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References

5.0 REFERENCES

Note: Citations in the text of this document are presented in three ways. Citations presented after a period refer to the sentences preceding the citation. Citations presented before a period refer only to the information in that sentence. Citations presented within a sentence refer specifically to the fact or title which they follow. Multiple references from the same source and the same year are distinguished by a lowercase letter following the year.

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Appendix A

LIST OF RELEVANT ENVIRONMENTAL DOCUMENTATION

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Appendix B

ENVIRONMENTAL ATTRIBUTES, APPLICABLE LAWS AND REGULATIONS, AND COMPLIANCE REQUIREMENTS

The following Federal environmental laws and regulations were reviewed to assist in determining the significance of environmental impacts under the National Environmental Policy Act.

Air Quality – The Clean Air Act seeks to achieve and maintain air quality to protect public health and welfare (42 USC 7401 et seq.). To accomplish this, Congress directed the Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS). Primary standards protect public health; secondary standards protect public welfare (e.g., vegetation, property damage, scenic value). NAAQS address six criteria pollutants: carbon monoxide, nitrogen oxides, lead, sulfur dioxides, ozone, and particulates.

Primary responsibility to implement the Clean Air Act rests with each state. However, each state must submit a state implementation plan (SIP) outlining the strategy for attaining and maintaining the NAAQS within the deadlines established by the act. If the state does not provide a SIP that is acceptable to the EPA, the EPA will provide a SIP which the state is then required to enforce.

The Clean Air Act mandates establishment of performance standards, called New Source Performance Standards, for selected categories of new and modified stationary sources to keep new pollution to a minimum. Under the act, the EPA can establish emission standards for hazardous air pollutants for both new and existing sources. So far, the EPA has set air emission standards for beryllium, mercury, asbestos, vinyl chloride, and other hazardous materials including radioactive materials.

The Clean Air Act also seeks to prevent significant deterioration of air quality in areas where the air is cleaner than that required by the NAAQS. Areas subject to prevention of significant deterioration regulations have a Class I, II, or III designation. Class I allows the least degradation.

Nonattainment policies also exist. A nonattainment area is one where monitoring data or air quality modeling demonstrates a violation of the NAAQS. The most widespread violation of NAAQS is related to ozone. For ozone, urban areas are sorted into five categories: marginal, moderate, serious, severe, and extreme. Additionally, stratospheric ozone and climate protection policies have been established. Interim reductions in the phaseout of chlorofluorocarbons, methyl chloroforms, and halons have been mandated. Hydrochlorofluorocarbons must be phased out of production beginning in 2015, with production elimination set for 2030. State and local governments are required to implement policies which prevent construction or modification of any source that will interfere with attainment and maintenance of ambient standards. A new source must demonstrate a net air quality benefit. The source must secure offsets from existing sources to achieve the air quality benefit.

The Clean Air Act Amendments of 1990 represent the first significant revisions to the Clean Air Act in the past 13 years (42 USC 7401 et seq.). The amendments strengthen and broaden earlier legislation by setting specific goals and timetables for reducing smog, airborne toxins, acid rain, and stratospheric ozone depletion over the next decade and beyond.

The Clean Air Act Amendments of 1990 contain eight major titles which address various issues of the National Air Pollution Control Program. Title I, Attainment and Maintenance of National Ambient Air Quality Standards, mandates technology-based emissions control for new and existing major air pollution sources. Title II, Mobile Sources, deals with emissions control for motor vehicles in the form of tailpipe standards, use of clean fuels, and mandatory acquisition of clean-fuel vehicles. Hazardous Air Pollutants, Title III, mainly addresses the control of hazardous air pollutants (HAPs) and contingency planning for the accidental release of hazardous substances. There are 189 HAPs identified in the new amendments. Title IV, Acid Rain, focuses on the reduction of sulfur dioxide and nitrogen oxides in the effort to eliminate acid rain. Permits, Title V, establishes a nationwide permit program for air pollution sources. The permits will clarify operating and control requirements for affected stationary sources. Stratospheric Ozone Protection, Title VI, restricts the production and use of chlorofluorocarbons, halons, and other halogenated solvents which, when released into the atmosphere, contribute to the decomposition of stratospheric ozone. Title VII, Enforcement, describes civil and criminal penalties which may be imposed for the violation of new and existing air pollution control requirements. Title VIII, Miscellaneous Provisions, similar to Title IV, addresses issues concerned with acid rain reduction.

Biological Resources – The Endangered Species Act declares that it is the policy of Congress that all Federal departments and agencies shall seek to conserve endangered species and threatened species (16 USC 1531 et seq.). Further, the act directs Federal agencies to use their authorities in furtherance of the purposes of the act.

Under the Endangered Species Act, the Secretary of the Interior creates lists of endangered and threatened species. The term endangered species means any species which is in danger of extinction throughout all or a significant portion of its range. The act defines a threatened species as any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

The key provision of the Endangered Species Act for Federal activities is Section 7 consultation. Under Section 7 of the act, every Federal agency must consult with the Secretary of the Interior, U.S. Fish and Wildlife Service (USFWS), to ensure that any agency action (authorization, funding, or execution) is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species.

The Bald and Golden Eagle Protection Act establishes penalties for the unauthorized taking, possession, selling, purchase, or transportation of bald or golden eagles, their nests, or their eggs (16 USC 668 et seq.). Any Federal activity that might disturb eagles requires consultation with the USFWS for appropriate mitigation.

In the Fish and Wildlife Coordination Act, Congress encourages all Federal departments and agencies to utilize their statutory and administrative authority, to the maximum extent practicable and consistent with each agency's statutory responsibilities, to conserve and to promote conservation of nongame fish and wildlife and their habitats (16 USC 2901 et seq.). Further, the act encourages each state to develop a conservation plan.

The Fish and Wildlife Coordination Act requires a Federal department or agency that proposes or authorizes the modification, control, or impoundment of the waters of any stream or body of water (greater than 4.1 hectares [10 acres]), including wetlands, to first consult with the USFWS. Any such project must make adequate provision for the conservation, maintenance, and management of wildlife resources. The act requires a Federal agency to give full consideration to the recommendations of the USFWS and to any recommendations of a state agency on the wildlife aspects of a project.

The Migratory Bird Treaty Act protects many species of migratory birds (16 USC 703-712). Specifically, the act prohibits the pursuit, hunting, taking, capture, possession, or killing of such species or their nests and eggs. The act further requires that any affected Federal agency or department must consult with the USFWS to evaluate ways to avoid or minimize adverse effects on migratory birds.

Cultural Resources – The Historic Sites Act of 1935 authorizes the Secretary of the Interior to designate areas as national natural landmarks for listing on the National Registry of Natural Landmarks (16 USC 461 et seq.). In conducting an environmental review of a proposed Department of Defense (DOD) action, the responsible official shall consider the existence and location of natural landmarks using information provided by the National Park Service pursuant to 35 Code of Federal Regulations (CFR) 62.6(d) to avoid undesirable impacts upon such landmarks.

Under Section 106 of the National Historic Preservation Act (16 USC 470 et seq.) and Executive Order 11593, if an DOD undertaking affects any property with historic, architectural, archaeological, or cultural value that is listed on or eligible for listing on the National Register of Historic Places, the responsible official shall comply with the procedures for consultation and comment promulgated by the Advisory Council on Historic Preservation in 36 CFR Part 800. The responsible official must identify properties affected by the undertaking that are potentially eligible for listing on the National Register and shall request a determination of eligibility from the Keeper of the National Register, Department of the Interior, under the procedures in 36 CFR Part 63.

Under the National Historic Preservation Act, if an DOD activity may cause irreparable loss or destruction of significant scientific, prehistoric, historic, or archaeological data, the responsible official or the Secretary of the Interior is authorized to undertake data recovery and preservation activities. Data recovery and preservation activities shall be conducted in accordance with implementing procedures promulgated by the Secretary of the Interior.

Army Regulation 420-40 – This Army regulation prescribes management responsibilities and standards for the treatment of historic properties including buildings, structures, objects, districts, sites, archaeological materials, and landmarks on land controlled or used by the Army. It describes the steps for locating, identifying, evaluating, and treating historic properties in compliance with the National Historic Preservation Act. It explains how these steps can be made through a Historic Preservation Plan and, as required, in consultation with the Advisory Council and the appropriate State Historic Preservation Officer.

Hazardous Materials and Waste – Under the Resource Conservation and Recovery Act (RCRA), Congress declares the national policy of the United States to be, whenever feasible, the reduction or elimination, as expeditiously as possible, of hazardous waste (42 USC 6901 et seq.). Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment.

The RCRA defines waste as hazardous through four characteristics: ignitability, corrosivity, reactivity, or toxicity. Once defined as a hazardous waste, the RCRA establishes a comprehensive cradle-to-grave program to regulate hazardous waste from generation through proper disposal or destruction.

The RCRA also establishes a specific permit program for the treatment, storage, and disposal of hazardous waste. Both interim status and final status permit programs exist.

Any underground tank containing hazardous waste is also subject to RCRA regulation. Under the act, an underground tank is one with 10 percent or more of its volume underground. Underground tank regulations include design, construction, installation, and release-detection standards.

The RCRA defines solid waste as any garbage, refuse, or sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. To regulate solid waste, the RCRA provides for the development of state plans for waste disposal and resource recovery. The RCRA encourages and affords assistance for solid waste disposal methods that are environmentally sound, maximize the utilization of valuable resources, and encourage resource conservation. The RCRA also regulates mixed wastes. A mixed waste contains both a hazardous waste and radioactive component.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) — commonly known as Superfund — provides for funding, cleanup, enforcement authority, and emergency response procedures for releases of hazardous substances into the environment (42 USC 9601 et seq.).

The CERCLA covers the cleanup of toxic releases at uncontrolled or abandoned hazardous waste sites. By comparison, the principal objective of the RCRA is to regulate active hazardous waste storage, treatment, and disposal sites to avoid new Superfund sites. The RCRA seeks to prevent hazardous releases; a release triggers the CERCLA.

The goal of the CERCLA-mandated program (Superfund) is to clean up sites where releases have occurred or may occur. A trust fund supported, in part, by a tax on petroleum and chemicals supports the Superfund. The Superfund allows the Government to take action now and seek reimbursement later.

The CERCLA also mandates spill-reporting requirements. The act requires immediate reporting of a release of a hazardous substance (other than a Federally permitted release) if the release is greater than or equal to the reportable quantity for that substance.

Title III of the Superfund Amendments and Reauthorization Act (SARA) (42 USC 9601 et seq.) is a freestanding legislative program known as the Emergency Planning and Community Right to Know Act of 1986. The act requires immediate notice for accidental releases of hazardous substances and extremely hazardous substances; provision of information to local emergency planning committees for the development of emergency plans; and availability of Material Safety Data Sheets, emergency and hazardous chemical inventory forms, and toxic release forms. (Emergency Planning and Community Right to Know Act of 1986, 42 USC 11001 et seq.)

The Emergency Planning and Community Right to Know Act of 1986 requires each state to designate a state emergency response commission. In turn, the state must designate emergency planning districts and local emergency planning commissions (42 USC 11001 et seq.). The primary responsibility for emergency planning is at the local level.

The Toxic Substances Control Act (TSCA) authorizes the administrator of the EPA broad authority to regulate chemical substances and mixtures which may present an unreasonable risk of injury to human health or the environment (15 USC 2601 et seq.).

Under the TSCA the EPA may regulate a chemical when the administrator finds that there is a reasonable basis to conclude that the manufacture, processing, distribution in commerce, use, or disposal of a chemical substance or mixture poses or will pose an unreasonable risk of injury to health or the environment.

Under the TSCA the EPA administrator, upon a finding of unreasonable risk, has a number of regulatory options or controls. The EPA's authority includes total or partial bans on production, content restrictions, operational constraints, product warning statements, instructions, disposal limits, public notice requirements, and monitoring and testing obligations.

The TSCA Chemical Substance Inventory is a database providing support for assessing human health and environmental risks posed by chemical substances. As such, the inventory is not a list of toxic chemicals. Toxicity is not a criterion used in determining the eligibility of a chemical substance for inclusion on the inventory.

Health and Safety – The purpose of the Occupational Safety and Health Act is to assure, so far as possible, every working man and woman in the nation safe and healthful working conditions and to preserve human resources (29 CFR Parts 1900-1990, as amended).

The act further provides that each Federal agency has the responsibility to establish and maintain an effective and comprehensive occupational safety and health program that is consistent with national standards. Each agency must:

- Provide safe and healthful conditions and places of employment
- Acquire, maintain, and require use of safety equipment
- Keep records of occupational accidents and illnesses
- Report annually to the Secretary of Labor

Finally, the Superfund Amendments and Reauthorization Act (42 USC 9601 et seq.) requires the Occupational Safety and Health Administration to issue regulations specifically designed to protect workers engaged in hazardous waste operations. The hazardous waste rules include requirements for hazard communication, medical surveillance, health and safety programs, air monitoring, decontamination, and training.

Noise – The Federal Noise Control Act directs all Federal agencies to the fullest extent within their authority to carry out programs within their control in a manner that furthers the promotion of an environment free from noise that jeopardizes the health or welfare of any American (42 USC 4901 et seq.). The act requires a Federal department or agency engaged in any activity resulting in the emission of noise to comply with Federal, state, interstate, and local requirements respecting control and abatement of environmental noise.

Water Quality – The objective of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters (33 USC 1251 et seq.).

The Clean Water Act prohibits any discharge of pollutants into any public waterway unless authorized by a permit (33 USC 1251 et seq.). Under the Clean Water Act the National Pollutant Discharge Elimination System (NPDES) permit establishes precisely defined requirements for water pollution control.

NPDES permit requirements typically include effluent limitations (numerical limits on the quantity of specific pollutants allowed in the discharge); compliance schedules (abatement program completion dates); self-monitoring and reporting requirements; and miscellaneous provisions governing modifications, emergencies, etc.

Under the Clean Water Act the EPA is the principal permitting and enforcement agency for NPDES permits. This authority may be delegated to the states.

The Clean Water Act requires all branches of the Federal government involved in an activity that may result in a point-source discharge or runoff of pollution to U.S. waters to comply with applicable Federal, interstate, state, and local requirements.

The Safe Drinking Water Act sets primary drinking water standards for owners or operators of public water systems and seeks to prevent underground injection that can contaminate drinking water sources (42 USC 300f et seq.).

Under the Safe Drinking Water Act, the EPA has adopted National Primary Drinking Water Regulations (40 CFR Part 141) that define maximum contaminant levels in public water systems. In addition, under the Safe Drinking Water Act the EPA may adopt a regulation that requires the use of a treatment technique in lieu of a maximum contaminant level. The EPA may delegate primary enforcement responsibility for public water systems to a state.

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Appendix C

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Washington, DC 20310

Assistant for Environmental Projects
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The Pentagon
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Ballistic Missile Defense Organization
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The Pentagon
Washington, DC 20301-7100

Commander, 15th Air Base Wing
Attn: 15LG/CD
800 Scott Circle
Hickam Air Force Base, HI 96853-5328

Commander, 15th Air Base Wing
Detachment 1
Wake Island, Pacific

Commander, 15th Civil Engineering Squadron
Attn: 15 CES/DEV
75 H Street
Hickam Air Force Base, HI 96853-5233

Headquarters, Air Combat Command
Attn: CEVA
129 Andrews Street, Suite 102
Langley Air Force Base, VA 23665-2769

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Attn: Lt. Col. Meister
25 E Street, Suite D306
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Headquarters, U.S. Air Force
Attn: AF-CEVP, Jack Bush
1260 Air Force
The Pentagon, Room 5B 269
Washington, DC 20030-1260

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Washington, DC 20310-0104

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Office of the Chief of Public Affairs
Attn: SAPA-PCD, Room 2E637
The Pentagon
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Office of the Deputy Chief of Staff for Operations and Plans
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Environmental Protection Agency
401 M Street SW
Mall Code A104
Washington, DC 20460

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Litigation Center, Environmental Law Division
901 North Stuart Street
Arlington, VA 22203-1837

Office of the Surgeon General
Attn: SGSP-PSP
5109 Leesburg Pike, Room 606
Falls Church, VA 22040-3258

Program Executive Office, Missile Defense
Attn: SFAE-MD-TMD/NMD-SS
P.O. Box 1500
Huntsville, AL 35807-3801

U.S. Army Space and Strategic Defense Command
CSSD/EN-F/IN-CS/KA-LV/LC/PA/SO/TE-O/TE-T/HO/EA
P.O. Box 1500
Huntsville, AL 35807-3801

U.S. Department of Commerce
National Marine Fisheries Service
Pacific Islands Environmental Coordinator
2570 Dole Street
Honolulu, HI 96822-2396

U.S. Department of Defense
Electromagnetic Compatibility Analysis Center, ECAC-CS
120 Worthington Basin
Annapolis, MD 21402-5064

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Appendix D

AIR QUALITY MODELING ANALYSIS

Launch operations constitute the largest source of uncontrolled emissions into the atmosphere. These emissions are generated in the ground cloud at lift-off and along the launch trajectory. Emissions are associated with the oxidation of fuel and propellants. Emission composition is determined by the type and composition of the various propellants and oxidizers.

Theater Missile Defense (TMD) activities at Wake Island may include the launch of both target and defensive missiles. Potential first-stage/second-stage target missile configurations are:

- SR19-AJ-1/M57A-1
- SR19-AJ-1/Orbis I
- Castor IVB/M57A-1
- Castor IVB/Orbis I
- Castor IV/M57A-1
- Castor IV/Orbis I
- M56A-1/M57A-1
- M56A-1/Orbis I

The combustion products for the SR19-AJ-1, M56A-1, M57A-1, and Castor IVB are given in table D-1. The chemical species listed in table D-1 are those that occur shortly after the exhaust exits the rocket motor nozzle. It is likely that, because of the high temperature of the exhaust (typically in excess of 1,650° Celsius (C) [3,000° Fahrenheit {F}]), chemical reactions continue to occur in the exhaust. This will naturally cause some changes in the relative amounts, and even the occurrence, of the various chemical species. However, data is not known to exist for the exhaust cloud once it reaches equilibrium, and it is not anticipated that the species or their amounts will differ significantly from those given.

Two configurations, the SR19-AJ-1/M57A-1 and Castor IVB/M57A-1, were chosen as the most conservative cases for the different representative configurations, and their air quality impacts are analyzed here.

The major emission products from rocket motors are carbon monoxide, aluminum oxide, and hydrogen chloride. Carbon monoxide is a criteria pollutant and will be compared to the National Ambient Air Quality Standards (NAAQS) (table 2-1).

Aluminum oxide has a very low toxic potential. The aluminum oxide in the rocket exhaust is a solid dust. Thus, as the most conservative estimate, all of the aluminum oxide can be assumed to be particulate matter with an aerodynamic diameter less than or equal to a nominal 10 microns (PM-10) and then compared to the NAAQS. Also, the aluminum oxide concentrations were compared to the 8-hour American Conference of Governmental Industrial Hygienists (ACGIH) standard given in table 2-2. This standard is also not specific to aluminum oxide but is a standard for any dust with no asbestos and less than 1 percent crystalline silica.

