAL ACTIONS TO ADDRESS ENVIRONMENTAL JUSTICE IN MINORITY POPULATIONS AND LOW-INCOME POPULATIONS (EXECUTIVE ORDER 12898)

Proposed activities would be conducted in a manner that would not substantially affect human health and the environment. This EA has identified no effects that would result in disproportionately high or adverse effect on minority or low-income populations in the area. The activities would also be conducted in a manner that would not exclude persons from participating in, deny persons the benefits of, or subject persons to discrimination because of their race, color, national origin, or socioeconomic status.

4.5 FEDERAL ACTIONS TO ADDRESS PROTECTION OF CHILDREN FROM ENVIRONMENTAL HEALTH RISKS AND SAFETY RISKS (EXECUTIVE ORDER 13045, AS AMENDED BY EXECUTIVE ORDER 13229)

This EA has not identified any environmental health and safety risks that may disproportionately affect children, in compliance with Executive Order 13045, as amended by Executive Order 13229.

5.0
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5.0 REFERENCES

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6.0
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6.0 LIST OF PREPARERS

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7.0
AGENCIES AND INDIVIDUALS CONTACTED

7.0 AGENCIES AND INDIVIDUALS CONTACTED

Federal Aviation Administration
Washington, D.C.

Reagan Test Site
U.S. Army Kwajalein Atoll

Republic of the Marshall Islands
Environmental Protection Agency
Majuro, MH

Space Exploration Technologies, Inc.
El Segundo, California

USAKA Directorate of Public Works
Environmental Office
Kwajalein, MH

U.S. Army Corps of Engineers
Fort Shafter, HI

U.S. Environmental Protection Agency
Pacific Islands Office
San Francisco, California

U.S. Fish and Wildlife Service
Pacific Islands Office
Honolulu, Hawaii

U.S. National Oceanic and Atmospheric Office
Pacific Islands Area Office
Honolulu, Hawaii

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APPENDIX A
DISTRIBUTION LIST

APPENDIX A
DISTRIBUTION LIST

USAKA Directorate of Public Works
Environmental Office
Attn: Kelly Busquets
Kwajalein, MH

Kwajalein Range Services
Reagan Test Site
U.S. Army Kwajalein Atoll

General Manager, Republic of the
Marshall Islands
Environmental Protection Authority
Attn: John Bungitak
Majuro Atoll, RMI

U.S. Army Corps of Engineers
District, Honolulu
Attention: CEPOH-PP-E (H. Takemoto)
Fort Shafter, Hawaii

National Marine Fisheries Service
Pacific Islands Regional Office
Habitat Conservation Division
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U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Attn: Michael Molina
Honolulu, Hawaii

U.S. Environmental Protection Agency
Region IX, Pacific Islands Office
Attn: John McCarroll
San Francisco, California

Federal Aviation Administration
Commercial Space Transportation
Attn: Stacey M. Zee, Environmental Specialist
Washington, DC

Space Exploration Technologies
El Segundo, California

Elizabeth Harding & Associates, P.C.
Centennial, Colorado

Alele Public Library
Majuro, Republic of the Marshall Islands

Majuro Public Library
Majuro, MH

Grace Sherwood Library
Kwajalein, Marshall Islands

APPENDIX B
CORRESPONDENCE

APPENDIX B
CORRESPONDENCE

From: Stacey Zee
Sent: Thursday, July 19, 2007 1:20 PM
To: Elliott, Julia Ms USASMDC
Cc: Ken Gidlow; charles huet
Subject: RE: FW: Falcon9 EA (UNCLASSIFIED)

Comments on SpaceX EA -

Julia -

FAA has a few comments on the coordinating draft EA for SpaceX launches at Kwaj - they are outlined below:

Section 1.1 – Add a description of FAA as a cooperating agency.
"SpaceX would apply for a launch license from the FAA for launches with commercial payloads. The FAA, which is a cooperating agency for this EA, will rely on this analysis to support its environmental determination for launch licenses for the Falcon launch vehicles or a reentry license for the Dragon reentry capsule. In addition to the environmental review and the determination, applicants for a launch or reentry license must complete a policy review and approval, safety review and approval, payload review, and a financial responsibility determination. All of these reviews must be completed prior to receiving a launch or reentry license."

Section 2: Add language clarifying whether launches are commercial, government, or some combination of both. Explain the difference between government and commercial launches.

Section 4: Add potential environmental impacts of Dragon capsule. If similar to impacts discussed for Falcon stage reentry and recovery, explain this information.

Thank you and let me know if you have any questions. Also - please provide a copy of the EA to me once it is finalized. Thanks again.

Regards,
Stacey Zee

"Elliott, Julia Ms USASMDC"
07/05/2007 11:56 AM

To Stacey Zee/AWA/FAA@FAA, "Busquets, Kelly Ms. USASMDCK"
cc
Subject RE: FW: Falcon9 EA (UNCLASSIFIED)

Classification: **UNCLASSIFIED**

Caveats: None

Hello Stacey,

I am the technical manager at USASMDC for the SpaceX Falcon Program Environmental Assessment (EA). The FAA certainly may participate as a cooperating agency in the EA process. You are welcome to submit comments on the Coordinating Draft EA and in doing so, please submit comments no later than July 18.
Submit comments to me or Rachel Jordan. Thank you kindly.

Julia Elliott
Deputy Chief of Staff, Engineer (Environmental Division)
Space & Missile Defense Command (SMDC)
Huntsville, AL 35807

From: Stacey Zee
Sent: Thursday, July 05, 2007 10:09 AM
To: Busquets, Kelly Ms. USASMDCK
Cc: jordanr; Elliott, Julia Ms USASMDC; Sharon Hurst; Tim Hughes; Anne Chinnery
Subject: Re: FW: Falcon9 EA

Kelly -

The FAA requests the opportunity to participate as a cooperating agency on the Environmental Assessment for SpaceX launches from Kwajalein. If SpaceX pursues a commercial launch license for any of their operations from Kwajalein, the FAA would use the analysis in the EA to support the licensing decision. We will make all reasonable efforts to ensure that FAA's participation in this EA process does not adversely affect the schedule, while, we trust, our participation will add value to the process.

Please let me know whether I'm able to still submit comments on the Coordinating Draft EA.

Stacey M. Zee
Environmental Specialist
Commercial Space Transportation
Federal Aviation Administration
Washington, DC 20591

DEPARTMENT OF THE ARMY
U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND/
ARMY FORCES STRATEGIC COMMAND
POST OFFICE BOX 1500
HUNTSVILLE, ALABAMA 35807-3801

REPLY TO
ATTENTION OF

MAY 7 2007

Environmental Division

Ms. Elizabeth Harding
Elizabeth Harding & Associates, P.C.
7744 S. Jackson Circle, Suite 112
Centennial, CO 80122

Dear Ms. Harding:

In compliance with the National Environmental Policy Act (NEPA) and the Council on Environmental Quality regulations implementing NEPA, an Environmental Assessment (EA) is being prepared by the US Army Space and Missile Defense Command for the proposed construction and operation to support launches of Falcon 1 and Falcon 9 launch vehicles from Omelek Islet, US Army Kwajalein Atoll/Reagan Test Site (USAKA/RTS). The Falcon Launch Vehicle Program is a venture by Space Exploration Technologies, Inc., to provide space launch operations with high reliability and low cost.

Located near the equator at approximately 9° North Latitude, USAKA/RTS provides the only US controlled equatorial launch site. An equatorial launch site is preferred because low inclination launch vehicles receive extra velocity from the Earth's rotation, which reduces the amount of fuel needed to launch spacecrafts and increases the size of the payload that can be lifted to a given orbit with a given amount of fuel. Launching near the equator also reduces the energy required for orbit plane change maneuvers, which saves fuel and increases the operational lifetime of satellite payloads.

The Falcon Launch Vehicle Program is designed to reduce vehicle assembly and payload processing times on the launch pad by completing much of the assembly at the SpaceX facilities in El Segundo, California. The goal is to launch within one month of payload arrival at the launch site. To meet this goal, payload processing must be accelerated and launch pad use must be limited. SpaceX plans an average of six Falcon 1 launches per year for the next 10 years and up to four Falcon 9 launches per year (starting after site preparation) in 2008.

The Proof-of-Principle Space Launches from the Omelek Island EA only analyzed the impacts of two launches, and modifications to the existing site were meant to be minimal or temporary. Equipment was removed from the island between missions, and the facilities were cleaned and secured after each launch. The two initial SpaceX launches were intended to test and verify the concept of the new launch vehicle before making a long term investment at USAKA (Omelek). The Finding of No Significant Impact was signed in 2005. A Record of Environmental Consideration was signed in August 2006 to allow an additional 5 Falcon 1 launches from Omelek.

The purpose of the Proposed Action is to conduct launches, beyond the Proof-of-Principle launches, of small and medium class satellites and sub-orbital payloads into space from Omelek Island at USAKA/RTS using the Falcon 1 launch vehicle and expanding SpaceX capabilities on the island to accommodate launches of the Falcon 9 vehicle.

Based on Proof-of-Principle launch results, SpaceX has committed to developing a permanent launch complex at Omelek and expanding capabilities to also accommodate launches of a larger launch vehicle (the Falcon 9). To support the proposed sustained launch activities, several improvements would be required on Omelek, including construction of a Falcon 9 launch pad and a hangar facility, upgrades to existing propellant storage and loading facilities, and several other site infrastructure improvements.

Two facilities are proposed for Kwajalein: a LOX plant facility and a Payload Processing Facility. All construction and launch activities of the Falcon 1 and 9 launch programs would comply with the USAKA Environmental Standards and the USAKA/RTS Range Safety Requirements.

The Coordinating Draft EA is being distributed to various agencies, including your office for review and comment prior to preparing the Final EA and draft Finding of No Significant Impact for public review. We desire to ensure that any concerns you might have about our efforts to identify natural resources and assess potential impacts are fully addressed. Please review this information and the Coordinating Draft EA and provide comments or any questions regarding the Falcon launch programs by no later than June 5, 2007 to Ms. Julia Elliott, SMDC-EN, PO Box 1500, Huntsville, AL 35807-3801 or by e-mail at julia.elliott@us.army.mil.

Sincerely,

David J. Bender
Colonel, US Army
Deputy Chief of Staff,
Engineer

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND/
ARMY FORCES STRATEGIC COMMAND
POST OFFICE BOX 1500
HUNTSVILLE, ALABAMA 35807-3801

REPLY TO
ATTENTION OF

MAY 7 2007

Environmental Division

General Manager/Mr. John Bungitak
Environmental Protection Authority
Republic of the Marshall Islands
PO Box 1322
Majuro, MH 96960-1322

Dear Mr. Bungitak:

In compliance with the National Environmental Policy Act (NEPA) and the Council on Environmental Quality regulations implementing NEPA, an Environmental Assessment (EA) is being prepared by the US Army Space and Missile Defense Command for the proposed construction and operation to support launches of Falcon 1 and Falcon 9 launch vehicles from Omelek Islet, US Army Kwajalein Atoll/Reagan Test Site (USAKA/RTS). The Falcon Launch Vehicle Program is a venture by Space Exploration Technologies, Inc., to provide space launch operations with high reliability and low cost.