Table D-1: Combustion Products for Selected Rocket Motors in Kilograms (Pounds)

Species	*M57A-1*	*M56A-1*	*SR19-AJ-1*	*Castor IVB*
Al_2O_3	*533 (1,174)*	*1,472 (3,246)*	*1,767 (3,886)*	*3,761 (8,292)*
CO	*420 (927)*	*1,212 (2,672)*	*1,327 (2,919)*	*2,230 (4,916)*
HCl	*331 (731)*	*852 (1,879)*	*1,402 (3,084)*	*2,062 (4,545)*
N_2	*135 (297)*	*382 (842)*	*545 (1,200)*	*822 (1,811)*
H_2O	*148 (325)*	*430 (947)*	*776 (1,708)*	*624 (1,376)*
H_2	*39 (87)*	*106 (234)*	*117 (257)*	*235 (519)*
CO_2	*48 (106)*	*106 (233)*	*288 (633)*	*184 (407)*
Other	*3.5 (7.7)*	*148 (326)*	*74 (164)*	*51 (112)*
Total	*1,658 (3,655)*	*4,708 (10,340)*	*6,296 (13,851)*	*9,969 (21,978)*

Sources: U.S. Army Space and Strategic Defense Command, 1993j; Dailey, 1993; Bowles, 1993.

Hydrogen chloride is not a criteria pollutant but is one of the 189 hazardous air pollutants (HAPs) listed in Title III of the Clean Air Act (CAA). Its concentrations will be compared to the guidelines from the National Research Council (1987) and the Environmental Protection Agency (1992), as given in table 2-2.

Flight Scenarios

The analysis of potential ambient air quality impacts from proposed TMD test activities considers both normal launch and early flight termination. It is assumed that during either scenario the only air pollutants emitted are the rocket motor combustion products.

During a normal launch scenario the missile accelerates while the rocket motor of the missile burns. This boost stage normally lasts only a few minutes (e.g., for a nominal M56A-1/M57A-1 TMD target flight the boost stage lasts only 117 seconds [Coleman Research Corporation, 1993a]). While the rocket motors are burning, the missile is accelerating; therefore, a higher concentration of combustion products occurs near the launch site than along the rest of the flight path.

Only a part of the exhaust products emitted during a normal flight will have any effect on the ambient air quality. Under the CAA, ambient is that portion of the atmosphere that is both external to buildings and to which the general public has access (40 CFR 50.1). Only that portion of the exhaust products that are emitted while the missile is in the troposphere have the potential to effect the ambient air quality. This is because air and pollutants above the troposphere mix extremely slowly with the air in the troposphere (Seinfeld, 1986). The troposphere occurs from ground level to an altitude of approximately 15 kilometers (km) (9.4 miles [mi]) (Seinfeld, 1986). For the nominal M56A-1/M57A-1 flight, the missile is above the troposphere in less than 60 seconds and has traveled approximately 20 km (12 mi) downrange by that time (Coleman Research Corporation, 1993a).

The combustion products' exhaust is much hotter than the ambient air (e.g., approximately 1,900° C (3,500°F) for the SR19-AJ-1 [Coleman Research Corporation, 1993a]). Because of this, buoyancy causes the cloud of rocket exhaust released near the ground to rise until it reaches an equilibrium height. For missiles similar to the TMD target missile, the ground cloud is expected to rise to heights of 300 meters (m) (984 feet [ft]) or more (Strategic Defense Initiative Organization, 1991). This process is discussed in detail in the Space Shuttle Advanced Solid Rocket Motor Program Supplemental EIS (National Aeronautics and Space Administration, 1990).

In addition to pollutants above the troposphere being essentially excluded from effecting ground-level air quality, pollutants that are above the top of the mixing layer, which exists below the top of the troposphere, are also excluded from affecting ground-level air quality. The mixing height (or depth) is defined as the height above the surface through which relatively vigorous vertical mixing occurs; the value of the mixing height is set primarily by the atmosphere's local vertical temperature profile (Environmental Protection Agency, 1972). The reason that pollutants emitted above these excluding layers have little or no effect on ambient air quality is that pollutants become diluted in the very large volume of air in these layers before they are very slowly transported down to ground level.

Normally, higher mixing heights lead to better air quality because they afford a larger volume of air in which emitted pollutants may diffuse and thus reach lower concentrations. This is always the case for normal sources of pollutants, such as smoke stacks. However, depending on how high a missile's ground cloud rises before reaching its equilibrium height, the reverse may be the case. If the ground cloud rises above the height of the mixing layer, then, because of the excluding effect, essentially none of the rocket emissions will affect the ambient air quality. (National Aeronautics and Space Administration, 1990)

The other flight scenario considered is missile failure. This includes vehicle destruction on the pad, in-flight failure, and command vehicle destruction. Emissions from these possibly would be the same as those during a normal launch, with the exception of a launch pad accident or one very shortly after liftoff. Otherwise the emissions would occur at an altitude that would allow significant dilution of the pollutants before they reached ground level.

Air Quality Modeling of Missile Flight Scenarios

The short-term air quality impacts caused by the launch of an individual target missile were modeled with the TSCREEN PUFF computer model. TSCREEN PUFF is part of TSCREEN, which is an Environmental Protection Agency application package of three screening dispersion computer models (Environmental Protection Agency, 1990). More specifically, TSCREEN automates the screening techniques from *A Workbook of Screening Techniques for Assessing the Impacts of Toxic Air Pollutants* (Environmental Protection Agency, 1988). Screening techniques use simplifying assumptions and generate estimates which are generally upper bounds on expected pollutant concentrations. The Environmental Protection Agency recommends that screening models be used first, and if the results exceed applicable concentration limits, then a more refined model should be used (Environmental Protection Agency, 1993).

Most sources of air pollution are continuous sources (e.g., emissions from stacks or equipment leaks); however, emissions from missile launches are essentially instantaneous.

The TSCREEN PUFF model is designed for use with instantaneous releases of pollutants, such as equipment openings or relief value discharges. TSCREEN PUFF is programmed to select the atmospheric stability class that yields the maximum ground-level pollutant concentration. (Environmental Protection Agency, 1988; 1993).

As inputs, TSCREEN PUFF requires the mass of the puff of material released and the elevation at which the puff was released. As mentioned, for normal flights only a portion of the missiles exhaust would be released below the top of the mixing layer. Using a conservative approach, for all modeling performed, the mass of the puff released during a normal flight was assumed to equal the total emissions from the first stage of the target missile: either the SR19-AJ-1 or the Castor IVB. The Castor IVB has the largest amount of emissions of any of the first-stage rocket motors under consideration.

For the TSCREEN model calculations, the puff of emissions was assumed to be released at its final ground cloud height. Although this assumption tends to under-predict concentrations very near the launch site, it will not significantly affect concentrations at points beyond the distance at which final ground cloud rise is reached. This assumption is generally made for these types of analyses (Strategic Defense Initiative Organization, 1991; Department of the Air Force, 1988). As mentioned earlier, the final altitude for ground clouds for missiles similar to the TMD target missile are expected to be 300 m (984 ft) or more (Strategic Defense Initiative Organization, 1991). Following the example of the previous analysis (Strategic Defense Initiative Organization, 1991), the conservative value of 200 m (656 ft) was chosen for the release height.

Furthermore, the TSCREEN PUFF model uses the conservative values of 320 m (1,050 ft) for the mixing height, which is above the assumed release height. Therefore, all the material in the puff will affect the calculated ground-level concentrations. Furthermore, the TSCREEN PUFF model makes the very conservative value of 1 m/s for the wind speed. Stronger wind speeds tend to more quickly disperse, and thus dilute, the emitted pollutants. Also, it should be noted that typical wind speeds are greater than 1 m/s for the proposed launch site.

For the missile failure, it is assumed that the mass of the puff equals all of the emissions from the target first-stage rocket motor and all emissions from the second-stage rocket motor. For a missile failure with this type of total conflagration, the final rise height of the ground cloud would be greater than that for a normal launch because of the greater amount of energy released and, thus, higher temperature of the exhaust (Strategic Defense Initiative Organization, 1991). However, in keeping with choosing values that will give conservative estimates for the air quality impacts, the same value as for normal launches, 200 m (656 ft), was used for the computations.

Results of the Air Quality Modeling

The TSCREEN PUFF computer model provides ground-level pollutants in terms of peak instantaneous concentrations and time-mean concentrations of up to 60 minutes. Time-mean concentrations for time periods longer than 1 hour are customarily estimated by a power law equation (Turner, 1970). The power law equation used is $X_S = X_K * (t_K / t_S)^p$, where X_S is the time-mean concentration for the desired longer time t_S, X_K is the time-mean concentration at the known time t_K, and p is the "power" to which you are raising the ratio of the times. A value of p between 0.17 and 0.20 is normally used (Turner, 1970). This method is more reliable for shorter than for longer time periods and for continuous rather than for instantaneous sources. Thus, for missile launches, extrapolating to even 8-hour time-mean concentrations is of questionable utility. For this reason, an aluminum oxide 24-hour time-mean concentration was not calculated for comparison to the 24-hour PM-10 NAAQS. In the 8-hour time-mean calculations, a value of $p = 0.20$ was used in order that the most conservative, that is, largest, time-mean concentrations were calculated. Local background concentrations need to be added to the time-mean concentrations calculated for missile launches. This is most applicable to carbon monoxide and aluminum oxide (as PM-10).

Results from the air quality modeling for the normal launch scenario are given in tables D-2 and D-4. The results are clearly below the corresponding NAAQS and guideline values.

Results from the air quality modeling for the missile failure accident scenario are given in tables D-3 and D-5. Again, with only one exception, the computed values are well below the applicable NAAQS and guideline values. The one exception is that the most conservative guidance value, the SPEGL for HCl, is exceeded for distances less than 7 km (4.3 mi) for an on-pad catastrophic failure of an SR19-AJ-1/M57A-1 target missile and for distances less than 10 km (6.2 mi) for an on-pad catastrophic failure of a Castor IVB/ M57A-1 target missile.

Since the results from the screening computer model do not exceed the NAAQS nor the exposure guidelines, additional modeling with a refined model, such as the Rocket Exhaust Effluent Diffusion Model: REEDM (Bjorkland, 1990), was not done. As more details become available for TMD activities, such refined modeling may be necessary.

Results from the screening model, if the assumptions made are valid, should be significantly greater than the actual concentrations. In review, the conservative assumptions made were that (1) emissions from the largest rocket motor were used, (2) all of the emissions from this first-stage rocket motor were assumed to be released near the ground for the normal launch scenario, (3) all of the emission from the first-stage rocket motor plus all of the emissions from the second-stage rocket motor were assumed to be released near the ground for the missile failure accident scenario, (4) all of the aluminum oxide released was assumed to be PM-10, (5) a very low wind speed of 1 m/s was used, and (6) a fairly low mixing height of 320 m (1,050 ft) was used.

Table D-2: Estimated Concentration from Normal Launch Conditions for an SR19-AJ-1 (mg/m^3)[a]

					Distance Downwind km (mi)					
Pollutant	Release kg (lb)	Average Period	Guideline (mg/m^3)	Exposure Term	1 (0.6)	3 (1.9)	5 (3.1)	7 (4.3)	10 (6.2)	30 (18.6)
Hydrogen Chloride	1,401.8 (3,090.4)	1 hour	6	MLE[b]	0.963	1.684	1.371	1.006	0.719	0.465
		15 minutes	20	MLE[b]	3.854	6.453	4.365	2.611	1.727	0.821
Carbon Monoxide	1,327.0 (2,925.5)	8 hours	10	NAAQS[c]	0.602	1.052	0.856	0.628	0.449	0.291
		1 hour	40	NAAQS[c]	0.912	1.594	1.298	0.952	0.681	0.441
Aluminum Oxide	1,766.6 (3,894.6)	8 hours	10	TLV-TWA[d]	0.801	1.400	1.140	0.836	0.598	0.387
		1 hour	–	–	1.214	2.122	1.727	1.267	0.906	0.587

[a]Values used in TSCREEN PUFF model (Environmental Protection Agency, 1990):
release height = 200 m (656.2 ft)
wind speed = 1 m/s (3.3 ft/s)
mixing height = 320 m (1,049.7 ft)
[b]Maximum Likelihood Estimate (Environmental Protection Agency, 1992)
[c]National Ambient Air Quality Standards (40 CFR 50.109)
[d]Threshold Limit Value – Time-weighted Average (American Conference of Government Industrial Hygienists, 1992)

Table D-3: Estimated Concentration from Two-stage Accident Conditions for an SR19-AJ-1 and M57A-1 (mg/m^3)[a]

					Distance Downwind km (mi)					
Pollutant	Release kg (lb)	Average Period	Guideline (mg/m^3)	Exposure Term	1 (0.6)	3 (1.9)	5 (3.1)	7 (4.3)	10 (6.2)	30 (18.6)
Hydrogen Chloride	1,733.2 (3,821)	1 hour	30	EEGL[b]	1.191	2.082	1.695	1.243	0.889	0.576
		1 hour	1.5	SPEGL[c]						
Carbon Monoxide	1,747.5 (3,852)	8 hours	10	NAAQS[d]	0.792	1.384	1.128	0.827	0.592	0.383
		1 hour	40	NAAQS[d]	1.201	2.099	1.709	1.254	0.897	0.580
Aluminum Oxide	2,299.3 (5,069)	8 hours	10	TLV-TWA[e]	1.042	1.822	1.483	1.088	0.778	0.503
		1 hour	–	–	1.580	2.762	2.248	1.649	1.180	0.763

[a]Values used in TSCREEN PUFF model (Environmental Protection Agency, 1990):
release height = 200 m (656.2 ft)
wind speed = 1 m/s (3.3 ft/s)
mixing height = 320 m (1,049.7 ft)
[b]Emergency Exposure Guidance Level (National Research Council, 1987)
[c]Short-term Public Emergency Guidance Level (National Research Council, 1987)
[d]National Ambient Air Quality Standards (40 CFR 50.109)
[e]Threshold Limit Value – Time-weighted Average (American Conference of Government Industrial Hygienists, 1992)

Table D-4: Estimated Concentration from Normal Launch Conditions from a Castor IVB (mg/m^3)[a]

Pollutant	Release kg (lb)	Average Period	Guideline (mg/m^3)	Exposure Term	Distance Downwind km (mi) 1 (0.6)	3 (1.9)	5 (3.1)	7 (4.3)	10 (6.2)	30 (18.6)
Hydrogen Chloride	2,062	1 hour	6	MLE[b]	1.417	2.477	2.016	1.479	1.058	0.685
	(4,546)	15 minutes	20	MLE[b]	5.668	9.492	6.421	3.840	2.540	1.209
Carbon Monoxide	2,230	8 hours	10	NAAQS[c]	1.011	1.767	1.439	1.056	0.755	0.488
	(4,916)	1 hour	40	NAAQS[c]	1.533	2.679	2.181	1.600	1.144	0.740
Aluminum Oxide	3,761	8 hours	10	TLV-TWA[d]	1.705	2.981	2.426	1.780	1.273	0.824
	(8,292)	1 hour	–	–	2.585	4.518	3.678	2.698	1.930	1.249

[a]Values used in TSCREEN PUFF model (Environmental Protection Agency, 1990):
release height = 200 m (656.2 ft)
wind speed = 1 m/s (3.3 ft/s)
mixing height = 320 m (1,049.7 ft)
[b]Maximum Likelihood Estimate (Environmental Protection Agency, 1992)
[c]National Ambient Air Quality Standards (40 CFR 50.109)
[d]Threshold Limit Value – Time-weighted Average (American Conference of Government Industrial Hygienists, 1992)

Table D-5: Estimated Concentration from Two-stage Accident Conditions for Castor IVB and M57A-1 (mg/m^3)[a]

Pollutant	Release kg (lb)	Average Period	Guideline (mg/m^3)	Exposure Term	Distance Downwind km (mi) 1 (0.6)	3 (1.9)	5 (3.1)	7 (4.3)	10 (6.2)	30 (18.6)
Hydrogen Chloride	2,393	1 hour	30	EEGL[b]	1.645	2.875	2.340	1.717	1.228	0.795
	(5,276)	1 hour	1.5	SPEGL[c]						
Carbon Monoxide	2,650	8 hours	10	NAAQS[d]	1.201	2.101	1.709	1.254	0.897	0.581
	(5,842)	1 hour	40	NAAQS[d]	1.821	3.184	2.591	1.901	1.360	0.880
Aluminum Oxide	4,294	8 hours	10	TLV-TWA[e]	1.947	3.404	2.770	2.032	1.453	0.941
	(9,467)	1 hour	–	–	2.951	5.159	4.199	3.080	2.203	1.426

[a]Values used in TSCREEN PUFF model (Environmental Protection Agency, 1990):
release height = 200 m (656.2 ft)
wind speed = 1 m/s (3.3 ft/s)
mixing height = 320 m (1,049.7 ft)
[b]Emergency Exposure Guidance Level (National Research Council, 1987)
[c]Short-term Public Emergency Guidance Level (National Research Council, 1987)
[d]National Ambient Air Quality Standards (40 CFR 50.109)
[e]Threshold Limit Value – Time-weighted Average (American Conference of Government Industrial Hygienists, 1992)

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Appendix E

NOTICE

This Ornithological Survey assesses some specific activity locations that were part of the proposed action at the time of the survey but were later removed from consideration. However, the data have been left in the report to provide baseline information for future studies. Additionally, this survey does not discuss some new facility construction locations in the proposed action that were identified after the field investigation was completed. The environmental assessment for these additional facilities was developed from the survey report and from unpublished field notes.

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ORNITHOLOGICAL SURVEY REPORT

FOR

ENVIRONMENTAL ASSESSMENT FOR LONG-TERM ACTIVITIES AT WAKE ATOLL

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April 1993

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Abstract

Approximately 10 species of seabirds and one species of rail, now extinct, have been recorded breeding or attempting to breed on Wake Atoll (Pratt et al. 1987; Rowland 1989a, 1989b; Sutherland 1989). All but one of these species (Laysan albatross) were observed during a field survey conducted from March 24 to April 1, 1993, and breeding activity was documented for five. Sooty terns (*Sterna fuscata*) were clearly the most abundant species on the island and were in the midst of breeding during the field survey period. A second species of tern, the brown noddy (*Anous stolidus*), was present in much smaller numbers and was in the nest construction and egg-laying phase of breeding. Three species of booby were present; two, the red-footed booby (*Sula sula*) and brown booby (*Sula leucogaster*), were nesting, and a third, the masked booby (*Sula dactylatra*), although present in small numbers, was apparently not breeding. One species of tropicbird, the red-tailed tropicbird (*Phaethon rubricauda*) was nesting, but another species reported to breed on Wake Atoll, the white-tailed tropicbird (*Phaethon lepturus*), was seen only once and was believed not to be breeding. Other species present, but apparently not breeding, were black-footed albatross (*Diomedea nigripes*), great frigatebird (*Fregata minor*), gray-backed tern (*Sterna lunata*), black noddy (*Sterna minutus*), and white tern (*Gygis alba*). The latter three species are not known to breed on Wake Island, although suitable habitat and conditions are apparently present.

Six additional transient species were observed, the most common being the Asian golden-plover (*Pluvialis fulva*), a common winter visitor on the island (Pratt et al.). Others observed were ruddy turnstone (*Arenaria interpres*), wandering tattler (*Tringa incana*), Siberian (gray-tailed) tattler (*Tringa brevipes*), and short-eared owl (*Asio flammeus*).

SECTION 1
INTRODUCTION

Surveys were conducted on Wake Atoll during the period March 24 to April 1, 1993, by a professional field ornithologist. The purpose of the surveys was to delineate the avifauna present on the atoll and to identify potential seabird nesting habitats and sites. In addition, specific sites proposed for long-term activities associated with Theater Missile Defense launch programs and infrastructure improvements were surveyed to determine whether implementation of the stated activities would potentially impact bird populations or nesting habitats. Recommended mitigation measures, aimed at avoiding, minimizing, or compensating for current or future anticipated impacts on bird populations or nesting habitats, are provided.

SECTION 2
METHODOLOGY

An initial reconnaissance survey entailed searching the atoll for seabird colonies (there are no breeding land birds). All seabirds present on the island at the time of the survey, except for tropicbirds, are conspicuous nesters, i.e., they lay their eggs in the open, either on the bare ground or exposed in shrubs or small trees. Tropicbird nests were located by first finding courting or vocalizing adults in flight and observing them until one or more hovered over or landed at a potential nest site. The number of breeding pairs of all but one species, the sooty tern (*Sterna fuscata*), were ascertained on this small atoll by direct count.

Two distinct sooty tern colonies were located, and in each, virtually all birds were in the nestling stage of their current breeding cycle. The colony on Wilkes Island was in an open, grassy area, thus facilitating counting of young birds in sample plots from a distance. Strip censuses were not feasible, as they are only accurate when the terns are on eggs and can be too disruptive when young are present. Young birds will scatter at the approach of humans, making strip-census counts both inaccurate and inadvisable (Harrison 1990). The number of nestlings in this colony was estimated by counting the number of young in a section of the colony through 8 by 42 binoculars from the roof of a vacant one-story building adjacent to the colony and extrapolating the total for the entire colony. Photographs and videotape of the colony were also obtained for later corroboration of these initial counts. The colony dimensions were obtained by pacing the length and widest breadth of the colony from a reasonable distance parallel to the colony in order to minimize disturbance. To ascertain the area of the colony, the shape (and subsequently, the area) of the colony, as viewed from atop an adjacent building, was outlined on a 600-scale (1 inch = 600 feet) map. One transect was walked through the colony to obtain a count of eggs. Additional transects were not deemed necessary, as none of the eggs examined while conducting this transect were viable.

On Peale Island, all young birds encountered along the shoreline during a circuit of the point were counted, as well as all individuals that could be seen in the vegetation adjacent to the shore. The Peale Island colony was too heavily vegetated to obtain more accurate counts.

SECTION 3
RESULTS

The following project sites were examined during the survey: the proposed new power plant site behind the softball field in the housing area; the water catchment basin area; the proposed new incinerator site between the catchment basins and the airfield; both launch complexes near Peacock Point; the proposed batch plant and lay-down areas behind the revetment area on the south side of the runway; and the borrow pit area on Wilkes Island. Several sites (batch plant and lay-down areas, borrow area, and general vicinity of launch pads and incinerator) presented suitable nesting habitat for the red-tailed tropicbird and, perhaps great frigatebird, black noddy, and white tern; however, the latter three species showed no sign of nesting on the island at the time of the survey, and have not been documented breeding at Wake Atoll.[1] All sites were heavily disturbed, although suitable habitat for these shrub-nesting species was plentiful in the general vicinity.

The results of avian surveys, conducted between March 24 and April 1, 1993, are presented below under separate headings for each species. Included in each account is a brief summary of the species' natural history, status on the island, and, where applicable, its breeding biology and breeding history on the island. The locations of bird nesting colonies as well as the sites of other ornithological observations, are noted on figures 1 and 2.

3.1 SPECIES ACCOUNTS

Laysan Albatross *Diomedea immutabilis*. This species breeds in the leeward Hawaiian Islands and in the Bonin Islands south of Japan, and ranges at sea throughout the northern Pacific Ocean (Harrison 1985). It was formerly more common and widespread and may have bred regularly on Wake Island. Laysan albatrosses prefer to nest on open ground close to vegetation, generally away from the shore or sandy areas (Harrison 1990). Like most seabirds, they lay one egg. In Hawaii, they nest during the winter, but it is not clear during what season this species has nested or attempted to nest on Wake Atoll. Typically, they arrive on their breeding island in early November where they lay one egg, usually in early December. Chicks hatch 65 days later and most have fledged by the end of July (Harrison 1990).

Exhibiting strong site fidelity, a pair will typically return to the same patch of land on the same island to breed year after year, and young rarely set foot on an island other than the one on which they were fledged (Harrison 1990). This makes recolonization of islands from which they have been extirpated difficult. Harrison points out that they have failed to recolonize Wake Island nearly a half-century after colonies were destroyed during the war.

Mr. Titian Peale, artist and naturalist on the United States Exploring Expedition in 1841, found "short-tailed albatrosses" here (Bryan 1959), which may have been this species. Rowland (1989b) mentions a 1936 photograph of the old Pan American Airways hotel in the Wake Island Museum that shows an adult Laysan albatross and several downy chicks on the lawn. Bailey (1951) suggests that some species of albatross bred on the island during the period of Japanese occupation in World War II.

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[1] Except possibly for the frigatebird.

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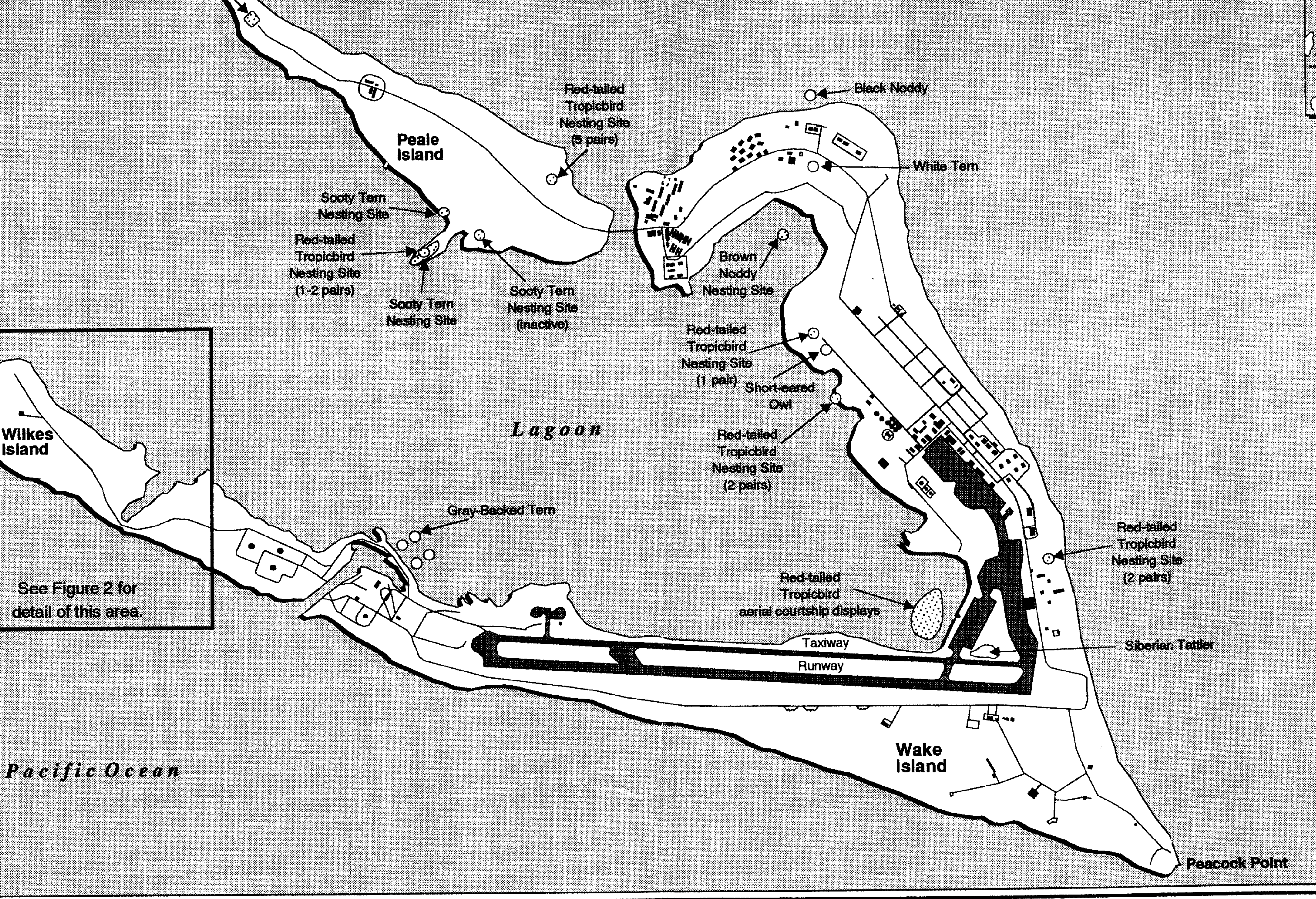

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Other Sightings:

Black noddy
Gray-backed tern
White tern

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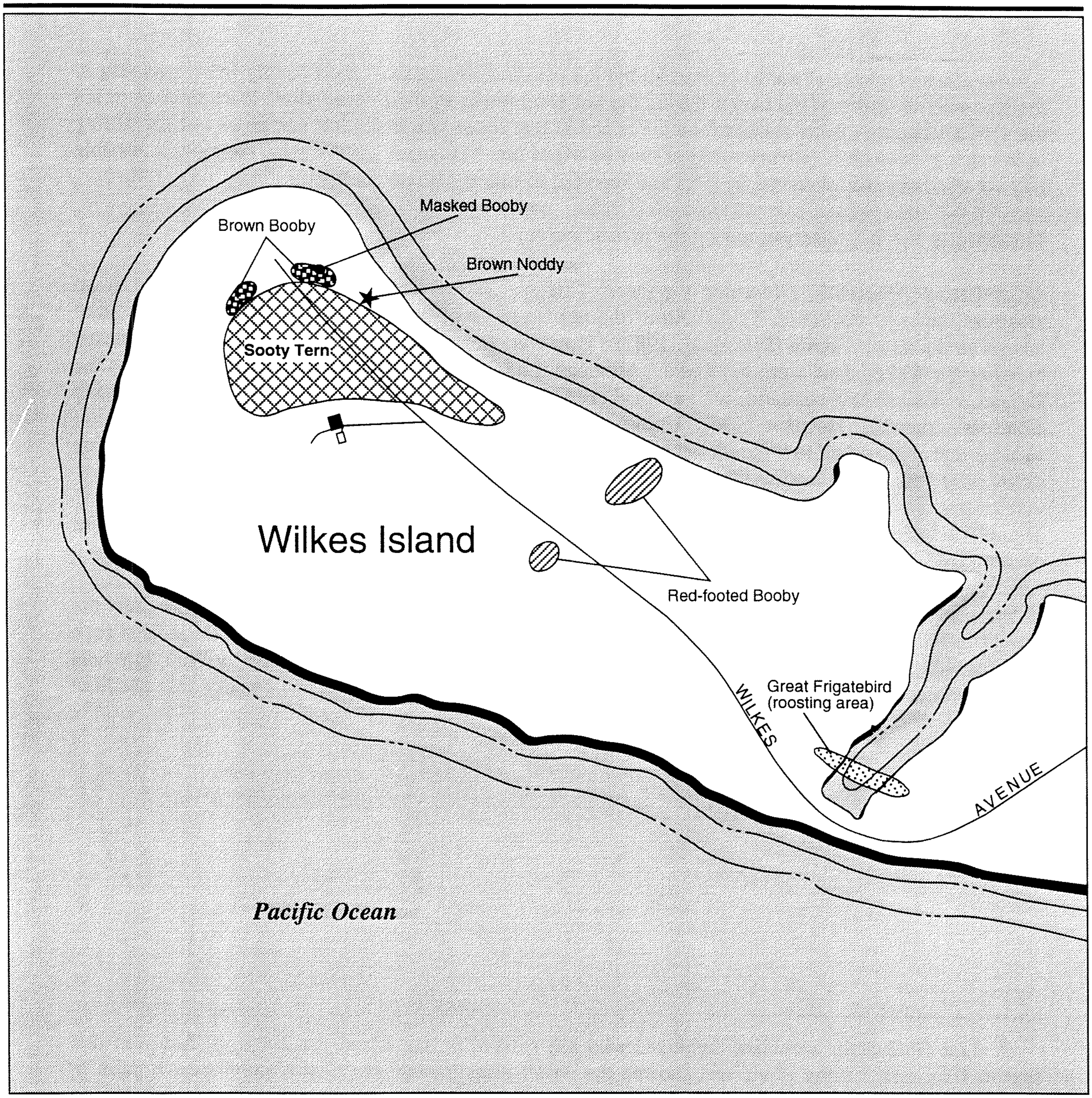

Seabird Nesting Locations

0 95 190 Meters
0 315 630 Feet

Wilkes Island

Figure 2

gr/Wake/073.mmo-1/3/94

An American blockade of the island had all but cut off the Japanese from their supply lines, resulting in the starvation of many of the troops during the last few months of their occupation. He quotes from the diary of a Japanese officer stationed on the island at that time: "An order has just come out forbidding us to catch gooney birds [albatrosses] lest they be wiped out." Rowland (1989b) also mentions a possible Laysan albatross nest observed in 1988 and reported to him by island residents.

This species was not observed during the present survey.[2]

Black-footed Albatross *Diomedea nigripes*. This species has a similar distribution as the Laysan albatross, but also breeds on Taongi Atoll (the nearest point of land to Wake Island) and a few other islands in the North Pacific (Pratt et al. 1987). However, literature references to breeding or suspected breeding on Wake Island were not found. Although it has a similar geographical breeding range as the Laysan, it is much less common, with a world breeding population only one-tenth the size of the Laysan albatross population (Harrison 1990). Unlike Laysan albatrosses, black-footed albatrosses prefer to nest in areas that are exposed to wind-blown sand. They are also winter breeders and have a similar breeding cycle; however, chicks mature faster and fledge about three weeks earlier than Laysans.

Two black-footed albatrosses were seen briefly flying together about 2 kilometers (km) off Peacock Point on March 25, and one was seen flying low over the airstrip on March 31.[3]

White-tailed Tropicbird *Phaethon lepturus*. This species breeds on many island groups throughout the tropics in the Atlantic, Pacific, and Indian oceans. It breeds primarily on high islands in shaded rock crevices along coastal headlands, but may also nest in reduced numbers on low-lying atolls. White-tails nest in early spring; their incubation period is 41 days and the young fledge 10 to 12 weeks after hatching (Harrison 1990).

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[2] Lou Hitchcock, a civilian employee who has resided on the island for 20 years, has seen this species frequently on the island and showed the writer a number of excellent photographs of pairs in apparent courtship. He said they generally can be found in the closely cropped grassy areas adjacent to the runway where they apparently lay their eggs. However, he has never seen young and believes the feral cats, and possibly rats, prevent them from nesting successfully.

[3] Gary Lumia, an Air Force maintenance technician, described up to six large, all-dark "gooney birds" he had seen regularly at Peacock Point for a period of time until about four weeks prior to this survey. He thought they might be nesting because of their courtship activities, but never saw eggs or young. Mr. Hitchcock, however, was not familiar with this species and does not recall seeing any all-dark albatrosses here.

One adult was seen briefly in flight near catchment basins between the personnel housing area and the air terminal on March 25.[4]

Red-tailed Tropicbird *Phaethon rubricauda*. This species has a similar distribution to the white-tailed tropicbird, but is absent from the Atlantic Ocean. Unlike the white-tailed tropicbird, it breeds primarily on atolls and other low-lying islands, generally in bunchgrass, under bushes, or adjacent to bushes that provide some cover (Harrison 1990). When nesting under bushes, they generally require an adjacent clearing or beach devoid of dense vegetation that may impede their access or ability to take flight easily. Pairs nest in spring and lay one egg. The incubation period is 41 days, and young usually hatch in April and fledge 12 to 13 weeks later (Harrison 1990).

The number of red-tailed tropicbirds observed during the eight-day survey period appeared to increase noticeably, suggesting that the survey period coincided with the earliest stages of the breeding cycle. Invariably, nests were found near the shoreline, or under shrubs or small trees with ground-hugging branches. In all, 10 incubating birds were located, and courtship activity was observed in other areas, suggesting additional unseen or not-yet-established nest sites. Nesting or courtship were observed in six more or less distinct areas on Peale Island and on Wake Island proper northwest of the air terminal (figure 1). Each nesting locality consisted of from one to five pairs; all nests were under large bushes or small trees with dense, protective branches and foliage down to ground level. Two or three individuals (probably representing one to two pairs) were seen repeatedly on Flipper Point, but no nests were found. Five more pairs were found nesting under two adjacent *Pemphis acidula* bushes at the upper edge of the shoreline north of the bridge connecting Peale with the main island (figure 1). One nest, although being attended, was empty; the contents of the other four were not determined. On Wake Island, one pair was nesting under a *Pemphis* bush just west of the catchment basin, on a nest containing one egg; two pairs were apparently nesting under a *Pemphis* bush along the lagoon shoreline adjacent to the catchment basins, although their nests were not actually observed (one bird was seen landing beside, and two were heard calling from beneath these two bushes); two pairs were nesting under two adjacent ironwoods (*Casuarina equisetifolia*) on the upper edge of the ocean shoreline just northwest of the air terminal, but the contents of the nests were not determined. All nests observed were nothing more than slight depressions in the leaf litter reasonably well hidden by the overhanging vegetation.

Masked Booby *Sula dactylatra*. This species breeds on islands throughout the tropics and is often found breeding in association with brown boobies. It prefers the perimeter of larger islands (Harrison 1990) where it is usually much more plentiful than the brown booby. On low-lying sandy atolls like Wake, it often nests in sand on the upper beach (Harrison 1990). Masked boobies usually begin nesting in spring. Incubation is 43 to 44 days. Young masked boobies in Hawaii take up to one month longer to fledge than do brown or red-footed boobies (Harrison 1990).

Three masked booby adults were present in the brown booby colonies, and these or other individuals were also seen on nearby offshore rocks at the west end of Wilkes Island (figure 2). No nests, eggs, or young were observed. These birds may have been in the early (pre-egg laying) stages of breeding.

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[4] Mr. Hitchcock sees this species every year and believes that a few breed each year. However, no references could be found in the literature to document breeding on the island, even though most investigators reported seeing 2 or 3 birds during their visits.

Apparently, this species never breeds on Wake in large numbers. Other accounts of this species all refer to less than six pairs. Bryan (1959) mentions that Fosberg saw only a very few on Peale Island in 1953. Rowland (1989b) saw only two active nests, both with chicks, on Wilkes Island in 1989. Sutterfield (1989) saw two masked boobies on eggs in late October 1989.