Located near the equator at approximately 9° North Latitude, USAKA/RTS provides the only US controlled equatorial launch site. An equatorial launch site is preferred because low inclination launch vehicles receive extra velocity from the Earth's rotation, which reduces the amount of fuel needed to launch spacecrafts and increases the size of the payload that can be lifted to a given orbit with a given amount of fuel. Launching near the equator also reduces the energy required for orbit plane change maneuvers, which saves fuel and increases the operational lifetime of satellite payloads.

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The purpose of the Proposed Action is to conduct launches, beyond the Proof-of-Principle launches, of small and medium class satellites and sub-orbital payloads into space from Omelek Island at USAKA/RTS using the Falcon 1 launch vehicle and expanding SpaceX capabilities on the island to accommodate launches of the Falcon 9 vehicle.

Based on Proof-of-Principle launch results, SpaceX has committed to developing a permanent launch complex at Omelek and expanding capabilities to also accommodate launches of a larger launch vehicle (the Falcon 9). To support the proposed sustained launch activities, several improvements would be required on Omelek, including construction of a Falcon 9 launch pad and a hangar facility, upgrades to existing propellant storage and loading facilities, and several other site infrastructure improvements.

Two facilities are proposed for Kwajalein: a LOX plant facility and a Payload Processing Facility. All construction and launch activities of the Falcon 1 and 9 launch programs would comply with the USAKA Environmental Standards and the USAKA/RTS Range Safety Requirements.

The Coordinating Draft EA is being distributed to various agencies, including your office for review and comment prior to preparing the Final EA and draft Finding of No Significant Impact for public review. We desire to ensure that any concerns you might have about our efforts to identify natural resources and assess potential impacts are fully addressed. Please review this information and the Coordinating Draft EA and provide comments or any questions regarding the Falcon launch programs by no later than June 5, 2007 to Ms. Julia Elliott, SMDC-EN, PO Box 1500, Huntsville, AL 35807-3801 or by e-mail at julia.elliott@us.army.mil.

Sincerely,

David J. Bender
Colonel, US Army
Deputy Chief of Staff,
Engineer

Enclosure

DEPARTMENT OF THE ARMY
U.S. ARMY SPACE AND MISSILE DEFENSE COMMAND/
ARMY FORCES STRATEGIC COMMAND
POST OFFICE BOX 1500
HUNTSVILLE, ALABAMA 35807-3801

REPLY TO
ATTENTION OF

SMDC-EN-V

07 MAY 2007

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Falcon Launch Vehicle Program

1. In compliance with the National Environmental Policy Act (NEPA) and the Council on Environmental Quality regulations implementing NEPA, an Environmental Assessment (EA) is being prepared by the US Army Space and Missile Defense Command for the proposed construction and operation to support launches of Falcon 1 and Falcon 9 launch vehicles from Omelek Islet, US Army Kwajalein Atoll/Reagan Test Site (USAKA/RTS). The Falcon Launch Vehicle Program is a venture by Space Exploration Technologies, Inc., to provide space launch operations with high reliability and low cost.

2. Located near the equator at approximately 9° North Latitude, USAKA/RTS provides the only US controlled equatorial launch site. An equatorial launch site is preferred because low inclination launch vehicles receive extra velocity from the Earth's rotation, which reduces the amount of fuel needed to launch spacecrafts and increases the size of the payload that can be lifted to a given orbit with a given amount of fuel. Launching near the equator also reduces the energy required for orbit plane change maneuvers, which saves fuel and increases the operational lifetime of satellite payloads.

3. The Falcon Launch Vehicle Program is designed to reduce vehicle assembly and payload processing times on the launch pad by completing much of the assembly at the SpaceX facilities in El Segundo, California. The goal is to launch within one month of payload arrival at the launch site. To meet this goal, payload processing must be accelerated and launch pad use must be limited. SpaceX plans an average of six Falcon 1 launches per year for the next 10 years and up to four Falcon 9 launches per year (starting after site preparation) in 2008.

4. The Proof-of-Principle Space Launches from the Omelek Island EA only analyzed the impacts of two launches, and modifications to the existing site were meant to be minimal or temporary. Equipment was removed from the island between missions, and the facilities were cleaned and secured after each launch. The two initial SpaceX launches were intended to test and verify the concept of the new launch vehicle before making a long term investment at USAKA (Omelek). The Finding of No Significant Impact was signed in 2005. A Record of Environmental Consideration was signed in August 2006 to allow an additional 5 Falcon 1 launches from Omelek.

5. The purpose of the Proposed Action is to conduct launches, beyond the Proof-of-Principle launches, of small and medium class satellites and sub-orbital payloads into space from Omelek

SMDC-EN-V
SUBJECT: Falcon Launch Vehicle Program 07 MAY 2007

Island at USAKA/RTS using the Falcon 1 launch vehicle and expanding SpaceX capabilities on the island to accommodate launches of the Falcon 9 vehicle.

6. Based on Proof-of-Principle launch results, SpaceX has committed to developing a permanent launch complex at Omelek and expanding capabilities to also accommodate launches of a larger launch vehicle (the Falcon 9). To support the proposed sustained launch activities, several improvements would be required on Omelek, including construction of a Falcon 9 launch pad and a hangar facility, upgrades to existing propellant storage and loading facilities, and several other site infrastructure improvements.

7. Two facilities are proposed for Kwajalein: a LOX plant facility and a Payload Processing Facility. All construction and launch activities of the Falcon 1 and 9 launch programs would comply with the USAKA Environmental Standards and the USAKA/RTS Range Safety Requirements.

8. The Coordinating Draft EA is being distributed to various agencies, including your office for review and comment prior to preparing the Final EA and draft Finding of No Significant Impact for public review. We desire to ensure that any concerns you might have about our efforts to identify natural resources and assess potential impacts are fully addressed. Please review this information and the Coordinating Draft EA and provide comments or any questions regarding the Falcon launch programs by no later than 5 June 2007 to Ms. Julia Elliott, SMDC-EN, PO Box 1500, Huntsville, AL 35807-3801 or by e-mail at julia.elliott@us.army.mil.

Encl

DAVID J. BENDER
Colonel, EN
Deputy Chief of Staff,
Engineer

2

SMDC-EN-V 07 MAY 2007
SUBJECT: Falcon Launch Vehicle Program

DISTRIBUTION:
US Army Engineer District, Honolulu, (CEPOH-PP-E/Ms. Helene Takemoto), Building 230, Room 306, Fort Shafter, HI 96858-5440
National Oceanic Atmospheric Administration Fisheries, Pacific Islands Regional Office, Habitat Conservation Division, (Mr. John Naughton) 1601 Kapiolani Boulevard, Suite 1110, Honolulu, HI 96814-4700
US Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office, (Mr. Michael Molina) PO Box 50088, Honolulu, HI 96850
US Environmental Protection Agency, Region IX, Pacific Islands Office, Mr. John McCarroll, 75 Hawthorne Street (CMD-6), San Francisco, CA 94105
US Army Kwajalein Atoll/Reagan Test Site, Environmental Management Office (SMDC-RDTC-TEK-W/Ms. Kelly Busquets), PO Box 26, Air Post Office, AP 96555-2526
US Army Kwajalein Atoll/Range Test Site, Kwajalein Range Support (Ms. Suzanne Pyle), PO Box 26, Air Post Office, AP 96555
US Army Kwajalein Atoll/Reagan test Site, PO Box 26, (SMDC-RD-TE-K-RI/D. Seelye), Air Post Office, AP 96555

CF:
✓Ms. Elizabeth Harding, Elizabeth Harding & Associates, PC, 7744 S. Jackson Circle, Suite 112, Centennial, Colorado 80122
General Manager/Mr. John Bungitak, Environmental Protection Agency, Republic of the Marshall Islands, PO Box 1322, Majuro, MH 96960-1322

3

APPENDIX C
DRAFT BIOLOGICAL SURVEY AND IMPACT ANALYSIS

USAKA Photograph File

FINAL REPORT
BIOLOGICAL SURVEY AND MITIGATION RECOMMENDATIONS

OMELEK ISLET MODIFICATIONS
for
FALCON 1 AND 9 SPACE LAUNCHES
at
U.S. ARMY KWAJALEIN ATOLL
REPUBLIC OF THE MARSHALL ISLANDS

November 2007

FINAL REPORT
BIOLOGICAL SURVEY AND MITIGATION RECOMMENDATIONS

OMELEK ISLET MODIFICATIONS
for
FALCON 1 AND 9 SPACE LAUNCHES
at
U.S. ARMY KWAJALEIN ATOLL
REPUBLIC OF THE MARSHALL ISLANDS

Prepared by

Kevin Foster,[1] Holly Freifeld,[1] Steve Kolinski, [2] and Evelyn Cox, [2]

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Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawaii

[2] U.S. Department of Commerce
National Marine Fisheries Service
Pacific Islands Regional Office
Honolulu, Hawaii

Prepared for

U.S. Army Kwajalein Atoll
Republic of the Marshall Islands

November 2007

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INTRODUCTION

The National Commercial Space Launch Act of 1995 allows commercial entities to use Department of Defense facilities for space launches when compatible with military missions at such facilities. The U.S. Army Space and Missile Defense Command (SMDC) is investigating expansion of the use of the Ronald Reagan Ballistic Missile Defense Test Site (RTS) at U.S. Army Kwajalein Atoll (USAKA) in the Republic of the Marshall Islands (RMI) by a private space launch company, Space Exploration Technologies Inc. (SpaceX), to include capability into this area. USAKA is leveraging its unique location to attract U.S. Government (USG) and Non-USG customers in this regard. Currently, USAKA is allowing Space Exploration Technologies Inc. (Space-X), to launch small and medium class payloads into earth's orbit using Falcon 1 space launch vehicles (SLVs) from Omelek Islet, USAKA. Test launches of the Falcon 1 SLV have already taken place, and an average of six Falcon 1 launches per year over a 10-year period is planned. Required site enhancements and test launches of the larger Falcon 9 SLV system are being analyzed and are scheduled to begin in 2008; up to four launches per year are planned thereafter.

Existing launch facilities at Omelek Islet are designed to support minimal SLV assembly or processing, with most of the SLV assembly occurring at facilities in California. Several improvements to existing facilities at Omelek are needed to support the project, particularly for the launch capabilities associated with the Falcon 9 SLV upgrades.

Project Description

Project plans call for an assortment of activities including construction of a launch pad and runway designed to accommodate the Falcon 9 SLV; a new hangar facility; a kerosene propellant (RP-1) and water storage and containment facility; a new liquid oxygen, helium and liquid nitrogen storage facility; new propellant line paths and trenching; vegetation removal around both Falcon 1 and Falcon 9 launch pads and at some facility areas; and trenching for water, communication, and power lines. Construction activities will occur in two phases.

Phase One construction will involve relocation of the existing office trailer to the west coast of the islet, adjacent to the harbor and replacement of the trailer with a larger (40- by 80-foot [ft]) facility that will likely be constructed on a concrete pad. Also, the helipad will be moved to the southeastern corner of the islet.

Construction of the Falcon 9 launch pad will occur at the northern tip of the islet. The launch pad will be approximately 20 square feet (ft^2) and the launch stand will be approximately 20 to 35 ft tall. The containment berm, about 50 ft^2 in area and with a maximum capacity of 30,000 gallons of fluids, will be located on the southern side of the launch pad. Additionally, a 200 ft-long by 20 ft-wide runway, about 12 inches thick, will be constructed leading up to the launch pad.

Construction of the launch vehicle processing hangar will occur on the eastern end of Omelek. The rocket assembly hangar will be about 290 ft long and range from 50 to 60 ft wide. The height of the facility will range between 50 ft at its northern end and 65 ft at its southern end.

A storage facility will be constructed for the RP-1 needed for the launch vehicles, as well as diesel for electrical generators. The propellant will be stored in above-ground tanks within a concrete containment area.

Liquid oxygen, helium and nitrogen containers will be located on a concrete pad at the southern end of the islet. The pad will be approximately 40 by 60 ft in area and at least 1 to 3 ft thick.

Most of the vegetation removal will occur at the northern end of the islet at the site of the Falcon 9 launch pad. Vegetation will be removed within a 150-ft radius from the launch pad. Also, some vegetation may be removed within 100 ft of the existing Falcon 1 launch pad. Vegetation will likely be removed at the proposed helipad site, as well as at the site of the proposed Falcon 9 hangar.

During Phase Two construction, the electrical generator facility will be moved to the eastern end of the islet near the RP-1 propellant storage area. Also, trenches will be dug for the burial of conduit for underground power lines.

An existing ordnance storage facility will be demolished and a new storage facility will be constructed in its place. Underground conduits will be laid between this facility and others to run power and communication lines. The conduits will follow an alignment adjacent to the islet's access road. Unimproved paths will be paved with asphalt or concrete. Rainwater drainage and runoff will be routed to vegetated areas or into the existing harbor.

Harbor modifications will include placement of four pilings into soft harbor bottom sediment on the southern side of the harbor. Also, a concrete barge dock, about 20 by 40 ft in area, will be constructed at the shoreline. Approximately 10 ft of the dock will extend into the harbor from the current shoreline. Dredging will not be necessary in order to put these pilings in place or to construct the barge dock. Several other site infrastructure improvements are also planned.

To help understand the potential environmental impacts of the proposed infrastructure changes, the SMDC requested that the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) collaboratively conduct a biological survey of the proposed project area. Data compiled during this survey included the identification of conspicuous marine and terrestrial species and habitats occurring within the potential affected area. Anticipated impacts on these resources, based upon current infrastructure project plans, were assessed and the results are presented in this report. Also included are recommendations on ways to avoid and minimize adverse impacts to fish and wildlife resources and on measures to replace ecological services of resources anticipated to be unavoidably lost as a result of the proposed infrastructure changes. The scope of this investigation was limited to the potential effects of proposed infrastructure changes and did not address potential impacts from Falcon Program launch activities or operations.

SURVEY METHODS

Terrestrial and marine surveys of the proposed project area at Omelek Islet were conducted on December 7, 2006. The terrestrial survey was conducted by USFWS biologist Dr. Holly Freifeld, who documented observations of vegetation and birds on field data sheets and on digital still camera while walking around to each part of the islet. The marine surveyors recorded species and habitat data on sheets of waterproof paper fastened to a clipboard and documented observations on an underwater digital still camera while scuba diving from the shore. Macro-invertebrate, marine alga, and Global Positioning System (GPS) data were collected by USFWS biologist Kevin Foster. Coral data were collected by NMFS biologist Dr. Steve Kolinski. Reef fish data were collected by NMFS biologist Dr. Evelyn Cox. Both the terrestrial and marine surveys were conducted between 0900 and 1600 hours. All photographs that appear in this report were taken by USFWS biologists Foster, Freifeld and Kolinski.

Survey stations were selected based on proposed project construction designs and potential direct and indirect impacts to coral reef resources. For each survey station, a weight (1 pound) tethered to a surface buoy was dropped to mark the survey location. A Global Positioning System (GPS) data point was collected over the 1-pound weight. Biologists descended to the reef substrate and checked the depth of the weight as it rested on the reef. The 0-meter (m) mark of the transect line was then attached to the 1-pound weight. With a compass and depth gauge, the biologists stretched out a transect line, generally laying it along a reef contour at the same depth, and collected reef fish, coral, algae and macro-invertebrate data along the transect line together. A second GPS point was collected at the 25-m mark on the transect line, where transect data collection was terminated. At Survey Station 1, a first 25-m transect line was laid on the reef crest and a second 25-m transect line was laid on the harbor bottom, parallel to the first one. Both transects were oriented in a direction from the inner harbor to the outer harbor. Survey Station 2 was located south of the entrance channel, in a north to south orientation. At Survey Station 2, two 25-m transect lines were laid end-to-end with a 5-m gap between the ends of the lines.

Corals

Reef-building hard corals (Order Scleractinia), non-reef-building hard corals (Order Milleporina), and soft corals (Order Alcyonacea) were surveyed within 10-m-long sections of the 25-m transect lines that were placed on the reef bottom. Two 10-m sections each were surveyed on the inner harbor reef crest and on the inner harbor bottom, and three 10-m sections were surveyed south of the harbor channel. All visible colonies having centers located within 0.5 m of each side of the line within each 10-m section were identified to genera and counted. The same colonies were visually sized into one of eight categories (0 to < 2 centimeters [cm] greatest diameter, 2 to < 5 cm, 5 to < 10 cm, 10 to < 20 cm, 20 to < 40 cm, 40 to < 80 cm, 80 to < 160 cm, and > 160 cm). Colonies were further categorized by growth form. Colonies completely separated by fission were noted, counted and sized by apparent genotype. Unattached fragments were identified and considered as separate individuals. A digital image of benthic substrate was collected at 0.5 m distance every 0.5 m along each 10-m transect line section, and general images of habitat along each transect were collected.

Mean colony densities and percentages of colonies that were fragments, "recent" visible sexual recruits, and large (≥ 10 cm) colonies parted by fission were determined for each site (i.e., inner harbor reef crest, inner harbor bottom, and south of the harbor channel) from the replicate transects. Recent sexual recruits are defined as observed colonies < 5 cm in greatest diameter that did not appear to result from processes of fission or fragmentation. Sexual recruits within this size range might be considered to initially have settled within the previous 5 years under favorable conditions (Kolinski 2004, unpub. data). Data collected from all transects at each site were combined for graphical presentation of colony size distributions. Rugosity (length of 1 cm linked chain draped to conform to substrate topography: 10 m) was measured for each 10-m transect as a general representation of topographic complexity.

Macro-invertebrates

Species Density Data: Conspicuous marine invertebrates were observed and recorded within 0.5 m of each side of the line within the same two 10-m-long sections of the 25-m transect lines that were placed on the reef bottom at each station. Two 10-m transect sections each were surveyed on the inner harbor reef crest and inner harbor bottom, and four 10-m transect sections were surveyed south of the harbor channel. Species targeted for observation included the following: cnidarians (*e.g.*, zoanthids and sea anemones), echinoderms (*e.g.*, sea urchins, sea cucumbers, and sea stars), mollusks (e.g., clams, oysters, sea snails, and octopus), and crustaceans (*e.g.*, hermit crabs, lobsters, large crabs, guard crabs, and shrimp). Along each 10-m transect section, a 1 square meter ($m^{2)}$ area was measured at 1-m intervals, for a total of 10 replicates per transect and 20 replicates per survey station. These data were used to calculate densities of conspicuous mobile (*e.g.*, sea urchin) and sessile (*e.g.*, oysters) organisms. The time allotted for the surveys was too short to employ methodologies aimed at providing accurate estimates of population densities of all macro-invertebrate species present.

Species Presence Data: Qualitative timed-swim surveys were conducted to record observations of conspicuous macro-invertebrates within a larger area. This area included reef substrate within approximately 5 m of each side of the line within the two10-m sections of the 25-m transect lines at each station. This was accomplished by swimming in a non-overlapping zigzag search pattern and recording species present within that area. The timed-swim was conducted for approximately 20 minutes over the combined area encompassed by both 10-m transect sections at each station. The purpose of the timed swim was to document the presence of less abundant species that might not be observed within the smaller 10-m-long transect sections surveyed earlier.

Reef fishes

Reef fish were identified and counted along the same 25-m-long transect lines that were placed on the reef bottom at each station. Each 25-m transect was first surveyed in one direction for larger species occurring within 2 m of each side of each transect line (100 m^2). Smaller species were then surveyed in the opposite direction within 2 m of each side of each transect line (50 m^2). All individual fishes were identified to species when possible, and their body lengths were estimated. Reef fishes were surveyed within only one 2 x 25-m transect area each on the inner harbor reef crest and inner harbor bottom. Reef fishes were surveyed within two 4 x 25-m transect areas south of the harbor channel. The average depth of reef fish observations occurred between 15 and 20 ft.

For each fish species, a length-weight relationship, where $W = a*L^b$, was used to estimate the biomass of each individual fish. The parameters *a* and *b* were obtained from FishBase for each species, or a closely related species of similar morphology if no data were available for the species observed. Because these data are only representative of the actual transects surveyed, data are reported for the total area surveyed at each site. Fish species were classified as herbivore, micro-carnivore, planktivore, or piscivore based on descriptions in Randall (2005) or Myers (1999).

Algae

The survey was conducted to detect the visible presence of conspicuous marine algae. Species of marine algae were identified within four separate areas of reef bottom that were each 10 x 10 m in size. This was accomplished by a surveyor who swam in a zigzag search pattern within 5 m of each side of the same 10-m-long sections of the 25-m transect lines that were placed on the reef bottom at each station.

SURVEY RESULTS

Terrestrial Environment

Southern end of Omelek Islet

This area was found to support a patch of mostly low, littoral shrub vegetation (Whistler and Steele 1999) composed of *Tournefortia argentea* and *Scaevola taccada*, which was approximately 2 to 4 m in height with scattered *Guettarda speciosa* and *Pandanus tectorius* up to approximately 5 m in height (Appendix 1 - Figs. 1-1 and 1-2). The sparse ground layer included the vines *Vigna marina* and *Cassytha filiformis*, the prostrate sub-shrub *Triumfetta procumbens*, and *Cocos* seedlings on the beach side. The substrate beneath this vegetation harbored numerous terrestrial hermit crabs. This vegetation does not provide foraging or resting habitat for migrant shorebirds or waterfowl, but the trees potentially are habitat for nesting white terns (*Gygis alba*) and noddies (*Anous* spp). No seabirds were observed nesting or resting in these trees on the day of the survey.