Brown Booby *Sula leucogaster*. Like the masked booby, this species is pantropical, but on a worldwide basis it is much less common than the masked and red-footed boobies. Most boobies (masked, brown, and red-footed) nest during spring and summer. The brown booby usually nests on substrates with some ground cover, often on the crest of a low ridge near the shore. Brown and masked boobies usually lay two eggs, but sometimes three or only one. The incubation period is the same as for masked boobies, but time to fledging is only three months, one month less than for masked boobies, at least in Hawaii. In both brown and masked boobies, generally only one egg hatches; when both eggs hatch, only one chick survives to fledge.

Two small sub-colonies were located on the outer perimeter of the Wilkes Island sooty tern colony (Exhibit 2). Nests were located just above the upper reaches of the non-vegetated sand/coral beach in grassy vegetation or, in a few cases, adjacent to small tree heliotrope (*Tournefortia argentea*) bushes. This narrow interface between beach and grassy plain was slightly raised in elevation and contained scattered large coral "rocks", giving the area at least some topographic relief. Approximately 56 nests were observed, 30 and 26 respectively, in each colony. No eggs were observed; however, several incubating birds may have been on eggs. Young were observed in all stages of growth from recently hatched to nearly full size downy young with moderate flight feather development. No nest contained more than two young and all nests with well developed young contained only one offspring.

From one to three adult brown boobies were frequently seen feeding from 1 to 2 km off Peacock Point 7 km to the east of the breeding colonies, and occasionally elsewhere, but seldom on the north side of the atoll (off Peale and adjacent portions of Wake).

Rowland (1989b) counted 106 nests on Wilkes Island in April 1989, most with young. Sutterfield (1989) found 148 brown boobies beginning nest construction and two on eggs in late October 1989.

Red-footed Booby *Sula sula*. This species is also pantropical, but unlike other boobies, nests in shrubs anywhere from a few centimeters (cm) to several meters (m) off the ground (Harrison 1990). These boobies build platforms of sticks in which they lay a single egg.

Two small sub-colonies were located in beach heliotrope and naupaka (*Scaevola sericea*) trees near the west end of Wilkes Island (figure 2). These two colonies were approximately 100 m apart at the interface between heliotrope scrub forest and the large grassy field (the Vortac area) at the island's west end, and between 1.5 and 4 m off the ground. Nestlings were observed in approximately one-third of the nests; the other nests may have contained eggs or recently hatched young. No young were more than two thirds grown. Approximately 26 nests were visible from the open grassy field and others were seen inside the scrub "forest", but only to a depth of about 15 m from the Vortac area. Approximately 35 nests in all were estimated to be present.

Frigatebirds were frequently seen perched in the nesting trees and flying in the vicinity of the red-footed booby colony. On one occasion (afternoon of March 25), about 15 frigatebirds had taken up temporary residence in the colony, but no birds were observed taking contents from any of the nests. On one occasion a frigatebird may have attempted to take either the eggs or young from one nest, but it was fended off by a booby. A feral cat was seen walking beneath the nesting trees on 25 March, perhaps searching for eggs or young that had fallen from the nests.

Most red-footed boobies on Wake Island are light-morph birds; however, at least two white-tailed brown morph individuals were observed. One of these was attending a nest with a white morph individual (the other one may have been as well). A few other birds with dusky, mottled backs, wings, and (in some cases) tails were presumed to be immatures of the light morph. No red-footed boobies were seen away from the immediate vicinity of the colony other than one seen flying in toward the colony from the ocean south of Wilkes Island on March 31, 1993.

Bailey (1951) saw no boobies of any species nesting on the island when he visited in May 1949; however, he attributed this to the near devastation of the island during the war which had ended only four years prior to his visit.

Rowland (1989b) counted 41 red-footed booby nests on Wilkes Island in April 1989. The eight nests in which he was able to determine the contents all had young.

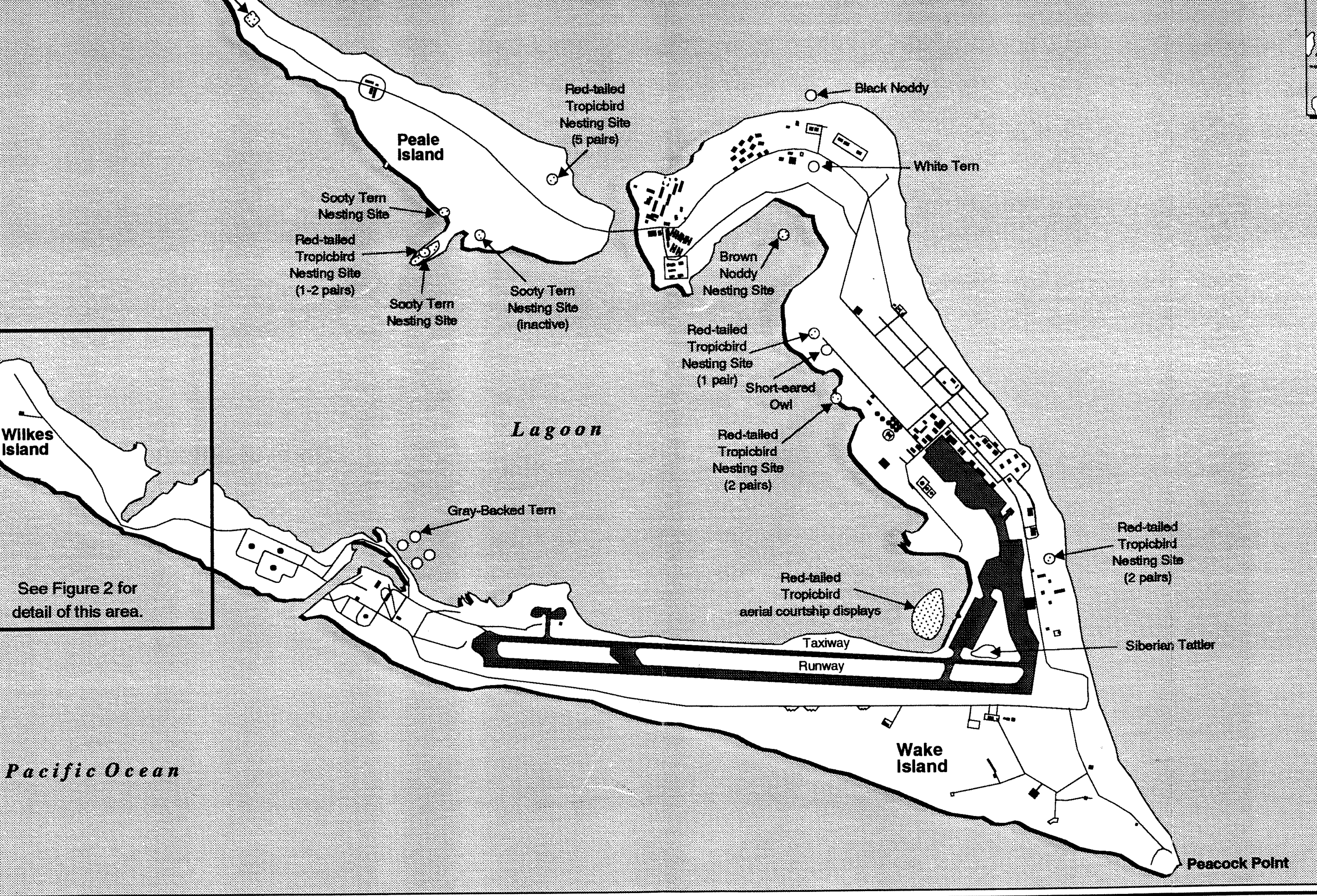
Great Frigatebird *Fregata minor*. This species of frigatebird is found in the Pacific and Indian oceans and in the Atlantic off the coast of Brazil. Its nesting requirements are similar to those of the red-footed booby, and the two species sometimes nest in adjacent colonies. Frigatebirds build their crude platform nests in bushes from 0.5 to 4 m off the ground. Their breeding season in Hawaii is in spring and summer; egg laying takes place in March and April and the young have fledged by October.

Up to 225 birds were seen perched on power lines that cross the manmade channel bisecting Wilkes Island about midway along its length (figure 2). Frigatebirds use these power lines for roosting; although a few were frequently seen there well into the morning and well before dusk. Most of the frigatebirds observed at the atoll (70 percent) were immatures. Other than at the power lines, frigatebirds were only seen in the red-footed booby colony (once) and flying over Wilkes Island. They were seldom seen over either Peale or Wake proper.

Frigatebirds showed no indication of breeding during the survey period. None of the references examined (Bailey 1951; Bryan 1959; Rowland 1989a, 1989b; Sutterfield 1989) indicated that frigatebirds nested on the island, although most found a number of birds present (Sutterfield counted 274 on the power lines across the Wilkes Island channel).

Pacific Golden-Plover *Pluvialis fulva*. Golden-plovers are widespread in the northern hemisphere, breeding in the arctic tundra and migrating south to the tropics in winter (see Hayman et al. 1986 for worldwide distributions of shorebirds). Most authorities (Hayman, et al. 1986; American Ornithologists' Union, in press) now recognize *P. fulva* as a separate species distinct from other golden-plovers in plumage characters, body size, and proportions. The Pacific (or lesser) golden-plover breeds in northern Siberia and western Alaska and winters in southern Asia, Australia, New Zealand, and the Pacific islands. Two other species, *P. apricaria* and *P. dominica* breed in Europe and North America, respectively.

This species is a fairly common and widespread winter visitor on Wilkes and Wake islands, but is relatively scarce on Peale Island due to the lack of open, grassy habitats. It was observed primarily in short-cropped grassy areas (especially along the runway, taxiway, and golf course, but also on both outer and inner beaches).



ty:

Other Sightings:

Black noddy
Gray-backed tern
White tern

Wandering Tattler *Tringa incana.* This species breeds in the arctic and sub-arctic regions of western North America and winters from the west coast of North America across the Pacific to Australia.

Several individuals were seen daily in habitats including outer rocky and pebbly beaches, calm channel shorelines, fresh and brackish water ponds, and sand flats in the inner lagoon.

Siberian Tattler *Tringa brevipes.* This bird breeds in eastern Siberia and winters in southeast Asia, Australia, and the western Pacific.

One individual was seen and heard calling at the fresh water pond located between the tarmac and taxiway at the air terminal (figure 1). This may represent the first record of this species from Wake Atoll; however, it is to be expected occasionally, as it is frequently seen in Micronesia and occasionally in the Marshall Islands (Pratt et al. 1987). Nearly identical in plumage to the wandering tattler, the Siberian tattler (also called gray-tailed tattler and Polynesian tattler in the literature) is undoubtedly often overlooked. If heard calling, however, the two species can be readily distinguished.

Ruddy Turnstone *Arenaria interpres.* The ruddy turnstone breeds in the arctic and migrates to the coasts of all continents but Antarctica in winter. It is a common migrant and winter visitor on most Pacific islands.

One individual was observed feeding in the closely cropped grass at west end of runway on 25 March. This species was abundant at Kwajalein Island on March 23 and 31 (March 24 and April 1, Wake Island time) so it is somewhat surprising that only one was seen on Wake.

Gray-backed (Spectacled) Tern *Sterna lunata.* This species has a somewhat limited distribution, being confined to the tropical Pacific Ocean from Hawaii south to the Tuamotu Archipelago, Tonga, and Fiji, and west to the Marianas. It often nests on the same islands and even in the same colonies with sooty terns, but because it is usually much less common than the sooty tern, it may be forced to nest at the perimeter of the colony, often in more exposed areas (Harrison 1990). Its breeding cycle is usually slightly ahead of the sooty tern, with eggs sometimes laid as early as February.

Four to eight individuals were seen perched on and flying in the vicinity of a cluster of wooden posts (possibly part of an old fish trap) just offshore on the lagoon side of the causeway between Wake and Wilkes islands (figure 1). Although present in this area most mornings, no indication of breeding was observed. It is possible that a few pairs of this species, which can easily be overlooked in a large mass of sooty terns, may breed at Wake Atoll occasionally, although breeding has not been documented. Harrison (1990) lists Wake as one of the islands where it breeds but gives no specific information.

Sooty Tern *Sterna fuscata.* The sooty tern is the most common and widespread of all tropical terns, and because it often nests in colonies numbering in the millions, some have considered it to be one of the most common birds in the world. However, like all highly gregarious species, it is vulnerable to mass extirpation by introduced predators such as feral cats and from habitat destruction in major breeding areas. In Hawaii, sooty terns have an annual breeding cycle, and this appears to be the case at Wake Atoll. Clearly, most, if not virtually all sooty terns at Wake nest in the spring, as on Hawaii.

The breeding cycle may vary according to oceanographic conditions which affect food supplies, but in general, sooty terns lay their single egg sometime between March and July. Observations on Wake, at least in 1989 and 1993, suggest an earlier breeding season, with the incubation period having ended by late March and early April; however, Bailey (1951) found sooty terns still on eggs in May. Sooty terns have an incubation period of 29 days. Young require eight weeks to fledge.

This is by far the most abundant bird on Wake Atoll. There is a large breeding colony at the west end of Wilkes Island (Exhibit 2) and a smaller active colony on Peale Island (figure 1). Evidence of two recently active colonies elsewhere on Peale was also noted. No birds were found breeding on Wake Island proper. The Wilkes colony occupied an area of 18,000 m^2 at the west end of an expansive grassy area just above the shoreline. The number of adults counted in this colony varied between approximately 10,000 and 25,000, with higher counts obtained at dawn and dusk. The number of young was estimated to be approximately 3,000 to 3,500 based on extrapolation from counts made in various sections of the colony. There were an estimated 9,800 eggs in the colony, but none examined were viable as most were cracked or broken. Young birds varied in age from only a few days old to nearly full grown. No flying young were seen in this colony during the first two days, but one newly-fledged bird was seen on March 26 and 27 flying over the shoreline just west of the colony (perhaps the same individual on both occasions). No predation on sooty tern eggs or young was observed; however, a feral cat was observed running through the colony on March 27. The cat did not attempt to capture any young but rather seemed harassed by the birds.

On Peale Island, the only breeding birds were found on and immediately adjacent to Flipper Point. Flipper Point is actually a separate island except at low tide when it is connected to Peale by a narrow sand spit. Young birds were seen in groups along the shoreline, and a few were seen in the vegetation just above the shoreline. An estimated 400 young were present in this colony; however, a direct count was not possible because of the dense vegetation over most of its area. Interestingly, in contrast with the Wilkes colony, many young in this colony had fledged and were seen flying about the colony on March 24 and afterward. On average, unfledged birds were about 1.5 to 2 weeks older than on Wilkes.[5] Evidence of recent nesting was present near Flipper Point and at the west end of Peale where a number of dead chicks and non-viable eggs were found. Most of these were in the colony near Flipper Point. Approximately 500 eggs and an undetermined number of dead chicks of all ages were found, as well as about 10 dead adults. The deterioration of the carcasses prevented any determination of cause of death. At the extreme west end of Peale, fewer than 20 hatchling-aged chick carcasses were found in a small clearing at the end of the road. No remains of eggs, adults, or older chicks were found. There was no evidence of nesting anywhere else on Peale. Much of Peale Island is heavily vegetated with *Tournefortia argentea*, *Scaevola sericea*, and *Pemphis acidula* shrubs, and does not appear to be suitable nesting habitat for sooty terns.

Rowland (1989a, 1989b) visited the atoll in early-April 1989 and found approximately 250,000 nestling sooty terns in a 48,000 m^2 colony at the west end of Wilkes Island. This stands in stark contrast to the 3,000 to 3,500 chicks found in a colony only three-eighths this size during the present visit at virtually the same time of year when birds were in about the same stage of their breeding cycle. Rowland also found considerably more birds on Peale Island. He estimated about 100,000 chicks on Flipper Point alone and 43,000 more in the general vicinity of Flipper Point. In contrast, a total of about 300 chicks

[5] Island residents mentioned that there were considerably more adult birds on Peale (they used the term "millions") a few weeks prior to the survey.

and recently fledged birds were found on Peale during the present survey.[6] Sutterfield (1989) found no nesting evidence on Wilkes Island in late October 1989, but did find "a few eggs" on the northwest point of Peale Island. He did not indicate if they were being incubated.

It should be noted that Bailey (1951) described the sooty tern colony on Peale Island as "...the largest I had ever seen", suggesting that the colony was much larger than the one encountered during this survey; however, he did not give estimates of size other than to say that he saw "thousands of birds on their eggs" on May 15.

Brown Noddy *Anous stolidus*. The brown noddy is also pantropical in its distribution, but in most areas is not as abundant as the sooty tern. It breeds on the ground, on cliffs and offshore rocks, and in trees, often well within the interior of larger islands. This species is much less colonial than the sooty tern and black noddy. Brown noddies in Hawaii have a protracted nesting season with two egg-laying peaks, one in spring, the other in summer (Harrison (1990). Consequently, the brown noddy may be seen on eggs any time between March and August. Its incubation period is about 35 days and the young remain dependent on their parents for up to three months.

Eight birds and two freshly constructed nests were seen on top a concrete bunker at the outer perimeter of the sooty tern colony on Wilkes on March 26 (figure 2), and four birds were seen perched, one with vegetation in its beak, atop a relatively large offshore coral "rock" covered with whitewash off the west end of Wilkes. On March 28, one nest with an egg was located atop a large concrete block in the lagoon near the golf course on Wake Island proper (figure 1). Also on this date, a flock of 65 noddies were seen throughout much of the day circling around a cluster of *Casuarina* trees on the golf course and perched on offshore coral near the golf course. By March 29 the number had grown to 90 individuals, plus two individual black noddies (*Anous minutus*). Other scattered individuals were seen throughout the atoll flying along shore or feeding offshore, with overall numbers on the atoll increasing noticeably over the duration of the survey period.

Bailey (1951) found brown noddies nesting in *Pisonia grandis* trees in May 1949. Bryan (1959) makes two additional references to brown noddies nesting at Wake Atoll: one nest of unknown contents seen by Fosberg in April 1952, and one nest with a half-grown young seen in October 1953.

Black Noddy *Anous minutus*. The black noddy is found throughout most of the tropical Atlantic and Pacific oceans. It breeds primarily in trees and bushes such as *Tournefortia*, *Casuarina*, and *Scaevola*, but also in bunchgrass and other plants (Harrison 1990). Black noddies in Hawaii may lay as early as November. Egg laying peaks in December and January, but can continue until June (Harrison 1990). Their incubation period is the same as for brown noddies, but black noddy young grow much faster, averaging 38 days from hatching to first flight.

Two individuals were seen perched together with brown noddies on a concrete structure just offshore along the outer beach opposite the golf course on March 29 (figure 1). This species may also breed on Wake Atoll on occasion; however, breeding has not been suspected by past observers and the species has apparently been seen on the atoll only on a few occasions.

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[6] Island residents described a much larger colony a few weeks prior to this visit.

White Tern *Gygis alba*. This species breeds in the western and central Pacific Ocean, the Atlantic Ocean south of the equator, and the Indian Ocean. It does not build a nest, but lays its egg on exposed rocks, tree crotches, ledges, and even fenceposts, window ledges, and bare branches (Harrison 1990). Birds generally breed during spring and summer in Hawaii. Their incubation period is 34 to 36 days and the young generally fledge in eight to nine weeks.