Southern side of Omelek Islet

On the southern (SSW) side of the existing Falcon 1 launch pad, a littoral forest having a canopy (8-12+ m high) dominated by *Tournefortia* with a large component of *Pisonia grandis* and an under story (3-8 m high) of *Guettarda*, *Terminalia samoensis,* scattered *Cocos nucifera*, and many seedlings of *P. grandis* was seen (Appendix 1 - Figs. 1-3a and b). The seaward edge of this patch was composed of a low, dense fringe of *Tournefortia* and *Scaevola*. Several large individuals of *Pisonia* were noted as an outstanding feature of this area. This patch of forest harbored numerous land crabs (Appendix 1 - Figs. 1-4a and b), terrestrial hermit crabs (Appendix 1 - Fig. 1-5), and the skink *Emoia cyanura*. This forest does not provide foraging or resting habitat for migrant shorebirds or waterfowl, but does provide potential nesting and resting habitat for white terns and noddies. One white tern was observed circling over this forest on the day of the survey. This forest patch already has experienced some alteration. An approximately 25 x 25-m area was cleared of all under story growth and woody debris in an effort to address concerns about the potential for fire caused by launches to jump to the fuel storage tanks located just west of the forest patch. Five minutes of walking parallel lines in both the cleared area (Appendix 1 - Fig. 1-6) and the adjacent uncleared area (Appendix 1 - Fig. 1-7) revealed a distinct paucity of crabs and skinks in the cleared area.

Eastern side of Omelek Islet

The vegetation on the eastern side of the islet was observed to be a fringe of dense *S. taccada* 2 to3 m in height mixed with the vine *Ipomoea macrantha* (Appendix 1 - Fig.1-8a). This fringe was backed by a forest dominated by *Tournefortia* 6 to 8 m in height (Appendix 1 - Fig. 1-8b) that extends almost to the northern end of the islet, an area discussed in greater detail in the following section. This vegetation does not provide habitat for migrant shorebirds or waterfowl, but the forest does provide nesting and/or resting habitat for white terns. At least two pairs of white terns were observed exiting and entering this forest from the seaward (eastern) edge. Similar to other vegetated areas on Omelek, the substrate of this area harbored hermit and land crabs. It should be noted that the cleared area in the immediate vicinity of the Falcon 1 launch pad is typical foraging habitat for migrant shorebirds, although birds are unlikely to use this area during periods of human presence and activity.

Northern end of Omelek Islet

The triangular northern end of the islet was seen to be forested on both sides of the path that runs north-south up its center (Appendix 1 - Fig. 1-9). On the ocean (or eastern) side, this forest was observed to be dominated by *Tournefortia* and toward the northern end by small *Pisonia* trees with lesser amounts of *Guettarda*, *Terminalia*, and *Cocos*. The forest on the western (or lagoon) side of the trail had a greater proportion of *Pisonia* and *Cocos*, and was seen to include *Neisosperma oppositifolium* as well as the other species already identified. The under story of the forest on both sides of the trail appeared to be mostly intact. Similar to other areas on Omelek, the substrate here is home to a variety of crabs and to *Emoia cyanura*. In addition to the two pairs of white terns observed using the forest on the ocean side of the path, a white tern was found incubating an egg in a *Pisonia* tree on the lagoon side (Appendix 1 - Fig. 1-10). The nest was approximately 2.5 m from the ground and 15 m from the northern edge of the forest and the cleared area where the Falcon 9 launch pad is proposed to be built. Included in the proposal is the removal of this forest to 50-100 m south of the islet's tip, and thus, this particular nest site would be lost.

Brown noddies (*Anous stolidus*) likely also use this forest; on the day of the survey, one individual was observed circling the lagoon side of the forest, approaching various *Cocos* trees, and calling intermittently for roughly 45 minutes. This behavior is highly suggestive of prospecting for nest sites or perhaps approaching an existing site attended by a mate. Brown noddies are known to nest in *Cocos* trees elsewhere at Kwajalein Atoll (*e.g.*, Illeginni and Eniwetak islets).

Low and prostrate vegetation dominated by *Lepturus* sp. and other grasses, the sedge *Fimbristylis cymosa*, the vines *Vigna marina* and *Ipomoaea pes-caprae*, and the alien herb *Phyla nodiflora*, and surrounded by a fringe of *Scaevola*, was observed to cover the northernmost tip of the islet (Appendix 1 - Fig. 1-11). This area also has an old concrete pad. The low, open vegetation in this area provides foraging habitat and the concrete pad provides resting habitat for migrant shorebirds.

Marine Environment

Inner Harbor Reef Crest (shallow coral reef adjacent to southern jetty)

Two-hundred-thirty-six scleractinian, 15 milleporinid, and 17 alcyonacean coral colonies representing eight genera and nine general growth forms were recorded across the edge of a topographically complex reef crest (rugosity = 1.30 ± 0.07 S.E. on crest top) at 0 to 1 m depth (Table 1a, Figure 1, and Appendix 2 Figs. 2-1 through 2-4). Corymbose *Acropora* (represented mainly by *A. digitifera*) dominated colony densities. Sixty-two percent of surveyed colonies (167 corals) were < 20 cm in greatest diameter and 4 % were ≥ 80 cm. Fragmentation was evident in four of the genera-functional form groups and on average represented 12 % of colonies. Recent sexual recruits (within 5 years) appeared evident in 45 % of the genera-functional form categories and averaged 11%. Nineteen percent of colonies ≥ 10 cm (9.3 % ± 1.7 S.E. of all colonies) were completely parted by fission. Mortality in colonies completely parted by fission averaged 51 % (± 5 S.E, range = 10 to 98 %, n = 25). Coral community development along this crest and adjoining flat appeared limited mainly by exposure at low tides.

Ten species from 10 families of non-coral macro-invertebrates were recorded at this site (Table 2a). Several species of sponges, *Chelonaplysilla* sp, *Acanthella* sp, *Haliclona* sp, and *Dysidea granulosa*, were observed in crevices and under small ledges. Crustaceans, such as the candy cane shrimp (*Stenopus hispidus*), and the swimming crab (*Portunus* sp) were observed under small ledges. Mobile snails, *Trochus niloticus* (0.03m^2) and *Conus flavidus* (0.06 m^2) were observed in small crevices (Table 2b). Small sessile giant clams, *Tridacna maxima* (0.02 m^2), were observed attached to small rocks. The abundance of other observed macro-invertebrates was very low.

Thirteen reef fish species from five families were observed along this transect, running along the crest of the reef flat (Table 3a). The most numerous fish were juvenile wrasses (Labridae), followed by the surgeonfish *Acanthurus nigrofuscus*. Over half of the biomass consisted of this surgeonfish and the damselfish *Plectroglyphidodon dickii* (Table 3a).

Four species from four families of marine algae were recorded at this site (Table 4). Two species of green algae (*Bryopsis pennata* and *Halimeda opuntia*), one species of blue-green algae (*Lyngbya* sp), and turf algae were recorded along this transect.

Inner Harbor Bottom (*adjacent to shallow coral reef and southern jetty*)

Fifteen scleractinian coral colonies representing five genera and four general growth forms were recorded across relatively flat (rugosity = 1.06 ± 0.01 S.E.) sand substrate at 4 m depth (Table 1b, Figure 2 and Appendix 2 - Figs. 2-5 through 2-8). Massive *Lobophyllia* and encrusting *Pavona* dominated colony densities. Thirty-three percent of surveyed colonies (5 corals) were < 20 cm in greatest diameter and 1 % (2 colonies) ≥ 80 cm. There was no evidence of recent sexual recruitment or fragmentation. Complete fission was noted in *Lobophyllia* and *Pavona* and did not occur in colonies < 10 cm. Mortality in colonies completely parted by fission averaged 23 % ± 8 S.E. (range = 10 to 40 %, n = 4). Population development along this area of harbor bottom appeared limited by available substrate for sexual recruitment and low rates of expansion by fragmentation.

Six species from six families of non-coral macro-invertebrates were recorded at this site (Table 2a). A single sponge species, *Axinyssa* sp, was observed attached to small rocks on the sandy harbor bottom. The mollusks, *Tonna perdix*, *Isognomon* sp, and *Spondylus* sp, were observed near the mouth of the harbor. The mantis fighting shrimp, *Gonodactylus* sp (0.075 m^2) (Table 2b), was observed in a small bore hole in sand habitat.

Ten reef fish species from five families were observed along the base of the reef (Table 3b). The most numerous fish were the damselfishes *Chromis viridis* and *Dascyllus aruanus*, and juvenile wrasses. Over half of the biomass consisted of the damselfishes *Chrysiptera biocellata*, and *Dascyllus aruanus*, and the goatfish *Parupeneus barberinus*.

Four species from four families of marine algae were recorded at this site (Table 4). Two species of green algae (*Neomeris annulata* and *Halimeda discoidea*), one species of blue-green algae (*Lyngbya* sp), and turf algae were record along this transect.

Reef South of Harbor Channel (lagoon side coral reef)

A total of 479 scleractinian, 23 milliporinid, and 16 alcyonacean corals representing 17 genera and 14 general growth forms were recorded across topographically complex (rugosity = 1.47 ± 0.06 S.E.) coral reef flat substrate at approximately 4.5 m depth (Table 1c, Figure 3, and Appendix 2 - Figs. 2-9 through 2-12). Arborescent and corymbose forms of *Acropora* dominated colony densities. Fifty-nine percent of surveyed colonies (306 corals) were < 20 cm in greatest diameter and 13 % were < 5 cm. Two percent of colonies exceeded 80 cm diameter. Fragments on average accounted for 28 % of observed colonies and dominated colony abundance in arborescent *Acropora*. Recent (within 5 years) sexual recruitment appeared evident in 56 % of observed genera-functional form groups. Only 3 % of colonies ≥ 10 cm (2.6 % ± 0.4 S.E. of all colonies) were completely parted by fission. Mortality in colonies completely parted by fission averaged 45 % (± 6 % S.E., range = 5 to 90 %, n = 13).

Fifteen species from ten families of non-coral macro-invertebrates were recorded at this site (Table 2a). Two sponge species, *Stylissa* sp and *Axinyssa* sp, were observed in crevices. Several mobile mollusks, such as *Trochus niloticus* (0.04 m^2), *T. maculata* (0.04 m^2), *Lambis lambis* (0.01 m^2), *L. truncata* (0.02 m^2), *Crypraea tigris* (0.01 m^2), as well as the sessile mollusks *Tridacna maxima* (0.14 m^2) and *T. squamosa* (0.02 m^2), were observed along this transect (Table 2b), suggesting good reproductive capacity for mollusks. The boring urchins

Echinostrephus acciculatus (0.05 m^2) and *Echinometra mathaei* (0.05 m^2) were observed within a mixed coral community.