Three birds were seen in flight near the west end of the runway on March 24. This species was not seen again until March 28 when six birds were seen circling around and perched in the cluster of *Casuarina* trees at the golf course on the main island (figure 1). These birds were seen there every day subsequently until the end of the survey period on April 1. They were not seen exhibiting any courtship behavior.

Short-eared Owl *Asio flammeus*. Nearly cosmopolitan, being found over much of North and South America, Europe, and Asia, as well as many of the Pacific Islands (Galapagos, Hawaii, and Pohnpei). Migrants have been found in the Marshall Islands and elsewhere in the Pacific.

An owl was flushed from beneath a small *Pemphis* bush at the southwest corner of the catchment basins in the late morning on March 28 (figure 1), and a few minutes later was observed flying low over the open scrubby area between the catchment basins and the golf course.[7]

Rock Dove (Feral Pigeon) *Columba livia*. A flock of 11 birds on March 28 and six birds on March 29 were seen in the vicinity of the golf course. These birds are apparently being bred by an island resident (Rowland 1989b).

3.2 OTHER OBSERVATIONS

Feral cats were frequently observed on both Peale and Wilkes islands, and one feral cat was seen in the sooty tern colony on Wilkes on March 26. The abandoned colony on Peale Island showed evidence of cat activity that may have caused at least partial failure of that colony. Island residents said that considerably more sooty terns have bred at Wake Atoll in past years (as indicated in the literature cited above), and attribute their decline to feral cats, which, according to some, can destroy hundreds of nestlings in a single night and cause others to disperse into dense vegetation where they are abandoned. One resident said that the Vortac area on Wilkes is graded each year prior to commencement of the sooty tern nesting season, in part, to destroy rats, their young, and any subsurface burrows, and to make feral cats more visible to the nesting birds.

Flipper Point on Peale Island may not have any resident cats because of its nearly complete isolation from the rest of Peale, and this may be the reason for the success of its relatively small colony.

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[7] Although unrecorded in the literature from Wake Island, Mr. Hitchcock has seen owls (presumably this species) at Wake on several occasions. They are usually seen in vehicle headlights when flushed from the roadside at night.

SECTION 4
DISCUSSION

4.1 SENSITIVE SPECIES

There are no threatened or endangered bird species on Wake Atoll. The Wake rail (*Rallus wakensis*), a flightless species endemic to Wake, has not been seen since World War II and is assumed to be extinct. Japanese soldiers who occupied Wake Atoll during the war are reported to have resorted to capturing and eating rails to avoid starvation (Fuller 1988). This activity either directly caused their extinction or reduced the population to a level low enough for feral cats to capture the few remaining birds.

All other naturally occurring bird species recorded from Wake Atoll are protected under the Migratory Bird Treaty Act of 1916 (16 U.S.C. 703-712). The act protects all non-game bird species native to the United States and its territories, including those that may be present only as migrants. Under the Act, it is unlawful to "pursue, hunt, take, capture, kill, attempt to take, capture, or kill...any migratory bird, any part, nest, or eggs of any such bird...". It is generally inferred that the destruction of any habitat known to contain birds actively engaged in nesting in that habitat would be in violation of the Act, as the nests, eggs, or young would almost certainly be destroyed along with the habitat.

4.2 ENVIRONMENTAL CONSIDERATIONS

Most colonial nesting seabirds found on Wake Atoll (sooty terns, boobies, frigatebirds) do not breed on Wake Island proper, presumably as a result of past and present human activities on the island. Non-colonial or semi-colonial nesters such as the red-tailed tropicbird, however, do nest on the main island. Colonial nesters are more vulnerable to direct disturbance by human intrusion and by feral cats, both of whom can cause abandonment of an entire colony through repeated disturbance. While feral cats are a problem on both Wilkes and Peale islands, humans and their activities generally are not. There are no regularly inhabited structures on Peale or the western half of Wilkes islands.

Most proposed project activities addressed in this document are restricted to Wake Island proper. Those that are not, are an extension of a water pipeline along an existing roadway on Peale Island and a borrow site in a small, disturbed area of Wilkes Island well away from any breeding colonies. The only seabirds with the potential for being impacted directly from project activities are the red-tailed tropicbird, brown noddy, and, perhaps, great frigatebird, black noddy, and white tern which nest in shrub vegetation and may nest on the main island (if they nest on Wake Atoll at all).

Most proposed construction activities should not have a direct impact on nesting seabirds at Wake Atoll. Colonial nesting species at Wake (sooty tern, boobies) are confined to Wilkes and Peale islands where little construction activity is proposed. The proposed potable water distribution pipeline, which will extend to Peale Island, will be confined to an existing road alignment. The proposed borrow area on Wilkes Island is in an already highly disturbed area where no seabirds currently nest. Construction activity could disrupt nearby breeding birds such as black noddies, white terns, and great frigatebirds; however, they apparently do not presently nest in any of the areas proposed for construction.

Nesting of red-tailed tropicbirds was observed on Wake Island; suitable tropicbird nesting habitat is present. However, it should be noted that all observed breeding activity for this species during the survey was in the northern arm of the atoll. The batch plant and lay-down areas are in the southern arm of the atoll.

The literature is not clear as to whether white-tailed tropicbirds nest on the island, but this species could potentially be affected by construction. Even if it nests on the island, it would never be common, as this species typically nests on high islands, not atolls. Black noddies and white terns are two tree-nesting species that could potentially breed on the main island. However, as there is no direct evidence of these species nesting on Wake Island, it is assumed that they will not be affected by construction. Great frigatebirds appear to be permanent residents at the atoll, and most observers have assumed that they breed here (despite apparent absence of breeding records in the literature).

As the areas of proposed construction are small and confined to populated areas of Wake Island proper, a small forested area of Wilkes Island (borrow site), and along an existing road alignment on Peale, any construction-related impacts to seabirds would not be considered significant. All of the seabirds breeding at Wake Island are widespread and common in the Pacific and would be minimally impacted (if at all) on Wake Atoll as a direct result of these activities.

Large aircraft such as the C-141 StarLifter taking off and landing are barely if at all audible from the Wilkes Island sooty tern colony which is only one mile from the end of the runway. Arriving and departing aircraft were not audible from Peale Island under conditions encountered during the survey (steady trade winds of 10 to 20 knots). These prevailing trade winds effectively mute the sound of aircraft at distances greater than a few hundred meters. Departing aircraft, which generate the most noise, take off to the east under most conditions, directly away from the seabird breeding colonies on Wilkes and Peale islands. The missile launch pads are also at the east end of the island several miles from any existing colonies. The constant calls of sooty terns at their nesting sites further mute any loud noises, even those emanating from relatively near the colony. It is not likely that future launches from launch pads three to four miles away would have any impact on seabirds nesting on Wilkes or Peale islands.

Effects of noise on birds and other wildlife have been extensively reviewed (Fletcher and Busnell 1978; Brattstrom 1982; Memphis State University 1971). Several studies have shown that intermittent noises (other than those at or near the threshold of pain) have little if any apparent effect on most animals, including birds (Dunnet 1977; Ellis 1981; Kushlan 1979). Birds, for example, accommodate quickly to most non-constant noise in their environment, even gun shots, explosives, nearby departing aircraft, and the like.[8] However, constant noise (such as the drone of freeway traffic), even as low as 60 decibels, may interfere with courtship and territorial defense in songbirds.

Persistent and relatively brisk trade winds should minimize any contamination of the air in the vicinity of Wake Atoll to levels below that which should have any impacts on birds or other wildlife.

Generally, hazardous materials contamination would be restricted to small areas near the source of pollution. Local spills of petroleum products such as gasoline, jet fuel, and oil could be harmful if they come into contact with or were ingested by birds. Spills into the lagoon may spread over the water

[8] H. Lee Jones, personal observations.

surface and result in impacts, including death of a small number of seabirds that may drink from or land on the water; however, no birds were seen doing either during the survey period. Golden-plovers and tattlers forage along the edge of the lagoon and could be affected. However, none of the proposed activities is likely to result in petroleum contamination.

Indirect impacts on birds may result from increasing human presence on the atoll. Human intrusion into seabird colonies can result in abandonment of the colony from repeated or prolonged disturbance. Also, nests exposed when birds are flushed may be susceptible to predation by frigatebirds. Without restrictions, an increased population of humans (and accompanying increases of air- and sea-based traffic to the atoll), could result in an increase in stray dogs, cats, and rats, as well as non-native pests that may be inadvertently transported to the island. For example, the inadvertent introduction of the brown tree snake (*Boiga irregularis*) from Guam to Wake is a very real threat, the risk of which is likely to increase in direct proportion to the number of cargo shipments to the island, especially if unregulated or unmonitored.

4.3 MITIGATION MEASURES

All island residents, including visitors, should be briefed on the importance of protecting the nesting seabirds at Wake Island from human disturbance. Access to certain areas is currently restricted or denied during periods when the sooty terns are nesting, and this policy should be continued, but enforced more rigorously. During the survey period (on March 25), seven island residents were observed parked within 20 m of the red-footed booby colony on Wilkes Island. Earlier in the day, about 25 frigatebirds were perched in these nesting trees. Although they had left by sunset, frigatebirds are well known for raiding the exposed eggs and chicks of booby nests left unattended, as when nesting birds are flushed by human intruders.

All shipments to Wake Island should be carefully checked for pest species such as the brown tree snake, rats, mice, and insects and insect larvae, both prior to shipment and at arrival on the island. Any such pest found should be promptly destroyed.

To avoid potential impacts to nesting birds, it is recommended that, to the extent feasible, construction activities be confined to the period between August and January, as birds are least likely to be nesting during these months.

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Appendix F

NOTICE

This Botanical Survey assesses some specific activity locations that were part of the proposed action at the time of the survey but were later removed from consideration. However, the data have been left in the report to provide baseline information for future studies. Additionally, this survey does not discuss some new facility construction locations in the proposed action that were identified after the field investigation was completed. The environmental assessment for these additional facilities was developed from the survey report and from unpublished field notes.

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BOTANICAL SURVEY REPORT

FOR

ENVIRONMENTAL ASSESSMENT FOR LONG-TERM ACTIVITIES AT WAKE ATOLL

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[1]Tables 1 through 6 appear at the end of Section 3; Table 7 appears at the end of Section 5.

SECTION 1
INTRODUCTION

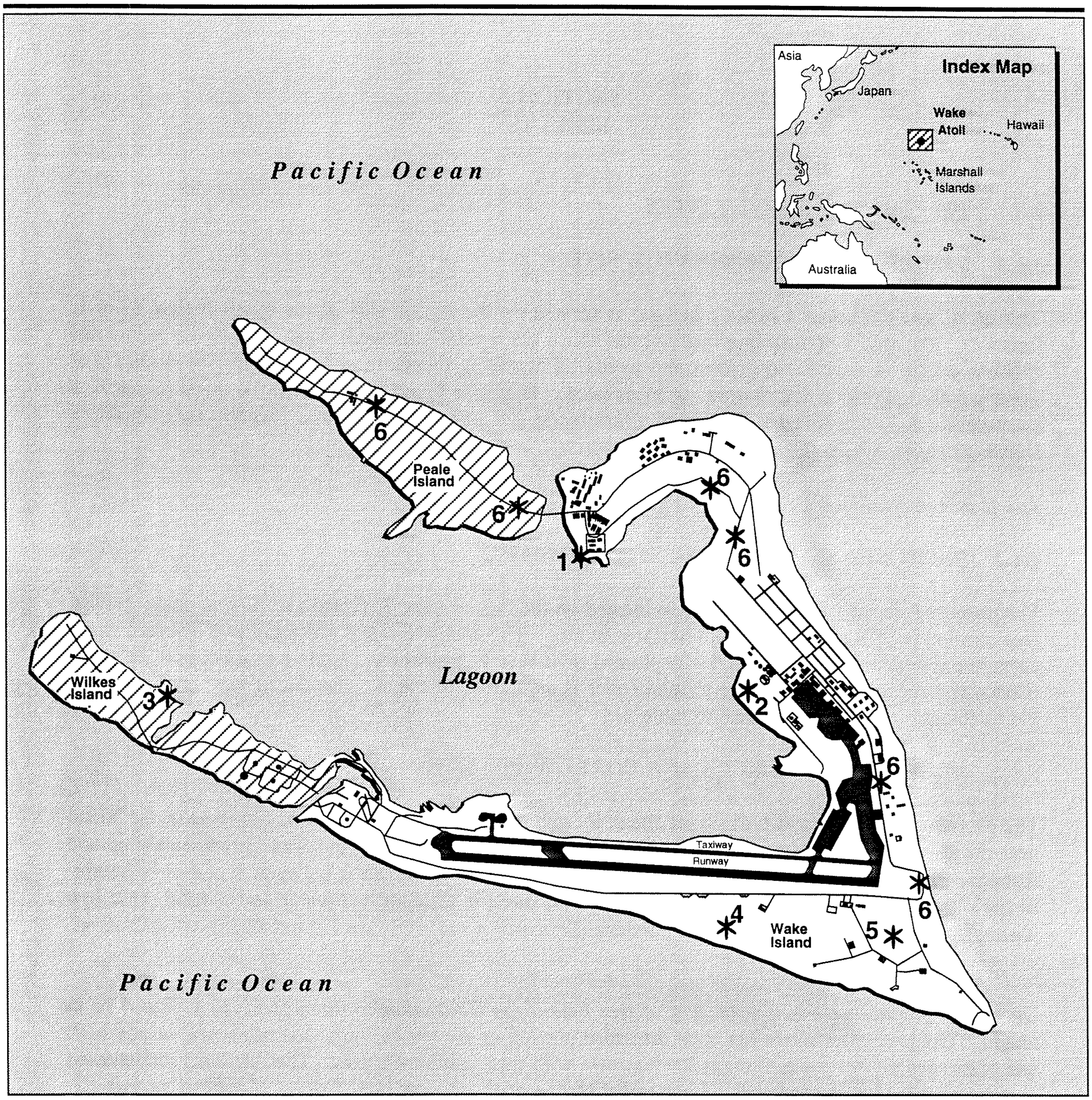
One hundred percent coverage botanical surveys were carried out on several selected sites on Wake Island during the last week of March 1993. In addition, overview botanical surveys were completed on both Wilkes and Peale islands. The purpose of these surveys was to collect data on and to describe the vegetation of the sites, to prepare species lists of the naturally occurring vegetation of the area, and to determine if any federally listed or proposed threatened or endangered species are present on these small islands (USFWS 1992).

The botanical history of Wake Island has been more than adequately reviewed by both Bryan (1959) and Fosberg (1959). Since Fosberg's publication, Rowland (1989) has reported the results of biological surveys on several project sites on Wake Island. While Fosberg recognized 93 species of vascular plants on the atoll, it should be noted that all plant taxa present on the island were recorded including plants in private gardens and those which were used in the landscaping of developed areas. Fosberg identified 19 species in 11 plant families which were indigenous to these islets.

During this study, only naturally occurring plants of the specified sites, of the undeveloped areas, and those plants which appear to be surviving and proliferating on their own among abandoned buildings were recorded.

SECTION 2
METHODS

Two botanists walking 6 to 10 meters (m) apart covered those sites on which 100 percent coverage surveys were requested (figure 1). On Wilkes and Peale islands circular transects were walked and cross island transects were carried out where the vegetation warranted. The vegetation of each 100 percent coverage survey site is described and a species list for each of these sites is included. General descriptions of the vegetation of Wilkes and Peale islands are also provided.



EXPLANATION

✱ 100% Coverage Surveys

▨ Overview Surveys

Numbers 1 Through 6 Are Site Survey Points

0 510 1,020 Meters
0 1,675 3,350 Feet

Botanical Survey Sites

Wake Island

Figure 1

gr/Wake/064.mdh-1/3/93

SECTION 3
RESULTS

3.1 <u>100 PERCENT SURVEY SITES</u>

3.1.1 PROPOSED NEW GENERATOR SITE

This small site, less than 1 hectare in size, is located on the lagoon side of the baseball field (Site 1, figure 1). The area is planted in mixed grasses which are regularly mowed. Species diversity is low and consists mostly of introduced grasses and weeds. Only along the shore of the lagoon is it evident that some woody vegetation was beginning to develop. Here are found some ironwood trees (*Casuarina equisetifolia* L.), a tropical almond tree (*Terminalia catappa* L.), and some shrubby individuals of *Leucaena leucocephala* (Lam.) deWit.

The plant species found on this site are listed in table 1.

3.1.2 PROPOSED INCINERATOR SITE NUMBER 2

The proposed site of Incinerator No. 2 is located on the lagoon (Site 2, figure 1). It is an open, mowed area consisting of approximately 0.5 hectares in size. The area is flat and presently two unpaved roads cross this small space. It is fringed with planted trees such as ironwoods, tropical almond, and sea grape (*Coccoloba uvifera* [L.] L.). The ground cover is composed of mixed, introduced grasses and weeds. Plants found on this site are listed in table 2.

3.1.3 PROPOSED WILKES ISLAND BORROW PIT SITE

The proposed Wilkes Island borrow pit site is located on the lagoon side (Site 3, figure 1) of the island near the manmade channel which was created by earlier borrowings from the area. Immediately upland from the shore, the vegetation is *Pemphis acidula* Forst. f. scrub which is between 3 to 4 m in height. In the old digging sites, which are below sea level, there is standing sea water and around these low places, dense mats of red-stemmed sea purslane (*Sesuvium portulacastrum* L.) have become established.

On higher ground there is a scattering of tree heliotrope (*Tournefortia argentea* L. fil.), 3 to 4 m in height. The ground cover in the most disturbed portion of the site is composed of several weedy herb and grass species, but much of the space is strewn with coral rubble and sand. The relatively undisturbed portion of this site is vegetated with tree heliotrope and common bunch grass (*Lepturus repens* [G. Forster] R. Br.) with small enclaves of native scurvy grass (*Lepidium bidentatum* Montin) found under the trees.

Like most of the rest of this atoll, the interior of this site displays the scars left from World War II. There are deep trenches which were dug to slow the movement of tanks, there are gun emplacement sites, and other types of protective excavations and pits, most of which are covered by dry, brown bunch grass (*Lepturus gasparricensis* Fosb. and *L. repens*).

Only the taxa listed in table 3 were found on this site.

3.1.4 PROPOSED BATCH PLANT SITE

The proposed batch plant site lies between the revetments and seaward from Elrod Road and the Pacific Ocean (Site 5, figure 1). This is a very disturbed site, some of which (the area closest to the ocean) appears to have been inundated by the large storms which raked the atoll in late 1992. The emergent vegetation is scattered, introduced ironwood trees, 8 to 15 m in height with tree heliotrope forming a canopy layer 3 to 4 m in height. Derelict bunkers and other fortifications are interspersed with discarded vehicles, metal, and concrete rubble. There are widely dispersed enclaves of *Pemphis*, naupaka (*Scaevola sericea* Vahl.), and sourbush (*Pluchea symphytifolia* [Mill.] Gillis). The ground layer, near the highway, is composed of introduced grasses and adventives while nearer the ocean, the ground layer is coral rubble and sand.

This is a somewhat larger site and the species diversity is correspondingly greater. The taxa found on the site are included in the listing shown in table 4.