Twenty-eight reef fish species from 11 families were observed on the reef just south of the harbor entrance (Table 3c). The most numerous fish on these transects were the damselfishes *Plectroglyphidodon lacrymatus*, *Pamacentrus vaiuli* and *Amblyglyphidodon curacao*, and juvenile wrasses. Species recorded on these transects cannot be considered completely representative of the larger area, as just below the transect area there were large schools of the snapper *Lutjanus gibbus*, the emperor *Monotaxis grandoculis*, rudderfishes (Kyphosidae) and parrotfishes (Scaridae), among other species observed in an non-exhaustive species survey following the transect data collection (Table 3c). Over half of the biomass consisted of the surgeonfish *Naso literatus*, the snapper *Lutjanus monostigma* and the parrotfish *Chlorurus microrhinos*. Overall, 62% of the biomass was contained within the herbivore tropic group, followed by 16.5% piscivore, 12.1% micro-carnivore, and 9.3% planktivore.

Twelve species from nine families of marine plants were recorded at this site (Table 4). One species of brown algae (*Turbinaria ornata*), nine species of green algae (*Bryopsis pennata*, *Caulerpa racemosa*, *Neomeris annulata*, *Halimeda discoidea*, *H. micronesica*, *H. opuntia*, *Avrainvillea amadelpha*, *Tydemania expeditionis*, and *Valonia fastigiata*), turf algae and one species of blue-green algae (*Schizothrix* sp) were record along this transect.

PROJECT IMPACTS AND MITIGATION RECOMMENDATIONS

If implemented, the proposed project will modify most terrestrial areas of Omelek Islet through the construction of launch support facilities at southern, eastern, northern and central locations of the islet. The proposed project will also result in the filling of a portion of the harbor bottom and southern harbor shoreline with new pilings and a dock structure, and it will also impact the reef community south of the harbor channel, particularly shallow corals during low tides, from the collection and diversion of runoff into the harbor if southerly currents prevail. A summary of anticipated project-related impacts to terrestrial and marine habitat from the Falcon 1 and 9 launch-related facility improvements, provided by SpaceX staff, is presented in Table 5.

Terrestrial Impacts

Littoral forest habitats, littoral shrub vegetation, and important native species will be unavoidably lost due to project construction-related activities at Omelek. We anticipate about 26,850 ft^2 of Littoral Shrub Habitat will be lost on Omelek due to a variety of activities, which include construction of the Office Trailer, New Helicopter Pad, Falcon 9 Launch Pad, Falcon 9 Hangar, RP-1 fuel/storage/containment, Liquid oxygen-helium-nitrogen containment site and additional vegetation removal around the Falcon 1 Launch Pad. Also, we anticipate the loss of about 15,000 ft^2 of Littoral Forest due to the construction of a New Helicopter Pad, Falcon 9 Launch Pad, and additional vegetation removal around the Falcon 1 Launch Pad (South Side). Total loss of Littoral Shrub and Littoral Forest Habitat at Omelek Islet is estimated to be approximately 41,850 ft^2. The active seabird nesting site that was located approximately 15 m from the northern edge of the forest and the cleared area where the proposed Falcon 9 launch pad would be built will be lost.

Therefore, we recommend that the project proponent compensate for these unavoidable losses of terrestrial resources at the project site. Enhancement of degraded migratory bird habitat is one way to compensate for the anticipated project-related loss of the ecological functions associated with the terrestrial habitat that will be unavoidably lost on Omelek. Since Space-X activities are likely to become so pervasive on Omelek, we recommend that a suitable off-site location for compensatory mitigation actions be identified. Appropriate compensatory mitigation actions could include: (1) removal of abandoned buildings and debris to restore migratory bird resting and nesting habitat; (2) removal of alien species (*e.g.*, rodents and vegetation) to improve conditions for seabirds; (3) Transplantation of certain native trees from Omelek to a suitable USAKA islet to offset lost functions.

While the compensatory mitigation actions identified above are considered acceptable, any action selected should be scaled to an appropriate amount before being implemented to assure that the implemented mitigation achieves its intended goal of offsetting project-related resource losses. We also recommend that final selection of compensatory mitigation actions appropriate for the proposed project be addressed in the project's Document of Environmental Protection (DEP).

Marine Impacts

The proposed project will also result in the filling of a portion of the harbor bottom and southern harbor shoreline with new pilings and a dock structure. Permanent loss of 408 ft^2 of habitat and benthic organisms (*i.e.*, corals, non-coral macro-invertebrates, and algae) on the harbor reef crest is anticipated to result from these project activities. The enhancement of degraded coral reef habitat is one way to compensate for the anticipated project-related resource losses associated with the harbor reef crest community.

Since the anticipated project-related loss of marine habitat is relatively small and since the habitat is currently influenced by existing harbor activities, we recommend implementation of two relatively simple actions to offset these losses. These actions include: (1) removal of metal debris, abandoned fishing nets, and other debris from the abandoned quarry at Omelek (USAKA Biennial Inventory Station OM-1); (2) removal of several large batteries, currently on the Omelek harbor bottom. We recommend that all debris removal activities be coordinated through the USAKA Environmental Office and conducted in a manner that does not result in direct or indirect adverse impacts to coral reef resources. Protocols for debris removal should be developed and incorporated into the final project design, with emphasis on avoidance of unnecessary impacts and minimization of unavoidable impacts to the point of insignificance. We also recommend that post-debris removal site inspections be coordinated through the USAKA Environmental Office to ensure debris removal activities were performed as planned. These measures should be described in the project DEP and incorporated into the project when implemented.

In addition, indirect impacts to 215 ft^2 of coral reef habitat are anticipated from the diversion of rainwater runoff into the harbor from hardening (*i.e.*, paving) various areas on the islet.

This runoff will impact the harbor reef crest community and also the reef community south of the harbor channel, particularly corals at shallow depths during low tides, if southerly currents prevail. Evidence of recent coral recruitment noted during the survey suggested some potential for elements of these reef communities to recover if runoff impacts are infrequent.

Nevertheless, recovery of impacted reef communities may be delayed or prevented if rainwater diverted into the harbor is contaminated. Since it is assumed that USAKA will require controls to prevent serious contamination from runoff, impacts from runoff are expected to be temporary and not significant. We recommend that runoff be collected in basins or diverted into the ground and allowed to percolate to the groundwater to reduce the effects of runoff on the adjacent coral reef communities. Implementation of these actions in a manner consistent with the USAKA Environmental Standards should offset project-related impacts to coral reef resources within Omelek Harbor and we recommend that their implementation be addressed in the project DEP.

Best Management Practices

Lastly, we recommend the following conservation measures to minimize the degradation of the coastal water quality and impacts to fish and wildlife resources and habitats. These measures should be incorporated into the project and included within the project DEP. The measures include:

- Turbidity and siltation from piling and dock construction removal shall be minimized and contained to within the vicinity of the site through the appropriate use of effective silt containment devices and the curtailment of work during adverse tidal and weather conditions;

- Dredging/filling in the marine environment shall be scheduled to avoid coral spawning and recruitment periods (*i.e.*, June – August);

- All project-related materials and equipment (dredges, barges, backhoes etc) to be placed in the water shall be cleaned of pollutants prior to use;

- No project-related materials (fill, revetment rock, pipe etc.) shall be stockpiled in the water (intertidal zones etc.);

- No contamination (trash or debris disposal, alien species introductions etc.) of adjacent marine environments (lagoon or seaward reef flats etc.) shall result from project-related activities;

- Fueling of project-related vehicles and equipment shall take place away from the water and a contingency plan to control petroleum products accidentally spilled during the project shall be developed. Absorbent pads and containment booms shall be stored on-site, if appropriate, to facilitate the clean-up of accidental petroleum releases; and

- All debris and material for disposal shall be disposed of at a designated site that is acceptable to the USAKA Environmental Office, as appropriate.

CONCLUSION

If implemented, it is anticipated that the proposed project will result in the loss of some terrestrial migratory bird habitat (Herbaceous Strand) comprised of Littoral Shrub and Littoral Forest habitats, and some marine habitat (Coral Reef Ecosystem) at Omelek Islet. Specifically, it is estimated that project related losses will include approximately 45,000 ft^2 of Herbaceous Strand habitat (*i.e.*, 26,850 ft^2 of Littoral Shrub and 15,000 ft^2 of Littoral Forest) and 623 ft^2 of marine habitat (*i.e.*, 8 ft^2 of sand flat and 615 ft^2 of shoreline and coral reef). Although sea turtles are known to exist in the waters around Omelek Islet, loss of sea turtle nesting habitat is not expected. Compensatory mitigation to replace project-related resource losses is warranted and several potential compensatory mitigation actions have been identified. It is recommended that specific compensatory mitigation action(s) selected for implementation be scaled to an appropriate level and addressed in detail in the project DEP. Several Best Management Practices to minimize the degradation of coastal water quality and impacts to fish and wildlife resources and habitats have been recommended for inclusion in the project DEP.

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U.S. Fish and Wildlife Service. 1981. U.S. Fish and Wildlife Service Mitigation Policy. Federal Register (46) 15: 7644-7663.

Table 1a. Inner Harbor (Station 1) Reef Crest: Coral species observed and average (± S.E.) values for coral species measured in two 10 m^2 transects (T1 and T2) along the inner harbor reef crest, Omelek Islet, USAKA, Republic of the Marshall Islands on December 7, 2006.

Genus-form	T1	T2	No. Colonies m^{-2}	% Colonies Observed as Fragments	% Recent Sexual Recruits (% attached colonies < 5 cm)	% Colonies ≥ 10 cm parted by fission
Acropora						
arborescent	0	3	0.15 ± 0.15	33.3	0	0
corymbose	59	76	6.75 ± 0.85	15.7 ± 1.2	5.9 ± 5.9	15.4 ± 7.9
small branching	7	25	1.60 ± 0.90	28.6 ± 28.6	12.0 ± 12.0	16.7 ± 16.7
unknown	2	0	0.10 ± 0.10	0	100	
Fungia						
Disc	0	1	0.05 ± 0.05	0	0	
Lobophyllia						
Massive	2	5	0.35 ± 0.15	20.0 ± 20.0	0	0
Millepora						
encrusting	7	8	0.75 ± 0.05	0	13.4 ± 0.9	0
Montipora						
encrusting	5	4	0.45 ± 0.05	0	0	45.8 ± 20.8
Pavona						
encrusting	1	3	0.20 ± 0.10	0	0	50.0 ± 50.0
Laminar	0	3	0.15 ± 0.15	0	0	0
Pocillopora						
small branching	36	4	2.00 ± 1.60	0	19.4	35.9 ± 2.6
Sinularia						
Soft	17	0	0.85 ± 0.85	0	35.3	0
Total	**136**	**132**	**13.40 ± 0.20**	**11.6 ± 0.9**	**11.1 ± 5.8**	**18.8 ± 7.5**

Table 1b. Inner Harbor (Station 1) Bottom: Coral species observed and average (± S.E.) values for coral species measured in two 10 m^2 transects (T-1 and T-2) along the inner harbor bottom, Omelek Islet, USAKA, Republic of the Marshall Islands on December 7, 2006.

Genus-form	T1	T2	No. Colonies m^{-2}	% Colonies Observed as Fragments	% Recent Sexual Recruits (% attached colonies < 5 cm)	% Colonies ≥ 10 cm parted by fission
Acropora						
arborescent	1	0	0.05 ± 0.05	0	0	0
corymbose	0	1	0.05 ± 0.05	0	0	0
Lobophyllia						
Massive	0	5	0.25 ± 0.25	0	0	40
Millepora						
encrusting	0	3	0.15 ± 0.15	0	0	0
Montipora						
encrusting	0	1	0.05 ± 0.05	0	0	0
Pavona						
encrusting	0	4	0.20 ± 0.20	0	0	50
Total	**1**	**14**	**0.75 ± 0.65**	**0**	**0**	**14.3 ± 14.3**

Table 1c. Reef South of Harbor Channel (Survey Station 2): Coral species observed average (± S.E.) values for coral species measured in three 10 m^2 transects (T-1, T-2, and T-3) representing reef flat south of the harbor channel, Omelek Islet, USAKA, Republic of the Marshall Islands on December 7, 2006.

Genus-form	T1	T2	T3	No. Colonies m^{-2}	% Colonies Observed as Fragments	% Recent Sexual Recruits (% attached colonies < 5 cm)	% Colonies ≥ 10 cm parted by fission
Acropora							
arborescent	53	83	59	6.50 ± 0.92	67.2 ± 2.4	2.5 ± 1.2	4.7 ± 2.5
corymbose	65	24	35	4.13 ± 1.23	4.6 ± 4.6	19.5 ± 2.6	1.9 ± 1.9
digitate	1	2	2	0.17 ± 0.03	0	16.7 ± 16.7	0
encrusting	0	1	0	0.03 ± 0.03	0		0
hispidose	19	22	3	1.47 ± 0.59	9.6 ± 5.3	7.6 ± 7.6	14.9 ± 9.2
table	12	2	2	0.53 ± 0.33	0	16.7 ± 16.7	0
Alveopora							
columnar	5	5	4	0.47 ± 0.03	0	15.0 ± 7.6	6.7 ± 6.7
Astreopora							
submassive	0	0	1	0.03 ± 0.03	0	0	0
Cyphastrea							
encrusting	0	0	1	0.03 ± 0.03	0	0	0
Favia							
submassive	3	0	0	0.10 ± 0.10	0	0	0
Favites							
submassive	1	0	0	0.03 ± 0.03	0	0	0
encrusting	0	1	0	0.03 ± 0.03	0	0	0
Fungia							
disk	11	2	3	0.53 ± 0.28	0	33.8 ± 9.2	0
Goniastrea							
submassive	0	1	0	0.03 ± 0.03	0	100	0
Millepora							
encrusting	12	10	1	0.77 ± 0.34	0	0	0
Montipora							
encrusting	6	9	18	1.10 ± 0.36	0	1.9 ± 1.9	3.7 ± 3.7
laminar	0	0	1	0.03 ± 0.03	0	0	0
Pavona							
encrusting	10	0	1	0.37 ± 0.32	0	15.0 ± 15.0	0
Pocillopora							
small branching	0	3	0	0.10 ± 0.10	0	33.3	0
cauliflower	2	0	2	0.13 ± 0.07	0	50.0 ± 50.0	0
Porites							
massive	0	0	1	0.03 ± 0.03	0	0	0
Sarcophytum							
soft	7	0	0	0.23 ± 0.23	0	14.3	0
Seriatopora							
small branching	1	0	1	0.07 ± 0.03	0	0	0
Sinularia							
soft	0	2	7	0.30 ± 0.36	0	21.4 ± 21.4	0
Stylophora							
cauliflower	0	1	0	0.03 ± 0.03	0	0	0
Total	**204**	**168**	**146**	**17.27 ± 1.69**	**28.0 ± 4.5**	**11.4 ± 2.2**	**3.3 ± 0.6**

Table 2a. Inner Harbor (Survey Station 1) and Reef South of Harbor Channel (Survey Station 2): Macro-invertebrate species observed at two survey stations at Omelek Islet, USAKA, Republic of the Marshall Islands on December 7, 2006.

FAMILY	SURVEY STATIONS (SS) and TRANSECTS (T)		
Genus/species	SS1 (T1)	SS1 (T2)	SS 2
DARWINELLIDAE			
Chelonaplysilla sp (orange/red)	x		
Haliclona osiris			
AXINELLIDAE			
Acanthella sp	x		
Stylissa sp			x
HALICHONDRIIDAE			
Axinyssa sp		x	x
Haliclona sp	x		
DYSIDEIDAE			
Dysidea granulosa	x		
SERPULIDAE			
Unidentified marine worm		x	
TROCHIDAE			
Trochus niloticus	x		x
T. maculata			x
TURBINIDAE			
Turbo argyrostoma			x
CYPRAEIDAE			
Cypraea tigris			x
VERMITIDAE			
Serpulorbis sp			x
CYPRAEIDAE			
Cypraea tigris			x
STROMBIDAE			
Lambis lambis			x
L. truncata			x
TONNIDAE			
Tonna perdix		x	
MURICIDAE			
Drupa morum	x		

Table 2a. Continued.

FAMILY *Genus/species*	SURVEY STATIONS (SS) and TRANSECTS (T) SS1 (T1)	SS1 (T2)	SS 2
CONIDAE			
Conus flavidus	x		
ISOGNOMONIDAE			
Isognomon sp		x	
PINNIDAE			
Pedum spondyloideum			x
SPONDYLIDAE			
Spondylus sp		x	
TRIDACNIDAE			
Tridacna maxima	x		x
T. squamosa			x
GONODACTYLOIDEA			
Gonodactylus sp		x	
STENOPODIDAE			
Stenopus hispidus	x		
PORTUNIDAE			
Portunus sp	x		
ECHINOMETRIDAE			
Echinometra mathaei			x
Echinostrephus acciculatus			x
Total Families per Survey Transect:	10	6	10
Total Species per Survey Transect:	10	6	15

Note:
SS1 = Survey Station 1 = Inner Harbor
SS2 = Survey Station 2 = Reef South of Harbor Channel
T1 = Transect on Inner Harbor Reef Crest
T2 = Transect on Inner Harbor Bottom

Table 2b. Inner Harbor (Survey Station 1) and Reef South of Harbor Channel (Survey Station 2): Macroinvertebrate species abundance at two survey stations at Omelek Islet, USAKA, Republic of the Marshall Islands on December 7, 2006.

PHYLUM	SURVEY STATIONS (SS) and TRANSECTS (T)		
Genus/species	SS1 (T1)	SS1 (T2)	SS 2
Mollusca			
Trochus niloticus	0.03	0	0.04
Trochus maculata	0	0	0.04
Lambis lambis	0	0	0.01
L. truncata	0	0	0.02
Cypraea tigris	0	0	0.01
Conus flavidus	0.06	0	0
Tridacna maxima	0.02	0	0.14
Tridacna squamosa	0	0	0.02
ARTHROPODA			
Gonodactylus sp	0	0.075	0
Echinodermata-Echinoids			
Echinostrephus acciculatus	0	0	0.05
Echinometra mathaei	0	0	0.05

Note 1:
Data in the table represent the average number of observations per square meter.

Note 2:
SS1 = Survey Station 1 = Inner Harbor
SS2 = Survey Station 2 = Reef Flat South of Harbor Channel
T1 = Inner Harbor Reef Crest
T2 = Inner Harbor Bottom

Table 3a. Inner Harbor (Survey Station 1) Reef Crest: Reef fish species observed on the inner harbor reef crest at Omelek Islet, USAKA, Republic of the Marshall Islands on December 7, 2006.

FAMILY **Species**	**Number of individuals 50m^{-2}**	**Biomass (g 50m^{-2})**
ACANTHURIDAE		
Acanthurus nigrofuscus	3	146
CHAETODONTIDAE		
Chaetodon citrinellus	1	25
LABRIDAE		
Juvenile wrasses	11	0.27
Gomphosus varius	2	25
Halichoeres hortulanus	2	28
Labropsis micronesica	1	10
Labroides dimidiatus	1	0.01
Thalassoma hardwicki	1	2.0
POMACENTRIDAE		0.02
Chrysiptera biocellata	1	68
Plectroglyphidodon dickii	2	3.5
Pomacentrus vaiuli	1	
Stegastes fasciolatus	1	27
SERRANIDAE		
Epinephelus merra	1	49
TOTAL	28	384

Table 3b. Inner Harbor (Survey Station 1) Bottom: Reef fish species observed on the inner harbor bottom at Omelek Islet, USAKA, Republic of the Marshall Islands on December 7, 2006.

FAMILY **Species**	**Number of individuals $50m^{-2}$**	**Biomass (g $50m^{-2}$)**
GOBIIDAE		
Amblygobius phalaena	7	27
Goby sp. 1	4	15
Goby sp. 2	4	27
LABRIDAE		
Juvenile wrasses	10	0.25
Halichoeres tramaculatus	2	17
MULLIDAE		
Parupeneus barberinus	1	41
POMACENTRIDAE		
Chromis viridis	45	34
Chrysiptera biocellata	3	48
Dascyllus aruanus	15	41
NEMIPTERIDAE		
Scolopsis lineata	3	6.8
TOTAL	94	257

Table 3c: Reef South of Harbor Channel (Survey Station 2): Reef fish species observed on the reef flat south of the harbor entrance channel at Omelek Islet, USAKA, Republic of the Marshall Islands on December 7, 2006. Figures represent the mean of data collected on two transects.