3.1.5 PEACOCK POINT AREA

The Peacock Point site extends from the control tower eastward along Elrod Drive to the ocean and from the tower to the Pacific Ocean (Site 6, figure 1). The vegetation of this area is a changing mosaic of scrub tree heliotrope, ironwood, and kou trees (*Cordia subcordata* L.) interspersed with dense stands of naupaka and cotton (*Abutilon albescens* Miq.). Eastward from Peacock Point Road the tree heliotrope is mostly scattered, shrubby individuals growing in coral rubble. West of this road, the tree heliotrope is interspersed with dense stands of naupaka and ironwood trees which become dominant at the west end of the site and in the near vicinity of the control tower. Just seaward of the tower, and to the east as far as Peacock Point Road, dense stands of kou trees, 6 to 8 m in height, can be found. The upper branches of these trees, like all of the kou trees on the atoll, are bare and dry, a reminder of the storms of last fall.

Of the 23 species of weedy plants found during this survey and not reported by Fosberg (1959), 14 were from the Peacock Point site.

There are two proposed launch sites within the Peacock Point study site. These areas were revisited and a 20 m radius around each site was re-examined. The area around Launch Site 1 has been cleared and the coral rubble has been scraped into long piles around the site. There is a scant covering of vegetation on the pushed up rubble. The principal species are kou and tree heliotrope. At the northwest edge of the cleared area, there is one *Pisonia grandis* tree, one of the few trees native to Wake Atoll. The remainder of the vegetation is mostly low growing weeds such as *Bidens*, pigweed, and mixed grasses.

Launch Site 2 has also been cleared and the tree heliotrope is just beginning to re-invade the area. Most of the plant cover is composed of weedy plants like *Tridax*, Jamaica vervain (*Stachytarpheta jamaicensis* [L.] Vahl), 'Uhaloa (*Waltheria indica* L.), and Nohu (*Tribulus cistoides* L.). The vegetation of the proposed launch pad sites is principally weeds, except for the few plants noted.

The taxa found on Peacock Point are recorded in table 5.

3.1.6 PROPOSED WATER DISTRIBUTION PROJECT

The proposed water distribution project study area included both sides of the main road from the control tower, through the developed areas, the principal side streets, and on to the ruins located on Peale Island (figure 1). The existing system is to be pressure tested and repaired or replaced to restore it to the original specifications. The botanical survey covered an area on either side of the road, 7 m from the centerline.

It was found that the road shoulders are, for the most part, kept mowed and the fringing vegetation is mostly composed of grasses and prostrate herbs. On Peale Island some shrubs such as *Pemphis*, sourbush, and sea grape infringe on the road shoulders. On the lagoon side of the road (near the ruins) some ironwood trees and a large enclave of thorny cactus (*Opuntia littoralis* [Tour.] Mill) will have to be removed.

These and other plants found along this alignment are listed in table 6.

3.2 OVERVIEW SURVEY SITES

3.2.1 WILKES ISLAND

Wilkes Island is connected to Wake Island by a narrow causeway. At the present time only a liquid fuel storage facility, a small building belonging to the University of Hawaii, and a small boat harbor are located on this small islet consisting of more than 100 hectares.

The western one-third of Wilkes Island has been set aside for a large sea bird colony (figure 2). The area has been cleared and is regularly mowed to protect the sea birds from the many feral cats which inhabit the island. The most conspicuous vegetation at this end of the island is a scant fringe of heliotrope trees, 4 to 6 m in height, and the broad mats formed by the nohu vines (*Tribulus cistoides* L.) which dominate the clipped, flattened landscape. Nohu vine was introduced into the area to help keep both predators and people away from the colony.[2]

From the eastern edge of the bird sanctuary clearing to the Wilkes Island channel and continuing on the south side of the road to as far as the fuel storage tanks, the vegetation cover is composed of scattered heliotrope trees from 1 to 8 m in height. The ground layer is mixed grasses, predominantly two species of bunch grass with intermittent patches of scurvy grass (*Lepidium bidentatum* Montin) and alena (*Boerhavia repens* L.).

On the south side of the dirt road, between the channel and the bird clearing, there is a long, deep tank trap. A dense colony of kou trees has grown up in this low area.

Along the lagoon shore of Wilkes Island, from the causeway to the proposed borrow pit site, the coastal vegetation is *Pemphis* with mats of sea purslane and a dense planting of ironwood trees near the point just north of the storage tanks. Between the coastal vegetation and the dirt road, many, many truck loads

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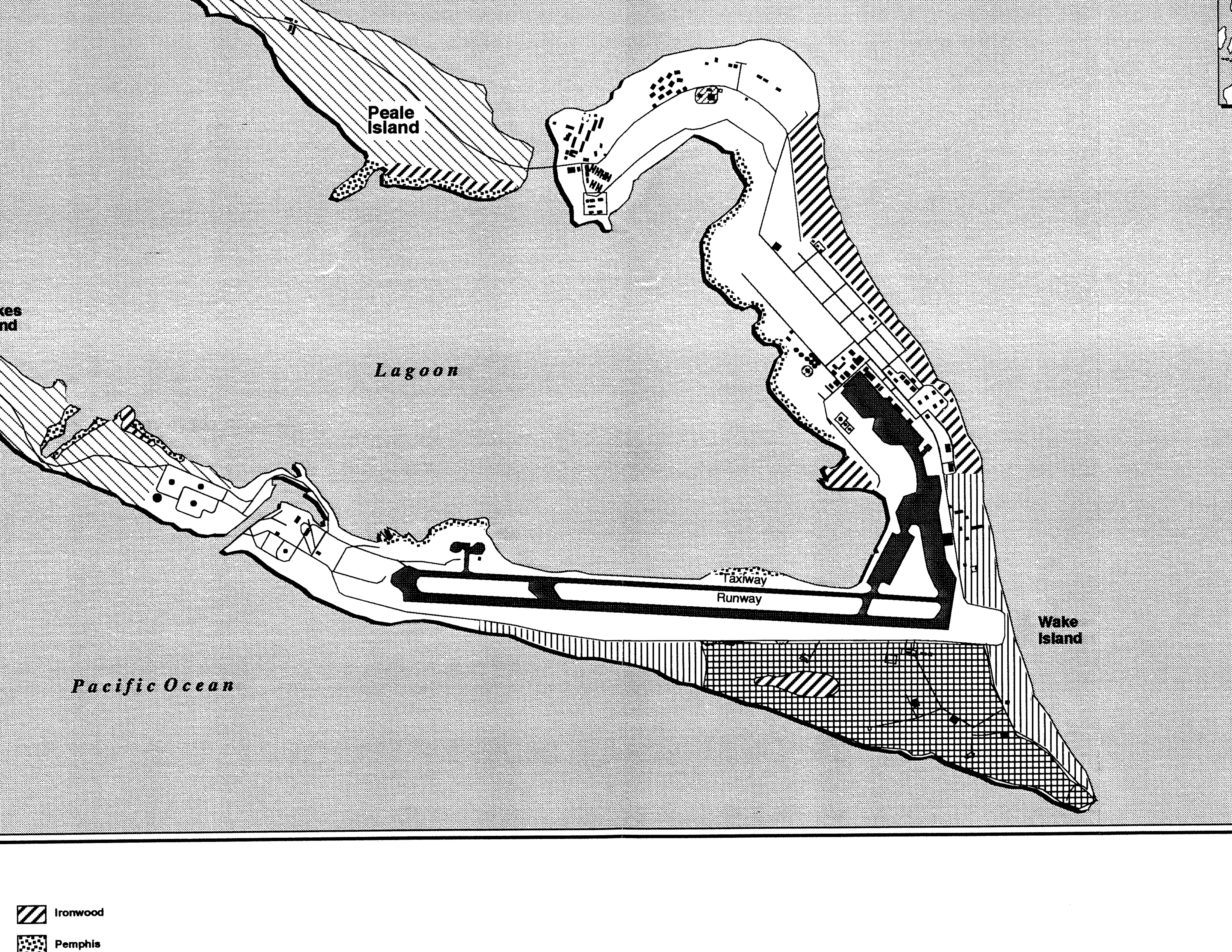
[2] Because of the two hard, stout spines (5 to 6 mm-long) which develop on its mericarps (one-half of a two-parted fruit), it was reasoned that a dense mat of these thorny vines would discourage entry into the area.


Peale Island
Lagoon
Taxiway
Runway
Wake Island
Pacific Ocean
Ironwood
Pemphis

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of coral rubble have been stored. A scant scrub of tree heliotrope, naupaka, sour bush, cotton, and various weeds and grasses cover about 50 percent of the ground surface. The remainder is coral rubble and metal and wood scrap.

All plants encountered on Wilkes Island are included in the comprehensive species list (Section 5).

3.2.2 PEALE ISLAND

A wooden bridge connects Peale Island to Wake Island at its northwestern tip (figure 2). Although Peale Island is uninhabited, a number of beach huts have been built along the shore as well as Thai Buddhist temple near the Wake Island Bridge.

Essentially, the dominant vegetation of Peale Island is tree heliotrope 2 to 8 m in height. The ground cover is mixed bunch grass and open coral rubble. Along the shore near the Wake Island Bridge, around to and including Flipper Point, and lining the inlets is a thriving *Pemphis* community with intermittent mats of red-stemmed sea purslane. Upland from, and intermingled with the *Pemphis*, is a burgeoning community of ironwood trees. About 150 m from the Wake Island Bridge on the ocean side of Peale Island Road can be found a scattering of *Pisonia grandis* and kou trees, almost all that is left of what Fosberg referred to as a *Pisonia/Cordia* forest (the only other *Pisonia* trees seen during this study were nine individuals near the golf course and a small colony of young trees coming up in the abandoned housing [both sites on Wake Island]).

About halfway between the Wake Island Bridge and the northwestern tip of Peale Island is a dirt road which leads to the old Pan American Seaplane Ramp. Just at the turn, there is a dense planting of *Opuntia littoralis* (Tour.) Mill. and a little further along the road is a reproducing stand of sisal (*Agave sisalana* Perrine). On either side of the dirt road are open areas where there are no heliotrope trees. In these open places can be found huge enclaves of the shrubby, wild cotton which is native to this atoll.

All plants found on Peale Island are reported in the comprehensive species list (Section 5).

TABLE 1
PLANTS AT PROPOSED NEW GENERATOR SITE, WAKE ISLAND[1]

FAMILY NAME *Scientific Name*	Common Name
AGAVACEAE - Agave Family	
**Agave sisalana* Perrine	Sisal
POACEAE - Grass Family	
**Cenchrus echinatus* L.	Common sandbur
**Cynodon dactylon* (l.) Pers.	Bermuda grass
**Dactyloctenium aegyptium* (L.) Willd.	Beach wiregrass
**Eleusine indica* (L.) Gaertn.	Wiregrass
**Eragrostis cilianensis* (All.) Link Stinkgrass	
**Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult	Lovegrass
Lepturus gasparricensis Fosb.	Broad-leaf bunchgrass
Paspalum vaginatum Sw.	Seashore paspalum
ARECACEAE - Palm Family	
**Cocos nucifera* L	Coconut
ASTERACEAE - Sunflower Family	
**Bidens alba* (L.) DC	
**Tridax procumbens* L.	Coat buttons
BORAGINACEAE - Borage Family	
Cordia subcordata Lam.	Kou
**Heliotropium anomalum* Hook. & Arnott	Hinahina
**Tournefortia argentea* L. fil.	Tree heliotrope
CASUARINACEAE - She-oak Family	
**Casuarina equisetifolia* L.	Ironwood tree
COMBRETACEAE - Indian almond Family	
Terminalia catappa L.	Tropical almond

TABLE 1 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name
CONVOLVULACEAE - Morning-glory Family	
*_Ipomoea pes-caprae_ (L.) R. Br.	Beach morning-glory
Ipomoea violacea L.	
CUCURBITACEAE - Gourd Family	
*_Coccinia grandis_ Ehrenb. ex Spach	Hedge hog
EUPHORBIACEAE - Spurge Family	
*_Chamaesyce hirta_ (L.) Millsp.	Hairy spurge
MALVACEAE - Hibiscus Family	
*_Abutilon albescens_ Miq.	
Sida fallax Walp.	'Ilima
PORTULACACEAE - Purslane Family	
*_Portulaca oleracea_ L.	Pigweed
VERBENACEAE - Verbena Family	
*_Stachytarpheta jamaicensis_ (L.) Vahl	Jamaica vervain
ZYGOPHYLLACEAE - Creosote Family	
*_Tribulus cistoides_ L.	Nohu

1. * = Non-native species introduced to Wake Atoll.

TABLE 2
PLANTS AT PROPOSED INCINERATOR SITE, WAKE ISLAND[1]

FAMILY NAME *Scientific Name*	Common Name
POACEAE - Grass Family	
**Cenchrus echinatus* L.	Common sandbur
**Chloris divaricata* R. Br.	Stargrass
**Cynodon dactylon* (l.) Pers.	Bermuda grass
**Dactyloctenium aegyptium* (L.) Willd.	Beach wiregrass
**Eleusine indica* (L.) Gaertn.	Wiregrass
**Eragrostis cilianensis* (All.) Link	Stinkgrass
**Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult	Lovegrass
Lepturus gasparricensis Fosb.	Broad-leaf bunchgrass
Paspalum vaginatum Sw.	Seashore paspalum
CYPERACEAE - Sedge Family	
**Cyperus rotundus* L.	Nut grass
**Fimbristylis cymosa* R. Br.	
ASTERACEAE - Sunflower Family	
**Bidens alba* (L.) DC	
**Tridax procumbens* L.	Coat buttons
BORAGINACEAE - Borage Family	
**Heliotropium anomalum* Hook. & Arnott	Hinahina
CASUARINACEAE - She-oak Family	
**Casuarina equisetifolia* L.	Ironwood tree
COMBRETACEAE - Indian almond Family	
Terminalia catappa L.	Tropical almond
CONVOLVULACEAE - Morningglory Family	
Ipomoea violacea L.	

TABLE 2 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name
POLYGONACEAE - Buckwheat Family	
**Coccoloba uvifera* (L.) L.	Sea grape
PORTULACACEAE - Purslane Family	
**Portulaca oleracea* L.	Pigweed
ZYGOPHYLLACEAE - Creosote Family	
**Tribulus cistoides* L.	Nohu

1. * = Non-native species introduced to Wake Atoll.

TABLE 3
PLANTS AT PROPOSED BORROW PIT SITE, WILKES ISLAND[1]

FAMILY NAME *Scientific Name*	Common Name
CYPERACEAE - Sedge Family	
**Fimbristylis cymosa* R. Br.	
POACEAE - Grass Family	
**Chloris divaricata* R. Br.	Stargrass
Lepturus gasparricensis Fosb.	Broad-leaf bunchgrass
Lepturus repens (G. Forster) R. Br.	Bunch grass
AIZOACEAE - Fig-marigold Family	
Sesuvium portulacastrum (L.) L.	Akulikuli
ASTERACEAE - Sunflower Family	
**Conyza bonariensis* (L.) Cronq.	Hairy horseweed
**Pluchea symphytifolia* (Mill.) Gillis	Sourbush
**Tridax procumbens* L.	Coat buttons
BORAGINACEAE - Borage Family	
**Heliotropium anomalum* Hook. & Arnott	Hinahina
**Tournefortia argentea* L. fil.	Tree heliotrope
BRASSICACEAE - Mustand Family	
Lepidium bidentatum Montin	Scurvy grass
CASUARINACEAE - She-oak Family	
**Casuarina equisetifolia* L.	Ironwood tree
CONVOLVULACEAE - Morning-glory Family	
Ipomoea violacea L.	

TABLE 3 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name
EUPHORBIACEAE - Spurge Family	
**Chamaesyce hypericifolia* (L.) Millsp.	Graceful spurge
**Euphorbia cyathophora* J. A. Murray	Mexican fire plant
LYTHRACEAE - Loosestrife Family	
Pemphis acidula Forst. f.	
MALVACEAE - Hibiscus Family	
Sida fallax Walp.	'Ilima
NYCTAGINACEAE - Four o'clock Family	
**Boerhavia repens* L.	Alena
PORTULACAEAE - Purslane Family	
Portulaca lutea Sol. ex G. Forster	'Ihi

1. * = Non-native species introduced to Wake Atoll.

TABLE 4
PLANTS AT PROPOSED BATCH PLANT SITE, WAKE ISLAND[1]

FAMILY NAME *Scientific Name*	Common Name
POACEAE - Grass Family	
**Cenchrus echinatus* L.	Common sandbur
**Chloris divaricata* R. Br.	Stargrass
**Cynodon dactylon* (l.) Pers.	Bermuda grass
**Dactyloctenium aegyptium* (L.) Willd.	Beach wiregrass
**Eleusine indica* (L.) Gaertn.	Wiregrass
**Eragrostis cilianensis* (All.) Link	Stinkgrass
**Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult	Lovegrass
Lepturus gasparricensis Fosb.	Broad-leaf bunchgrass
Paspalum vaginatum Sw.	Seashore paspalum
CYPERACEAE - Sedge Family	
**Cyperus rotundus* L.	Nut grass
**Fimbristylis cymosa* R. Br.	
ASTERACEAE - Sunflower Family	
**Bidens alba* (L.) DC	
**Conyza bonariensis* (L.) Cronq.	Hairy horseweed
**Pluchea symphytifolia* (Mill.) Gillis	Sourbush
**Tridax procumbens* L.	Coat buttons
BORAGINACEAE - Borage Family	
**Heliotropium anomalum* Hook. & Arnott	Hinahina
**Tournefortia argentea* L. fil.	Tree heliotrope
CASUARINACEAE - She-oak Family	
**Casuarina equisetifolia* L.	Ironwood tree
CONVOLVULACEAE - Morning-glory Family	
**Ipomoea pes-caprae* (L.) Rb.	Beach morning-glory
Ipomoea violacea L.	

TABLE 4 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name
EUPHORBIACEAE - Spurge Family	
Chamaesyce hirta (L.) Millsp.	Hairy spurge
Chamaesyce hypericifolia (L.) Millsp.	Graceful spurge
Euphorbia cyathophora J. A. Murray	Mexican fire plant
GOODENIACEAE - Goodenia Family	
Scaevola sericea Vahl	Naupaka
LYTHRACEAE - Loosestrife Family	
Pemphis acidula Forst. f.	
MALVACEAE - Hibiscus Family	
Abutilon albescens Miq.	
Gossypium religiosum L.	Wild cotton
Sida fallax Walp.	'Ilima
PORTULACACEAE - Purslane Family	
Portulaca lutea Sol ex G. Forster	
Portulaca oleracea L.	Pigweed
STERCULIACEAE - Cacao Family	
Waltheria indica L.	'Uhaloa
VERBENACEAE - Verbena Family	
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain

1. * = Non-native species introduced to Wake Atoll.