FAMILY **Species**	**Number of individuals 200m^{-2}** **mean ± s.e.**	**Biomass (g 200m^{-2})** **mean ± s.e**
ACANTHURIDAE		
Acanthurus nigrofuscus	14 ± 14	1210 ± 1210
Naso brevirostris	1 ± 1	310 ± 310
N. literatus	6 ± 2	3510 ± 2530
CHAETODONTIDAE		
Chaetodon lunulatus	4 ± 4	314 ± 314
CIRRHITIDAE		
Paracirrhites arcatus	2 ± 2	34 ± 34
LABRIDAE		
Juvenile wrasses	16 ± 16	0.39 ± 0.39
Gomphosus varius	6 ± 6	11 ± 11
Halichoeres hortulanus	6 ± 2	151 ± 96
Labrichthys unilineatus	2 ± 2	68 ± 68
Labroides dimidiatus	2 ± 2	2.2 ± 2.2
Labropsis micronesica	4 ± 0	39 ± 0
LETHRINIDAE		
Gnathodentex aurolineatus	6 ± 60	297 ± 297
LUTJANIDAE		
Lutjanus monostigma	1 ± 1	2330 ± 2330
MONACANTHIDAE		
Oxymonacanthus longirostris	4 ± 4	53 ± 53
POMACANTHIDAE		
Centropyge flavissima	2 ± 2	55 ± 55
Pygoplites diacanthus	2 ± 2	442 ± 442
POMACENTRIDAE		
Amblyglyphidodon curacao	16 ± 0	980 ± 51
Chromis viridis	2 ± 2	34 ± 34
Plectroglyphidodon johnstonianus	4 ± 4	137 ± 137
P. lacrymatus	30 ± 2	970 ± 10
Pomacentrus brachialis	2 ± 2	46 ± 46
P. vaiuli	18 ± 6	580 ± 95
SCARIDAE		
Cetoscarus bicolor	2 ± 2	490 ± 490
Chlororus microrhinos	3 ± 1	1530 ± 256
C. sordidus	1 ± 1	155 ± 155
Scarus frenatus	1 ± 1	360 ± 360
SERRANIDAE		
Epinephelus merra	2 ± 2	31 ± 31
TETRAODONTIDAE		
Arothron nigropunctatus	2 ± 2	180 ± 180
TOTAL	161	13,784

Table 3c. Continued

ADDITIONAL SPECIES SEEN IN AREA:
ACANTHURIDAE
Acanthurus lineatus
Zebrasoma scopas
BALISTIDAE
Balistoides viridescens
CARANGIDAE
Caranx melampygus
CHAETODONTIDAE
Chaetodon trifascialis
C. reticulates
KYPHOSIDAE
Kyphosus sp.
LABRIDAE
Cheilinus undulatus
Labroides bicolor
Stethojulis bandanensis
Thalassoma lutescens
LETHRINIDAE
Monotaxis grandoculis
LUTJANIDAE
Lutjanus gibbus
Macolor macularis
M. niger
MULLIDAE
Upeneus sp.
SERRANIDAE
Plectropomus laevis
SIGANIDAE
Siganus sp.

Table 4. Inner Harbor (Survey Station 1) and Reef South of Harbor Channel (Survey Station 2): Marine plnat species observed at two survey stations at Omelek Islet, USAKA, Republic of the Marshall Islands on December 7, 2006.

PHYLUM **FAMILY** *Genus/species*	SURVEY STATIONS (SS) and TRANSECTS (T) SS1 (T1)	 SS1 (T2)	 SS2
PHAEOPHYTA (Brown Algae)			
SARGASSACEAE			
Turbinaria ornata			x
CHLOROPHYTA (Green Algae)			
BRYOPSIDACEAE			
Bryopsis pennata	x		x
CAULERPACEAE			
Caulerpa racemosa			x
DASYCLADACEAE			
Neomeris annulata		x	x
HALIMEDACEAE			
Halimeda discoidea		x	x
H. micronesica			x
H. opuntia	x		x
UDOTEACEAE			
Avrainvillea amadelpha			x
Tydemania expeditionis			x
VALONIACEAE			
Valonia fastigiata			x
Unidentified turf algae	x	x	x
CYANOPHYTA (Blue-green Algae)			
OSCILLATORIALES			
Lyngbya sp	x	x	
SCHIZOTHRICHAECEAE			
Schizothrix sp			x
Total Families per Survey Transect:	4	4	9
Total Species per Survey Transect:	4	4	12

Note:
SS1 = Survey Station 1 = Inner Harbor
SS2 = Survey Station 2 = Reef South of Harbor Channel
T1 = Transect on Inner Harbor Reef Crest
T2 = Transect on Inner Harbor Bottom

Table 5. Summary of anticipated project-related impacts to terrestrial and marine habitat from the Falcon 1 and 9 launch-related facility improvements based on information obtained from Space-X staff.

Construction Activity		Area of Impact	Habitat Type
(1)	Office Trailer	500 ft^2	Littoral Shrub*
(2)	New Helicopter Pad	6,000 ft^2	Littoral Forest**
		4,000 ft^2	Littoral Shrub
(3)	Falcon 9 Launch Site		
	(a) Launch Pad	20 ft^2	
	(b) Containment berm	2,500 ft^2	
	(c) Runway	4,000 ft^2	
	(d) Vegetation removal	4,000 ft^2	Littoral Forest
		12,000 ft^2	Littoral Shrub
(4)	Falcon 9 Hangar	1,000 ft^2	Littoral Shrub
(5)	RP-1 fuel/storage/containment	3,850 ft^2	Littoral Shrub
(6)	Liquid oxygen/helium/nitrogen containment site	500 ft^2	Littoral Shrub
(7a.)	Falcon 1 Launch Pad (South Side) Vegetation Removal	5,000 ft^2	Littoral Forest
(7b.)	Falcon 1 Launch Pad (North Side) Vegetation Removal	5,000 ft^2	Littoral Shrub
	Subtotal (Shrub)	**26,850 ft^2**	
	Subtotal (Forest)	**15,000 ft^2**	
(8)	Paving unimproved paths	45,000 ft^2	Herbaceous Strand
	Subtotal (Strand)	**45,000 ft^2**	
(9)	Harbor modifications		
	Pilings (2 ft diameter x 4 pilings)	8 ft^2	Sand
	Dock	400 ft^2	Shoreline and Shallow Reef habitat
	Rainwater runoff diverted into harbor (1.8 million gallons per year)	215 ft^2	Shallow Coral Reef
	Subtotal (Sand)	**8 ft^2**	
	Subtotal (Shore/Reef)	**615 ft^2**	

Note: *(*e.g.*, *Tournefortia argentea*, *Scaevola taccada*)
**(*e.g.*, *Tournefortia*, *Pisonia grandis*, *Guettarda speciosa*, *Terminalia samoensis*, *Cocos nucifera*)

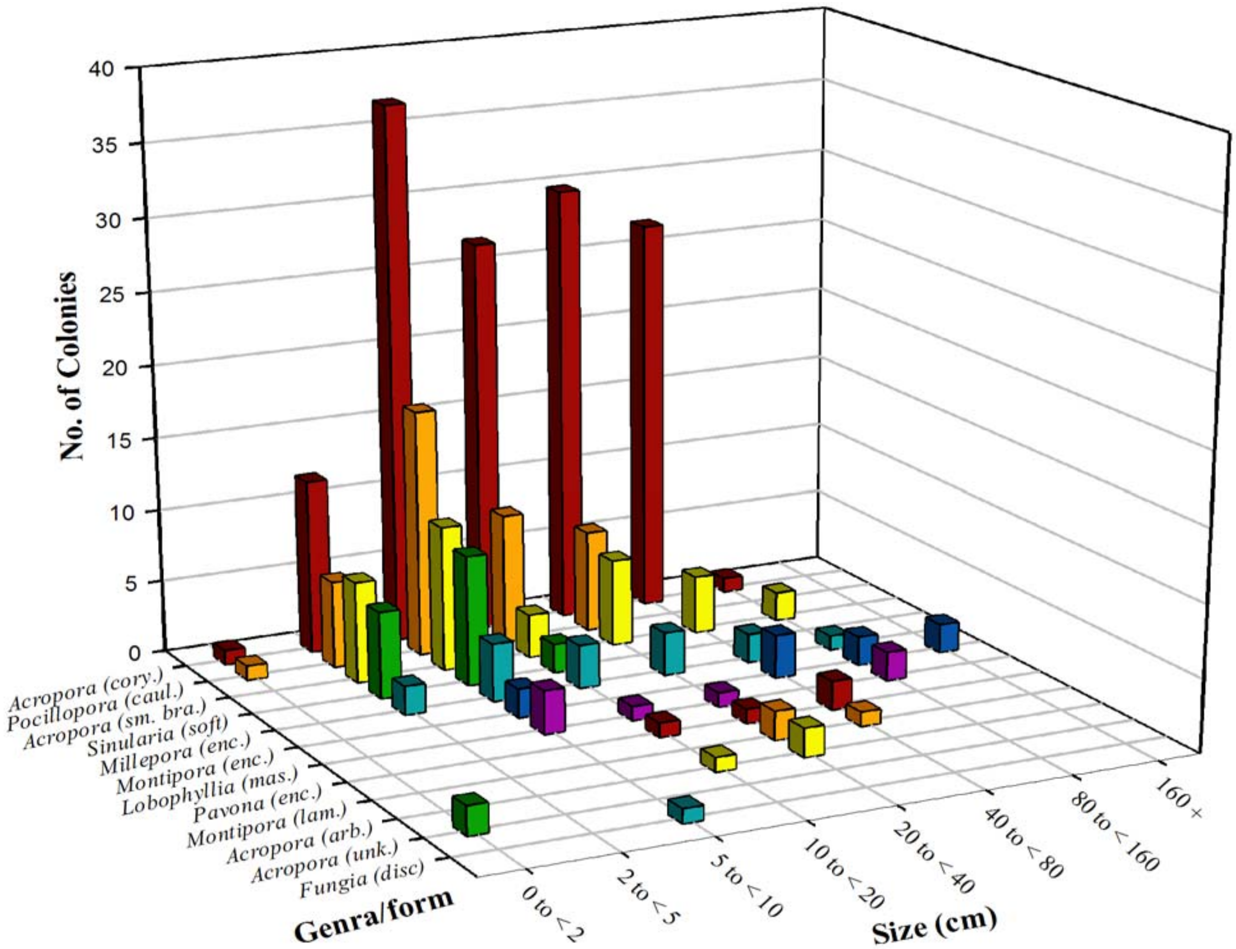


Figure 1. Size distributions of coral colonies by genera and form along two 10 m^2 transects, Survey Station 1(Inner Harbor Reef Crest), Omelek Islet, USAKA on December 7, 2006. Note: cory = corymbose, caul = cauliflower, sm. bra. = small branching, enc. = encrusting, mas = massive, lam = laminar, arb. = arborescent, unk. = unknown.

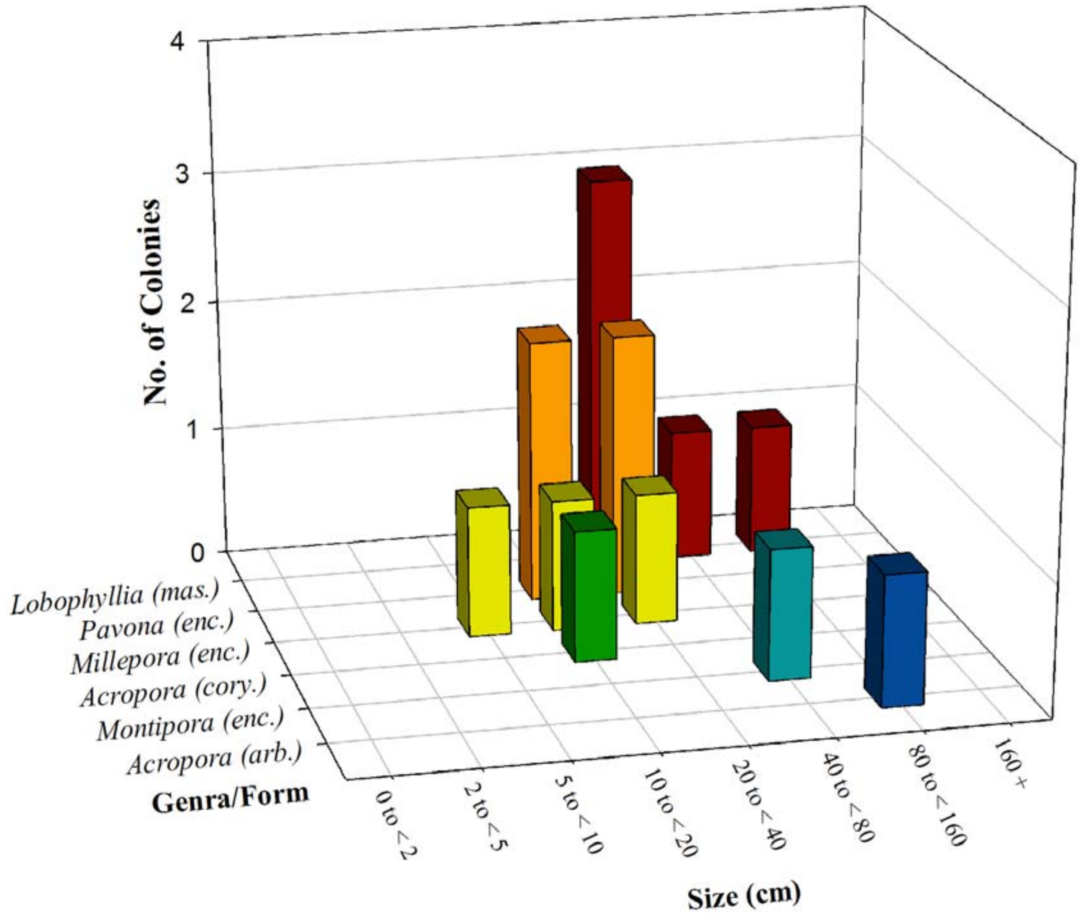


Figure 2. Size distributions of coral colonies by genera and form along two 10 m^2 transects, Survey Station 1(Inner Harbor Bottom), Omelek Islet, USAKA on December 7, 2006. Note: cory = corymbose, enc. = encrusting, mas = massive, arb. = arborescent).

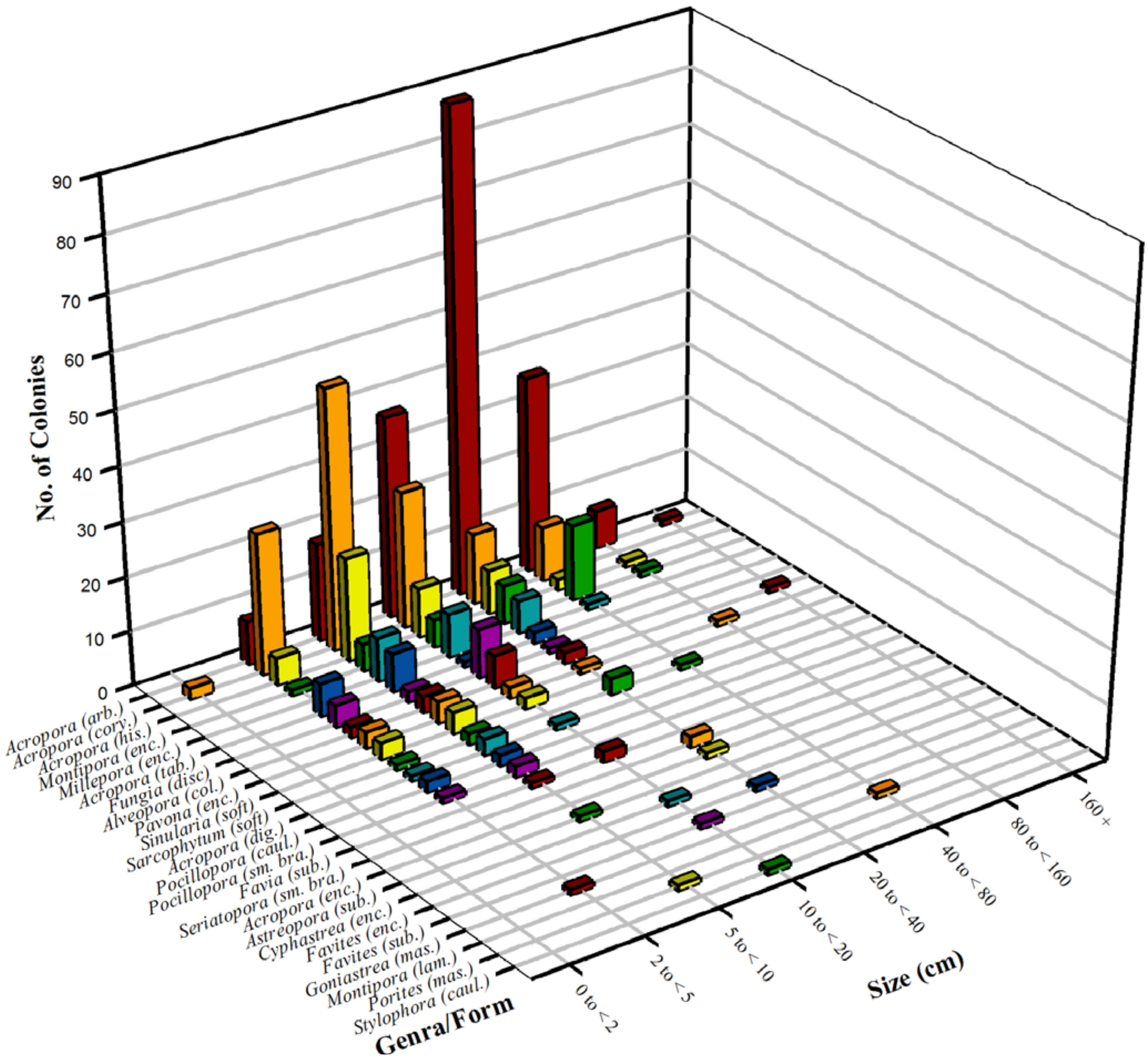


Figure 3. Size distributions of coral colonies by genera and form along three 10 m^2 transects, Survey Station 2 (Reef South of Harbor Channel), Omelek Islet, USAKA on December 7, 2006. Note: arb. = arborescent cory = corymbose, his = hispidose, enc. = encrusting, tab. = table, col. = columnar, dig. = digitate, caul = cauliflower, sm. bra. = small branching, sub. = submassive, mas = massive, lam = laminar.

APPENDIX 1
TERRESTRIAL PHOTOS

1-1. Proposed site for new helipad, inland side.

1-2. Proposed site for new helipad, beach side.

1-3a & b. *Tournefortia* and *Pisonia* forest patch south of Falcon 1 launch pad.

1-4a & b. Land crabs observed in forest patch south of Falcon 1 launch pad.

1-5. Terrestrial hermit crab observed in forest patch south of Falcon 1 launch pad.

1-6. Area cleared of undergrowth and woody debris.

1-7. Area with undergrowth and woody debris intact.

1-8a & b. *Scaevola* and *Tournefortia* on north side of Falcon 1 launch pad.

1-9. Forested north end of Omelek, looking north along path toward proposed Falcon 9 launch site.

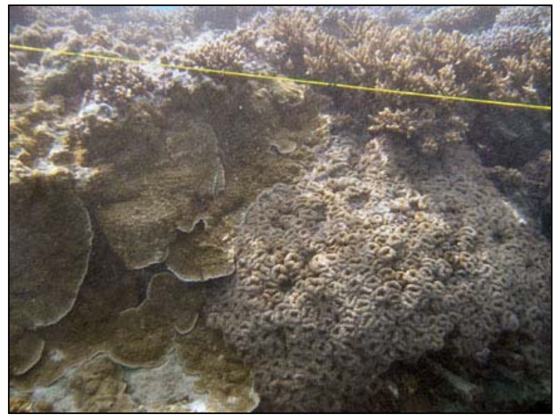
1-10. White tern (*Gygis alba*) incubating an egg in a *Pisonia* tree near the north end of Omelek.


1-11. Proposed Falcon 9 launch site, looking south.

APPENDIX 2
MARINE PHOTOS

Survey Station 1 Transect 1 (Reef Crest Habitat)

2-1. Hard Coral

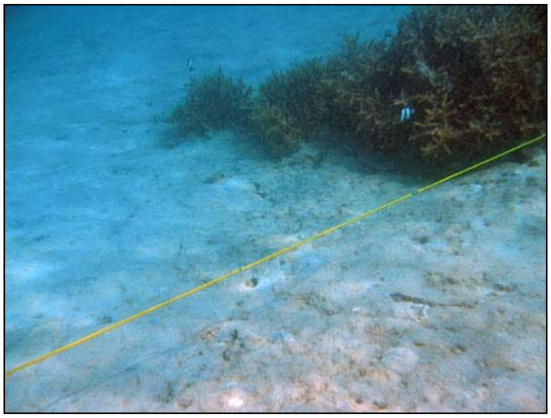


2-2. Hard Coral

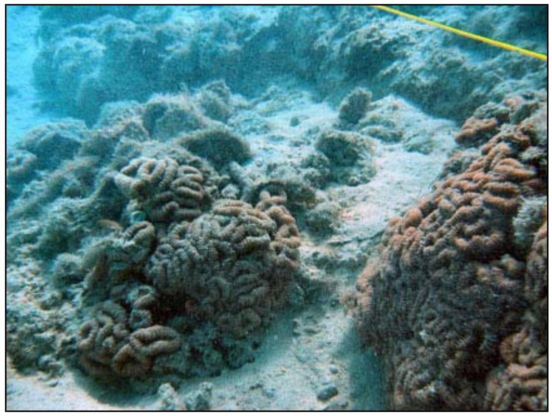
2-3. Candy Cane Shrimp

2-4. Pink Sponge

Survey Station 1 Transect 2 (Harbor Bottom Habitat)



2-5. Sand Habitat



2-6. Hard Corals

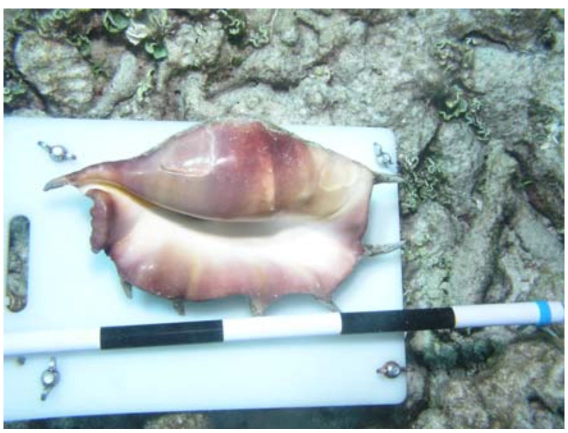
2-7. Lion Reef Fish

2-8. Flounder Reef Fish

Survey Station 2 (Lagoon Reef Flat Habitat)


2-9. Hard Corals


2-10. Hard Corals


2-11. Finger Conch


2-12. Giant Clam