TABLE 5
PLANTS OF PEACOCK POINT AREA, WAKE ISLAND[1]

FAMILY NAME *Scientific Name*	Common Name
ARECACEAE - Palm Family	
**Cocos nucifera* L.	Coconut
CYPERACEAE - Sedge Family	
**Cyperus rotundus* L.	Nut grass
**Fimbristylis cymosa* R. Br.	
**Fimbristylis dichotoma* (L.) Vahl	Fringe rush
POACEAE - Grass Family	
**Cenchrus echinatus* L.	Common sandbur
**Chloris barbata* (L.) Sw.	Swollen fingergrass
**Chloris divaricata* R. Br.	Stargrass
**Cynodon dactylon* (l.) Pers.	Bermuda grass
**Dactyloctenium aegyptium* (L.) Willd.	Beach wiregrass
**Digitaria insularis* (L.) Mez ex Ekman	Sourgrass
**Eleusine indica* (L.) Gaertn.	Wiregrass
**Eragrostis cilianensis* (All.) Link	Stinkgrass
**Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult	Lovegrass
Lepturus gasparricensis Fosb.	Broad-leaf bunchgrass
Lepturus repens (G. Forster) R. Br.	Bunch grass
Paspalum vaginatum Sw.	Seashore paspalum
**Zoysia japonica* Steud.	Temple grass
AIZOACEAE - Fig-marigold Family	
Sesuvium portulacastrum (L.) L.	Akulikuli
APOCYNACEAE - Dogbane Family	
**Catharanthus roseus* (L.) G. Don	Madagascar Perwinkle
ASTERACEAE - Sunflower Family	
**Bidens alba* (L.) DC	
Conyza bonariensis (L.) Cronq.	Hairy horseweed
**Pluchea symphytifolia* (Mill.) Gillis	Sourbush
**Tridax procumbens* L.	Coat buttons

TABLE 5 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name
BORAGINACEAE - Borage Family	
**Cordia subcordata* Lam.	Kou
Heliotropium sp.	
**Heliotropium anomalum* Hook. & Arnott	Hinahina
**Tournefortia argentea* L. fil.	Tree heliotrope
CASUARINACEAE - She-oak Family	
**Casuarina equisetifolia* L.	Ironwood tree
CONVOLVULACEAE - Morning-glory Family	
**Ipomoea pes-caprae* (L.) R. Br.	Beach morning-glory
Ipomoea violacea L.	
EUPHORBIACEAE - Spurge Family	
**Chamaesyce hirta* (L.) Millsp.	Hairy spurge
**Chamaesyce hypericifolia* (L.) Millsp.	Graceful spurge
**Chamaesyce prostrata* (Aiton) Sma.	Prostrate spurge
**Euphorbia cyathophora* J. A. Murray	Mexican fire plant
FABACEAE - Bean Family	
**Leucaena leucocephala* (Lam). deWit	Koa haole
GOODENIACEAE - Goodenia Family	
**Scaevola sericea* Vahl	Naupaka
LYTHRACEAE - Loosestrife Family	
Pemphis acidula Forst. f.	
MALVACEAE - Hibiscus Family	
**Abutilon albescens* Miq.	
**Gossypium religiosum* L.	Wild cotton
Sida fallax Walp.	'Ilima
**Thespesia populnea* (L.) Sol ex. Correa	Milo

TABLE 5 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name
NYCTAGINACEAE - Four o'clock Family	
**Boerhavia repens* L.	Alena
Pisonia grandis R. Br.	Puka
PASSIFLORACEAE - Passion flower Family	
**Passiflora foetida* L.	Love-in-a-mist
POLYGONACEAE - Buckwheat Family	
**Coccoloba uvifera* (L.) L.	Sea grape
PORTULACAEAE - Purslane Family	
Portulaca lutea Sol. ex G. Forster	'Ihi
**Portulaca oleracea* L.	Pigweed
**Portulaca pilosa* L.	Akulikuli
Portulaca samoensis L.	
STERCULIACEAE - Cacao Family	
Waltheria indica L.	'Uhaloa
VERBENACEAE - Verbena Family	
**Stachytarpheta jamaicensis* (L.) Vahl	Jamaica vervain
ZYGOPHYLLACEAE - Creosote Family	
**Tribulus cistoides* L.	Nohu

1. * = Non-native species introduced to Wake Atoll.

TABLE 6
PLANTS ALONG PROPOSED WATER SUPPLY ALIGNMENT, WAKE ISLAND[1]

FAMILY NAME *Scientific Name*	Common Name
AGAVACEAE - Agave Family	
**Agave sisalana* Perrine	Sisal
ARECACEAE - Palm Family	
**Cocos nucifera* L.	Coconut
CYPERACEAE - Sedge Family	
**Cyperus rotundus* L.	Nut grass
**Fimbristylis cymosa* R. Br.	
**Fimbristylis dichotoma* (L.) Vahl	Fringe rush
POACEAE - Grass Family	
**Bothriochloa pertusa* (L.) A Camus	Pitted beardgrass
**Cenchrus echinatus* L.	Common sandbur
**Chloris divaricata* R. Br.	Stargrass
**Cynodon dactylon* (l.) Pers.	Bermuda grass
**Dactyloctenium aegyptium* (L.) Willd.	Beach wiregrass
**Eleusine indica* (L.) Gaertn.	Wiregrass
**Eragrostis cilianensis* (All.) Link	Stinkgrass
**Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult	Lovegrass
Lepturus gasparricensis Fosb.	Broad-leaf bunchgrass
Lepturus repens (G. Forster) R. Br.	Bunch grass
Paspalum vaginatum Sw.	Seashore paspalum
AIZOACEAE - Fig-marigold Family	
Sesuvium portulacastrum (L.) L.	Akulikuli
APOCYNACEAE - Dogbane Family	
**Catharanthus roseus* (L.) G. Don	Madagascar Perwinkle
ASTERACEAE - Sunflower Family	
**Bidens alba* (L.) DC	
**Conyza bonariensis* (L.) Cronq.	Hairy horseweed

TABLE 6 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name
**Pluchea symphytifolia* (Mill.) Gillis	Sourbush
**Tridax procumbens* L.	Coat buttons
BORAGINACEAE - Borage Family	
**Cordia subcordata* Lam.	Kou
**Heliotropium anomalum* Hook. & Arnott	Hinahina
**Tournefortia argentea* L. fil.	Tree heliotrope
CACTACEAE - Cactus Family	
**Opuntia littoralis* (Tour.) Mill.	Panini
CASUARINACEAE - She-oak Family	
**Casuarina equisetifolia* L.	Ironwood tree
CONVOLVULACEAE - Morning-glory Family	
**Ipomoea pes-caprae* (L.) R. Br.	Beach morning-glory
Ipomoea violacea L.	
EUPHORBIACEAE - Spurge Family	
**Chamaesyce hirta* (L.) Millsp.	Hairy spurge
**Chamaesyce prostrata* (Aiton) Sma.	Prostrate spurge
**Euphorbia cyathophora* J. A. Murray	Mexican fire plant
FABACEAE - Bean Family	
**Leucaena leucocephala* (Lam). deWit	Koa haole
GOODENIACEAE - Goodenia Family	
**Scaevola sericea* Vahl	Naupaka
LYTHRACEAE - Loosestrife Family	
Pemphis acidula Forst. f.	

TABLE 6 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name
MALVACEAE - Hibiscus Family	
**Abutilon albescens* Miq.	
**Gossypium religiosum* L.	Wild cotton
Sida fallax Walp.	'Ilima
**Thespesia populnea* (L.) Sol ex. Correa	Milo
NYCTAGINACEAE - Four o'clock Family	
**Boerhavia repens* L.	Alena
Pisonia grandis R. Br.	Puka
POLYGONACEAE - Buckwheat Family	
**Coccoloba uvifera* (L.) L.	Sea grape
PORTULACAEAE - Purslane Family	
Portulaca lutea Sol. ex G. Forster	'Ihi
**Portulaca oleracea* L.	Pigweed
STERCULIACEAE - Cacao Family	
Waltheria indica L.	'Uhaloa
VERBENACEAE - Verbena Family	
**Stachytarpheta jamaicensis* (L.) Vahl	Jamaica vervain
ZYGOPHYLLACEAE - Creosote Family	
**Tribulus cistoides* L.	Nohu

1. * = Non-native species introduced to Wake Atoll.

SECTION 4
DISCUSSION

4.1 OBSERVATIONS AND RECOMMENDATIONS

Several plant species, many of which were intentionally introduced to Wake Atoll, have proliferated uncontrollably. Following is a discussion of several specific plants and recommended actions regarding their control.

Ironwoods. In 1959, Fosberg reported that ironwood trees "were growing behind shelters and in wind breaks". During the 1970s "family tree planting days" were held on the atoll to set out young ironwood trees.[3] These early efforts have been extremely successful for today, ironwood trees 15 m or more in height are common and young trees are beginning to take over in all parts of the atoll. Young plants are common around buildings and are beginning to crowd out the native vegetation. If the abandoned housing area is to be put to any useful purpose, the young ironwood trees should be bulldozed now while it is relatively easy to do.

Ivory Gourd. Two ivory gourd (*Coccinia grandis* Ehrenb. ex Spach) vines are now growing on the atoll. One is near the baseball field and the other one is north of the water catchment. This robust vine with grape-like leaves, white flowers, and bright red fruits and can develop a stem 10 to 12 centimeters (cm) across. Unfortunately, while this plant is quite attractive and provides vegetative cover on fences and unsightly structures, in less than 10 years, it has become a major pest in Hawaii. Left uncurbed, its spread on Wake may occur as quickly.

Nohu. As mentioned earlier, Nohu or *Tribulus cistoides* L. is a vine which was purposely introduced to the atoll. Unfortunately, it is now well established on all three islets. In addition, a second species, puncture vine (*Tribulus terrestris* L.), is now becoming part of the atoll flora. Several vines were seen near the men's dormitory. Nohu is quite attractive with its downy leaves and bright yellow flowers; however, it is the thorny seed coat which is injurious to animals and people. As for the second species, puncture vine, it has been declared a noxious weed because its spiny burrs can penetrate automobile tires, shoes, and animal feet.

Prickly Pear Cactus. A large colony of this cactus (*Opuntia littoralis* [Tour.] Mill.) growing near the turn-off from Peale Island Road to the track leading to the old seaplane ramp should be carefully examined. The pads of this cactus are bright green, the flowers are large and pure yellow, and the fruit is bright red, altogether a fairly attractive colony of plants. However, the plant is easily propagated by seed or detached pads and the pads are covered with long and short, sharp, spiny thorns. In its present form, the colony is controllable by bulldozing; left unattended this cactus could conceivably take over large parts of this islet.

Opiuma. Among the ruins, near the cactus patch on Peale Island, were found three individuals of Opiuma or Manila tamarind (*Pithecellobium dulce* [Roxb.] Benth). One of these plants is a sapling which indicates that the tree is viable and could spread. This is a tree which thrives in dry, hot places and

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[3]Personal Communication from Robert Watanabe, National Oceanic and Atomospheric Administration, and former resident of Wake Atoll.

produces masses of greenish white to pale yellow mimosaceous flowers which are very attractive to bees. It also produces sharp spines along its stems and branches. Because of these spines it may not be desirable to keep these trees.

4.2 NEW WEED SPECIES, UNDESCRIBED SPECIES, AND ENDANGERED SPECIES

New Weed Species. Fosberg (1959) recorded 96 species of vascular plants on Wake Atoll. This included cultivars such as broccoli, radishes, and cucumbers which were being grown in private gardens. It also included such landscape plants as banyan trees. Fifty-seven of Fosberg's recorded taxa can be said to have been self-perpetuating at the time of his study. In addition, nine of the weed species recorded by Fosberg were not found during this survey. In other words, 63 species which were present in 1959 are still thriving on the atoll.

As stated earlier, plants which were being grown in garden situations or plants which had been planted and were being cared for as a part of landscaping were not included in the present survey. A total of 72 taxa were found, 23 of which do not appear on Fosberg's species list.

Most of the newly found taxa can be classed as weeds and were found in the Peacock Point area and in the glide path of the runways indicating that original propagules were hitchhikers on either airplanes or cargo.

Undescribed Species. Fosberg noted and collected what is probably an indigenous (native to the atoll) and unnamed species of *Boerhavia*. This plant was found growing on the dunes near the weather station. It was collected during this survey and has been placed in the herbarium of the Bernice P. Bishop Museum, Honolulu, Hawaii for future identification.

An undescribed species of beach heliotrope (*Heliotropium* sp.) was found in four places on the atoll. A colony of approximately 100 individuals is growing in front of the weather station. A large colony of about 500 plants is to be found at the high water line just east of the old Wake Island School site. A small group of 5 plants was found on the lagoon side of Wilkes Island near the manmade channel and a single plant is located on Peacock Point. A sample of this taxon has also been placed in the Bernice P. Bishop Museum herbarium for future identification.

E. H. Bryan reported "some kind of water lemon" on Wake Atoll in the 1940s. Today, the water lemon known as Love-in-a-mist (*Passiflora foetida* L.) is extremely common in the Peacock Point area where the vines form large, tangled mats on the sand and coral dunes.

Endangered Species. No proposed or listed threatened or endangered plant species as set forth in the Endangered Species Act of 1973 (16 U.S.C. 1531-1543), were encountered (U.S. Department of the Interior Fish and Wildlife Service [USFWS] 1992).

SECTION 5
COMPREHENSIVE SPECIES LIST

In the following species list (table 7) the plant families have been arranged alphabetically within three groups: Ferns, Monocotyledones, and Dicotyledones. The genera and species have been arranged alphabetically within the families. The taxonomy and nomenclature follow that of Fosberg 1959, with taxonomic updating using Wagner, Herbst, and Sohmer (1990), St. John (1973), and Neal (1965). For each taxon the following information is provided:

- An asterisk before the plant name indicates a plant introduced to Wake Atoll since the arrival of the Wilkes Expedition (Pickering 1876).

- The scientific name.

- The mostly widely used common name.

- Abundance ratings: These are for this site only and have the following meanings:

    - Uncommon = a plant that was found less than five times.
    - Occasional = a plant that was found between five to ten times.
    - Frequent = a plant that was found in widely scattered parts of the site in low numbers.
    - Common = a plant considered an important part of the vegetation
    - Locally abundant = plants found in large numbers over a limited area. For example, the plants found in grassy patches.

This species list is the result of extensive surveys of these sites completed well past the end of the rainy season (late fall according to Fosberg 1959), and it reflects the vegetative composition of the flora during a single dry season. Changes in the vegetation will occur due to introductions and losses, and a slightly different species list would result from a survey conducted during a different growing season. In addition, there may be environmental factors such as fire which will lead to species composition alteration.

Only plants that appeared to be surviving on their own were recorded. Plants in private gardens or plants which were tended as part of the landscaping are not included on this list.

TABLE 7
PLANTS OF WAKE ATOLL, SURVEY OF MARCH 1993[1]

FAMILY NAME *Scientific Name*	Common Name	Abundance
1. FERNS AND FERN ALLIES		
POLYPODIACEAE - Fern Family		
**Polypodium scolopendrium* Burm. f.	Rabbit-foot fern	Uncommon
2. MONOCOTYLEDONES		
AGAVACEAE - Agave Family		
**Agave sisalana* Perrine	Sisal	Locally abundant
**Cordyline fruticosa* (L.) A. Chev.	Ti	Uncommon
ARECACEAE - Palm Family		
**Cocos nucifera* L.	Coconut	Occasional
CYPERACEAE - Sedge Family		
**Cyperus rotundus* L.	Nut grass	Locally abundant
**Fimbristylis cymosa* R. Br.		Locally abundant
**Fimbristylis dichotoma* (L.) Vahl	Fringe rush	Occasional
LILIACEAE - Lily Family		
**Aloe vera* L.	Aloe	Locally abundant
PANDANACEAE - Screwpine Family		
**Pandanus tectorius* S. Parkinson ex Z	Screw pine	Uncommon
POACEAE - Grass Family		
**Bothriochloa pertusa* (L.) A Camus	Pitted beardgrass	Locally abundant
**Cenchrus echinatus* L.	Common sandbur	Common
**Chloris barbata* (L.) Sw.	Swollen fingergrass	Occasional
**Chloris divaricata* R. Br.	Stargrass	Common

TABLE 7 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name	Abundance
**Cynodon dactylon* (l.) Pers.	Bermuda grass	Locally abundant
**Dactyloctenium aegyptium* (L.) Willd.	Beach wiregrass	Common
POACEAE - Grass Family (continued)		
**Digitaria insularis* (L.) Mez ex Ekman	Sourgrass	Uncommon
**Eleusine indica* (L.) Gaertn.	Wiregrass	Locally abundant
**Eragrostis cilianensis* (All.) Link	Stinkgrass	Common
**Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult	Lovegrass	Common
Lepturus gasparricensis Fosb.	Broad-leaf bunchgrass	Common
Lepturus repens (G. Forster) R. Br.	Bunch grass	Common
Paspalum vaginatum Sw.	Seashore paspalum	Common
**Zoysia japonica* Steud.	Temple grass	Rare

3. DICOTYLEDONES

AIZOACEAE - Fig-marigold Family		
Sesuvium portulacastrum (L.) L.	Red-stemmed sea purslane	Locally abundant
APOCYNACEAE - Dogbane Family		
**Catharanthus roseus* (L.) G. Don	Madagascar Perwinkle	Common
ASTERACEAE - Sunflower Family		
**Bidens alba* (L.) DC		Common
**Conyza bonariensis* (L.) Cronq.	Hairy horseweed	Frequent
**Pluchea symphytifolia* (Mill.) Gillis	Sourbush	Common
**Tridax procumbens* L.	Coat buttons	Common
BORAGINACEAE - Borage Family		
**Cordia subcordata* Lam.	Kou	Common
**Heliotropium anomalum* Hook. & Arnott	Hinahina	Occasional
Heliotropium sp.		Occasional
**Tournefortia argentea* L. fil.	Tree heliotrope	Common

TABLE 7 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name	Abundance
BRASSICACEAE - Mustand Family		
Lepidium bidentatum Montin	Scurvy grass	Locally abundant
CACTACEAE - Cactus Family		
**Opuntia littoralis* (Tour.) Mill.		Locally abundant
**Opuntia ficus-indica* (L.) Mill.	Panini	Locally abundant
CASUARINACEAE - She-oak Family		
**Casuarina equisetifolia* L.	Ironwood tree	Common
COMBRETACEAE - Indian almond Family		
Terminalia catappa L.	Tropical almond	Uncommon
CONVOLVULACEAE - Morning-glory Family		
**Ipomoea pes-caprae* (L.) R. Br.	Beach morning glory	Common
Ipomoea violacea L.		Common
CRASSULACEAE - Orpine Family		
**Kalanchoe pinnata* (Lam.) Pers	Mother-of-thousands	Locally abundant
CUCURBITACEAE - Gourd Family		
**Coccinia grandis* Ehrenb. ex Spach	Hedge hog	Uncommon
EUPHORBIACEAE - Spurge Family		
**Chamaesyce hirta* (L.) Millsp.	Hairy spurge	Common
**Chamaesyce hypericifolia* (L.) Millsp.	Graceful spurge	Locally abundant
**Chamaesyce prostrata* (Aiton) Sma.	Prostrate spurge	Uncommon
**Euphorbia cyathophora* J.A. Murray	Mexican fire plant	Locally abundant
**Euphorbia tirucalli* L.	Pencil tree	Uncommon
**Phyllanthus debilis* Kleen ex Willd.	Niruri	Uncommon

TABLE 7 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name	Abundance
FABACEAE - Bean Family		
**Desmanthus virgatus* (L.) Willd.	Slender mimosa	Occasional
**Leucaena leucocephala* (Lam). deWit	Koa haole	Occasional
**Pithecellobium dulce* (Roxb.) Benth	Manila tamarind	Uncommon
GOODENIACEAE - Goodenia Family		
**Scaevola sericea* Vahl	Naupaka	Locally abundant
LYTHRACEAE - Loosestrife Family		
Pemphis acidula Forst. f.		Common
MALVACEAE - Hibiscus Family		
**Abutilon albescens* Miq.		Occasional
**Gossypium religiosum* L.	Wild cotton	Common
Sida fallax Walp.	'Ilima	Common
**Thespesia populnea* (L.) Sol ex. Correa	Milo	Uncommon
NYCTAGINACEAE - Four o'clock Family		
Boerhavia sp.		Uncommon
**Boerhavia repens* L.	Alena	Locally abundant
**Bougainvillea* sp. Commerson ex Juss.	Bougainvillea	Occasional
Pisonia grandis R. Br.	Puka	Locally abundant
PASSIFLORACEAE - Passion flower Family		
**Passiflora foetida* L.	Love-in-a-mist	Locally abundant
POLYGONACEAE - Buckwheat Family		
**Coccoloba uvifera* (L.) L.	Sea grape	Occasional
PORTULACAEAE - Purslane Family		
Portulaca lutea Sol. ex G. Forster	'Ihi	Common

TABLE 7 (CONTINUED)

FAMILY NAME *Scientific Name*	Common Name	Abundance
Portulaca oleracea L.	Pigweed	Occasional
Portulaca pilosa L.	Akulikuli	Uncommon
Portulaca samoensis L.		Occasional
STERCULIACEAE - Cacao Family		
Waltheria indica L.	'Uhaloa	Common
VERBENACEAE - Verbena Family		
**Stachytarpheta jamaicensis* (L.) Vahl	Jamaica vervain	Common
ZYGOPHYLLACEAE - Creosote Family		
**Tribulus cistoides* L.	Nohu	Common
**Tribulus terrestris* L.	Puncture vine	Occasional

1. * = Non-native species introduced to Wake Atoll.

SECTION 6
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Appendix G

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

REPLY TO ATTENTION OF

November 17, 1993

Environmental and
Engineering Office

Mr. Robert P. Smith
U.S. Department of the Interior
Fish and Wildlife Service
P.O. Box 50167
Honolulu, Hawaii 96850

Dear Mr. Smith:

First I would like to take the opportunity to thank you and your staff for the timely response to our Coordinating Draft Environmental Assessment for Wake Island. You should be aware that the proposed action has changed in several respects since that draft was issued. It is our intent to publish the preliminary final environmental assessment that will address these changes and review comments received from the coordinating draft on October 1, 1993. A copy of this document will be provided to the Fish and Wildlife Service.

In regard to the response received from your office on August 12, 1993, the U.S. Army Space and Strategic Defense Command (USASSDC) has the following comments:

While Code of Federal Regulations (CFR) 1508.7 defines "cumulative impact" as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such actions," we believe that the operative word in this case is "added." While the USASSDC acknowledges, and has addressed in the coordinating draft environmental assessment, the potential for the introduction of alien plant and animal species and the minor loss of vegetation, the actions leading to the extinction of the Wake Rail ceased with the recapture of Wake Island by Allied Forces in 1945. Unfortunately, it came too late to save the rail. However, ongoing activities, and those of the past 48 years, cannot be linked in any way to the rail's extinction and certainly should not be considered ongoing cumulative impacts in this regard.

The proposed action would not, in fact, directly or indirectly impact nesting seabirds by adding to the feral cat population. Theater Missile Defense related personnel would not be allowed to bring cats or other pets to the island or to feed feral cats; therefore, there is no significant potential for incremental impacts from the proposed action. The Wake Island Environmental Assessment has satisfied the intent of the National Environmental Policy Act in that it fully addresses the potential cumulative impacts of the proposed action in this regard. Nevertheless, the USASSDC and the Ballistic Missile Defense Organization are committed to work with Hickam Air Force Base, the islands administrator, and the U.S. Fish and Wildlife Service to develop a long term program to enhance the Wake Island environment for seabirds nesting.

A reasonable baseline for discussion of past impacts to the island's vegetation is very difficult to identify. As you know, vegetation on the island was completely devastated during World War II. The few records available for the period since that time indicate that there has been a general pattern of increasing areal distribution and density of vegetation and, therefore, increased nesting habitat for some seabird species. During the period when the island was operated by the Federal Aviation Administration, there were about 1,600 residents on Wake Island and substantially more activity on Wilkes and Peale Islands. Air Force activities and new construction since its acquisition of the island have been very minimal relative to the previous user. Currently, there are only about 206 island residents, and many of the structures constructed by the Federal Aviation Administration have been demolished, allowing vegetation to grow freely in these areas. Therefore, while many non-indigenous species of vegetation have been introduced, there has been a net beneficial effect on the amount of potential seabird nesting habitat on the atoll over the last 20 years. The presently proposed programs would require the removal of less than 1 percent of the mixed scrub vegetation in the Peacock Point area and considerably less than 1 percent of the other vegetation associations on other parts of Wake Island. As no active nests or signs of past nesting activity were identified in the Peacock Point area during the ornithological survey, and there is no record of significant numbers of seabirds nesting anywhere on Wake Island proper, we believe there will be no substantive effect on the amount of available nesting habitat. In addition, since the small amount of vegetation to be impacted directly through project actions is neither rare, threatened, or endangered, no mitigation for its loss is being proposed.

As far as restricting access to seabird nesting areas is concerned, permanent and visiting personnel are already being briefed on the protected status of the island's seabirds. Additionally, visiting personnel are restricted from Peale and Wilkes islands without a permit issued by the base commanding officer's office or without being escorted by an island resident. These actions minimize human disturbance of the seabird nesting colonies on these islands. While there are no controlled access areas on Wake Island, tropicbirds, the only birds found to be nesting on Wake Island during the field survey, typically nest away from human activity.

Regarding the comment on the methodology used to detect tropicbird nests, it was not intended that the ornithological survey locate all tropicbird nests on Wake Island. However, we believe that the method employed enabled us to locate the great majority of active nests for the following reasons: the prevalence of courtship activity observed during the survey period, coupled with the daily increase in number of tropicbirds observed at the island over the 7 days of observation, suggest that the breeding season was in its early stages; also, no nestlings or tropicbirds carrying food to nestlings were observed. It is only during a relatively brief period when birds would still be incubating subsequent to all courtship activity and prior to hatching of young that nests may be difficult to locate. It should be noted that the entire island was searched daily for tropicbird activity, and any activity observed, other than "flybys," was investigated. Several areas were investigated numerous times during the week. Only areas where no tropicbird activity was observed during the entire survey period and where no project activity is proposed were not investigated. However, we recognize that the possibility certainly exists that a few incubating birds were overlooked.

The purpose of the quick transect through the Sooty Tern colony was to determine the number and condition of what appeared to be an unusually large number of addled eggs. This decision was made only after 3 days of observing the colony from a distance and obtaining counts of adults and young in selected portions of the colony from the roof of a nearby building through binoculars and a telescope and extrapolating the colony size from those counts. As no birds appeared to be incubating and most young were a week or more old at this time, disturbance to the colony from walking a brief transect was determined to be minimal. Care was taken to see that young did not continue dispersing ahead of the observer but to the side. The transect was conducted at a fast pace that took only 2 minutes, and eggs were counted in blocks of five and ten rather than through more time-consuming direct counts. A few whole eggs were picked up "on the move" for closer examination. All proved to be addled. No predators were observed in the area prior to conducting the transect, and no predation was observed after completion of the transect. It should be noted that the original suggestion to walk selected transects through the tern colonies, discussed with Fish and Wildlife Service personnel prior to the study, met with no objections at the time. Only after arriving on the island and assessing the situation was it decided that transects, other than the one described above, were neither necessary or advisable.

The following modifications and corrections will be made in the assessment:

a. Reference to a feral cat management program will be changed in the text and the appendices to read as follows: "Efforts will be made to protect populations of native plants and wildlife from introduced species."

b. The Tim Sutterfield report citation will be corrected to accurately reflect that the report was generated by the U.S. Navy.

c. In reference to frigatebird nest-raiding behavior, the words "the exposed eggs and chicks of" will be deleted so that the sentence reads "...frigatebirds are well known for raiding unattended booby nests..."

The USASSDC plans to include the following additional mitigation measures for the proposed actions in the preliminary final environmental assessment:

a. No additional cats or other pets will be brought to the island by the U.S. Army program personnel.

b. The preconstruction site survey for seabird nests will be conducted by a trained field ornithologist 1 to 2 weeks prior to the start of construction.

c. Cargo-handling personnel will inspect arriving aircraft for pest species of plants and animals and will be briefed on methods for their detection.

d. Facility construction and launch activities will be restricted when possible to the period between August and January to reduce activity during the seabird nesting season. However, it is recognized that this measure may not always be possible.

Your assistance in this matter is greatly appreciated. Should you need additional information, please contact Ms. Linda Ninh at (205) 955-1154.

Sincerely,

Robert F. Shearer
Chief, Environmental
and Engineering Office

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

REPLY TO
ATTENTION OF

November 17, 1993

Environmental and
Engineering Office

Mr. John Naughton
Pacific Islands Environmental Coordinator
National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii 96822-2396

Dear Mr. Naughton:

The Ballistic Missile Defense program is an extensive research program designed to determine the feasibility of developing an effective ballistic missile defense system. The program includes research of theater missile defense (TMD) technologies necessary for the protection of deployed U.S. forces, as well as U.S. friends and allies throughout the world, from future missile threats.

Congress has called for the development of what could be a stand-alone TMD system. The Ballistic Missile Defense Organization (BMDO), previously known as the Strategic Defense Initiative Organization, has been designated as the management office, with various elements of the TMD program being delegated to the Army, Air Force, Navy, and Marine Corps. The BMDO will be the principal architect for this system. The U.S. Army Space and Strategic Defense Command (USASSDC) proposes to conduct long-distance missile flight tests to support the developmental requirements needed to validate system design and operational effectiveness of Army ground-based TMD missile and sensor systems.

The purpose of the program is to provide a realistic TMD quantification of intercept lethality against chemical, biological, and nuclear/conventional weapons and to collect data from liquid-fuel motors for plume signature recognition. The target system would be designed to deliver single or multiple reentry vehicles toward the U.S. Army Kwajalein Atoll (USAKA). For target launches from Wake Island, the defensive missile would be launched from the USAKA. If defensive missiles are launched from Wake Island, the targets could be launched from the USAKA or from a Missile Launch Ship located south of Wake Island. In either case, target and defensive missile flight azimuths and test profiles will be designed so that no lethal debris would fall on Wake Island or any other land mass as a result of nominal flight tests.

Wake Island has been proposed as one of the potential sites for conducting the TMD flight experiments for the following reasons:

a. Existing infrastructure on the island will minimize the necessity for new construction or major modifications that would be required elsewhere which could potentially impact natural resources.

b. Remote location, relative to inhabited land areas.

c. Geographic location and distance of U.S. Army Kwajalein Atoll as an existing downrange sensor facility.

To support the proposed action, construction of several new facilities and modifications to some existing facilities will be required. The locations of these proposed actions are shown on Figure 1-3 in the Preliminary Final Environmental Assessment provided under separate cover. As shown on the map, two of the proposed activities are located in the marine or near-shore environment. These are the placement of a fiber optic cable on the south side of Wake Island and refurbishment of the bridge between Wake and Peale Islands.

A fiber optics cable has been proposed that would link Wake Island and Kwajalein Island. The route of the cable has not been determined. The cable could be trenched and laid along the south side of Wake Island and brought on shore near Launch Pad 1 or near the proposed location for liquid fuel storage. From there a likely route would be along the access road to one of these sites to the Range Support Building (1601) in existing utility trenches. The reef that surrounds the island is very narrow along the southern shore and this location would require the minimum of potential off-shore blasting and trenching for cable placement.

It is expected that the bridge strengthening would include additional pier supports into the lagoon and additional or replacement of cross members above the high tide line. Replacement would be designed to minimize disruption of water flow between the lagoon and the open ocean area.

Based on existing information gathered through past field surveys, these are the only ground activities in the proposed action that could adversely affect the green sea turtle (Chelonia mydas), the only federal listed species known to occur near the site with any frequency. To mitigate the potential for accidental taking of these animals, the U.S. Army is proposing to use underwater divers to survey the area immediately prior to any explosive detonation. Explosives will not be detonated until all sensitive species are clear of the area. Additionally, bridge modifications would be designed such that sea turtles would not be trapped or ensnared by the structure.

There is also a potential for the accidental taking of sea turtles or federally listed marine mammals during flight testing. Whole booster motors and missile debris will impact in the open ocean area between Wake and Kwajalein islands. Although the taking of protected species would be significant, the probability of such an occurrence is extremely remote, thus no significant impacts are anticipated.

In accordance with the National Environmental Policy Act, the Council on Environmental Quality regulations implementing the Act, Department of Defense Directive 6050.1, Environmental Effects in the United States Department Actions, and Army Regulation 200-2, Environmental Effects of Army Actions, the USASSDC is conducting an Environmental Assessment to determine potential impacts to the natural resources by the proposed actions. We would appreciate any comments or concerns you may wish to express regarding this proposed action.

Your assistance in this matter is greatly appreciated. Should you need additional information, please contact Ms. Linda Ninh at (205) 955-1154.

Sincerely,

Robert F. Shearer
Chief, Environmental
and Engineering Office

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

REPLY TO
ATTENTION OF

November 17, 1993

Environmental and
Engineering Office

Ms. Claudia Nissley
Advisory Council on Historic Preservation
Western Office of Project Review
730 Simms Street, Room 401
Golden, Colorado 80401

Dear Ms. Nissley:

The Ballistic Missile Defense program is an extensive research program designed to determine the feasibility of developing an effective ballistic missile defense system. The program includes research of theater missile defense (TMD) technologies necessary for the protection of deployed U.S. forces, as well as U.S. friends and allies throughout the world, from future missile threats.

Congress has called for the development of what could be a stand-alone TMD system. The Ballistic Missile Defense Organization (BMDO), previously known as the Strategic Defense Initiative Organization, has been designated as the management office, with various elements of the TMD program being delegated to the Army, Air Force, Navy, and Marine Corps. The BMDO will be the principal architect for this system. The U.S. Army Space and Strategic Defense Command (USASSDC) proposes to conduct long-distance missile flight tests to support the developmental requirements needed to validate system design and operational effectiveness of Army ground-based TMD missile and sensor systems.

The purpose of the program is to provide a realistic TMD quantification of intercept lethality against chemical, biological, and nuclear/conventional weapons and to collect data from liquid-fuel motors for plume signature recognition. The target system would be designed to deliver single or multiple re-entry vehicles toward the U.S. Army Kwajalein Atoll (USAKA). For target launches from Wake Island, the defensive missile would be launched from the USAKA. If defensive missiles are launched from Wake Island, the targets could be launched from the USAKA or from a Missile Launch Ship located south of Wake Island. In either case, target and defensive missile flight azimuths and test profiles will be designed so that no lethal debris would fall on Wake Island or any other land mass as a result of nominal flight tests.

Wake Island has been proposed as one potential site for conducting the TMD flight experiments for the following reasons:

a. Existing infrastructure on the island will minimize the necessity for new construction or major modifications that would be required elsewhere which could potentially impact natural and cultural resources.

b. Remote location, relative to inhabited land areas.

c. Geographic location and distance of U.S. Army Kwajalein Atoll as an existing downrange sensor facility.

To support the proposed action, construction of several new facilities and modifications to some existing facilities will be required. The location of these proposed actions are shown on Figure 1-3 in the Preliminary Final Environmental Assessment provided under separate cover. A general description of the proposed facility activities is provided below:

a. The construction of a new missile storage and a new missile assembly building has been proposed. Ground disruption at each site would consist of a shallow excavation for a concrete pad, road clearing and grading to each building, and trenching for the placement of utility and communication lines. The total area affected by the construction of each facility would be about 0.25 acres.

b. A launch equipment building may be required at Launch Pad 1 and Launch Pad 2 on Wake Island. Each building would be about 500 square feet and require concrete foundation of slightly larger dimensions. The area of land disturbance required will depend on the exact site location. Final building locations will be selected to minimize or avoid land disturbance, but in no case will more than 0.1 acres be required for each structure.

c. Launch Pad 2 will be used for target missile launches and may be used for defense missile launches. Additional new construction at this site could include a vertical launch stool and trenches to building 1601 for utility and communication lines. The total area potentially disturbed by this construction would be up to 0.3 acres including the launch equipment building site and clearing for fire safety.

d. A fiber optics cable has been proposed that would link Wake Island and Kwajalein Island. The route of the cable has not been determined. The cable could be trenched and laid along the south side of Wake Island and brought on shore near Launch Pad 1 or near the proposed location for liquid fuel storage. From there a likely route would be along the access road to one of these sites to the Range Support Building (1601) in existing utility trenches. The reef that surrounds the island is very narrow along the southern shore and this location would provide the shortest overland route to the Range Support Building and the least ground disturbance if previously trenched areas for utilities were used.

e. An additional refuse incinerator may be required to support the influx of project-related personnel. The unit would be similar to the existing unit in size and would be located adjacent to the existing incinerator an approximately 0.1 acres of previously disturbed land.

f. The proposed site for the location of permanent range support sensors is the abandoned U.S. Coast Guard facility on Peale Island. Site preparation would include the refurbishment of building 1203 for electronic equipment, construction of a concrete foundation approximately 30 feet by 30 feet for a MPS-36 or similar radar, trenching along the existing road to the billeting area for utility and communication lines, and strengthening of the bridge between Wake and Peale Islands. The total area expected to be disturbed for this option is about 0.25 acres.

g. A New mobile, TMD ground-based radar system would be used in some testing. This radar is currently being developed as an integral part of the TMD system and would provide surveillance, target missile detection, fire control support, and kill assessment for TMD defensive missile systems. This radar and the supporting power plant and antenna mast group will be road and aircraft transportable systems of modular design. This system would require dedicated areas ranging from 0.8 hectare (2 acres) to 2.53 hectares (6.25 acre) for the electromagnetic radiation hazard zone and mobile unit parking areas. The system would be located adjacent to the power plant or on the old hot cargo pad on the northwest end of the runway. Ground disturbance would not be required at either site.

In accordance with the National Environmental Policy Act, the Council on Environmental Quality regulations implementing the Act, Department of Defense Directive 6050.1, Environmental Effects in the United States Department Actions, and Army Regulation 200-2, Environmental Effects of Army Actions, the USASSDC is conducting an Environmental Assessment to determine potential impacts to the natural and cultural resources by the proposed actions.

In fulfilling its responsibilities for complying with Sections 106 and 110 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's regulations implementing Section 106 (36 Code of Federal Regulations 800), the USASSDC is taking into account the effect of this undertaking on historic properties. We would appreciate any comments or concerns you may wish to express regarding this proposed action and the cultural resources of the area.

Your assistance in this matter is greatly appreciated. Should you need additional information, please contact Linda Ninh at (205) 955-1154.

Sincerely,

Robert F. Shearer
Chief, Environmental
and Engineering Office