ENVIRONMENTAL ASSESSMENT FOR THE OUTRIGGER TELESCOPES PROJECT

Mauna Kea Science Reserve, Island of Hawai'i

National Aeronautics and Space Administration
Office of Space Science
Washington, DC

February 2002

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ABSTRACT

Lead Agency: National Aeronautics and Space Administration (NASA), Office of Space Science

Proposed Action: NASA's Proposed Action is to fund the on-site construction, installation, and operation of six Outrigger Telescopes near the twin Keck Telescopes at the W.M. Keck Observatory (WMKO), within the Mauna Kea Science Reserve on the island of Hawai'i. It is anticipated the on-site construction and installation of four of the six Outrigger Telescopes, along with on-site construction of the underground structures for Outrigger Telescopes 5 and 6, will begin in 2002, with start of operations anticipated in 2003. If funding is available, NASA intends to complete the on-site construction, installation, and operation of Outrigger Telescopes 5 and 6, with on-site construction and installation likely to begin in 2007.

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Abstract: The Outrigger Telescopes are an important element of NASA's Origins program. The environmental impacts of concern that may arise from locating the Outrigger Telescopes at the WMKO site are impacts on the Wēkiu bug (a candidate for listing under the Endangered Species Act), and adverse effects on the historical and cultural values of the cinder cone, known as Pu'u Hau 'Oki, and the Mauna Kea summit region. Pu'u Hau 'Oki is part of a cluster of cinder cones, that is considered to satisfy the criteria to be eligible for listing in the National Register of Historic Places (NRHP) as a historic property. The Mauna Kea summit region is considered to meet the criteria to be eligible for listing in the NRHP as a historic district.

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EXECUTIVE SUMMARY

This Environmental Assessment (EA) has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. §4321 *et seq.*); the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508); and the National Aeronautics and Space Administration's (NASA) policy and procedures (14 CFR Subpart 1216.3) to support decision-making regarding whether to fund the on-site construction, installation, and operation of the Outrigger Telescopes Project. This Federal NEPA process is distinct from the State environmental process currently underway by the University of Hawai'i (UH) in accordance with applicable State of Hawai'i environmental laws and regulations. No final action will be taken on the Proposed Action until the decision-making process under NEPA has been completed. On-site construction would not begin until all State and local permits and approvals have been obtained.

Purpose and Need. The Outrigger Telescopes Project is a key element in NASA's Origins program which is directed at answering two basic questions: (1) How do galaxies, stars, and planets form (or, "Where do we come from?"); and (2) Are there other planets aside from ours, that have the conditions necessary to support life (or, "Are we alone?"). To find answers to these questions, NASA has developed a set of goals. Meeting these goals requires the use of a technique called interferometry, for which NASA has defined six specific ground-based interferometry objectives (see Section 1.3). The first two of the six objectives can be achieved using the Keck-Keck Interferometer, at the W.M. Keck Observatory (WMKO) on Mauna Kea, on the island of Hawai'i.

Meeting the final four interferometry objectives requires higher resolution of astronomical objects by allowing the objects to be studied from different angles. NASA has determined that the best way to achieve this is by the construction and operation of four to six Outrigger Telescopes used in conjunction with one or more large telescopes. A number of scientific and technical factors were considered in determining the number and required capabilities of these telescopes (see Section 2.3).

Proposed Action. NASA proposes funding the on-site construction, installation, and operation of six Outrigger Telescopes at the WMKO. The WMKO, located within the Astronomy Precinct on the summit of Mauna Kea, is the site of the two most powerful optical telescopes in the world—Keck I and Keck II. The light from the two telescopes was combined on March 12, 2001, forming the Keck-Keck Interferometer.

The proposed Outrigger Telescopes would be placed strategically around the existing Keck Telescopes on the area of the cinder cone, Pu'u Hau 'Oki, that was previously disturbed for construction of the two Keck Telescopes. A complex optical system is proposed to combine the light received

> **TERMS TO KNOW**
>
> *Outrigger Telescope refers to any of the 6 1.8-meter (6-foot) diameter telescopes.*
>
> *Keck Telescope refers to a single 10-meter (33-foot) diameter telescope.*
>
> *Keck-Keck Interferometer refers to the Keck I and Keck II Telescopes used together as an interferometer (without the Outrigger Telescopes).*
>
> *Keck Interferometric Array refers to any combination of some or all of the Outrigger Telescopes with one or both Keck Telescopes.*

simultaneously by various combinations of the Outrigger Telescopes and the Keck Telescopes to create a high resolution synthesized image. The Outrigger Telescopes would be a permanent addition to the WMKO. Four of the Outrigger Telescopes are currently budgeted and proposed for on-site construction and installation beginning in 2002, if all permits have been obtained, with start of operations anticipated in 2003. If funding is available, NASA intends to complete the on-site construction, installation, and operation of Outrigger Telescopes 5 and 6, with on-site construction and installation likely to begin in 2007.

As proposed, each Outrigger Telescope would consist of a 1.8-meter (6-foot) diameter, f/1.5 primary mirror, a secondary mirror, a tertiary mirror, a dual star module and a starlight beam on the telescope yoke. A dome, measuring 9.1 meters (30 feet) in diameter at its widest point and 8 meters (26 feet) in diameter at its base, would enclose each telescope to protect it from the harsh conditions on Mauna Kea. Each dome would be large enough to accommodate both a telescope and a dual star module and have a slit width adequate for unobstructed viewing with a 1.8-meter (6-foot) diameter primary mirror. The proposed domes would stand less than 10.7-meters (35-feet) high as measured from the top of the level grade at elevation 4,146 meters (13,603 feet). By comparison, each of the Keck domes is 37 meters (121 feet) in diameter at its widest point and 33.9-meters (111-feet) high. Each proposed telescope would be supported by an underground concrete telescope instrument room, which would serve as a telescope pier. Junction boxes would house the mirrors that direct the starlight beams through underground light pipes to the basement of the Keck II Telescope building, where the interferometer instrumentation will be located.

Potential Environmental Impacts That Could Result from the Proposed Action. The on-site construction, installation, and operation of the Outrigger Telescopes could result in environmental impacts. The principal areas of potential environmental impact addressed in this EA are summarized below. Mitigation measures to address environmental impacts resulting from the Proposed Action are also discussed in this EA.

Arthropod Fauna: The Wēkiu bug (*Nysius wekiuicola*) is a candidate for listing under the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*). The Pu'u Hau 'Oki cinder cone was identified in 1982 as having a high density of the Wēkiu bug. In 1982, and again in 1999, the Wēkiu bug population was surveyed in certain areas. Based on those surveys, the Wēkiu bug population in those areas apparently experienced a 99.7 percent decline (Howarth and Stone 1982; Howarth and others 1999).

The proposed Outrigger Telescopes would be located at the existing WMKO site primarily within the approximately 1.1-hectare (2.8-acre) area leveled in 1985 and 1991, respectively, for the Keck I and Keck II Telescopes. A small amount of previously disturbed Wēkiu bug habitat (0.009 hectare (0.022 acre)) along the sloped crater wall would be directly affected by on-site construction of the proposed project. A Wēkiu Bug Mitigation Report has been developed by a natural resource management consulting firm (Pacific Analytics 2000). This report made recommendations for how to protect the Wēkiu bug and its habitat within and immediately surrounding the WMKO site. The Wēkiu Bug Mitigation Plan developed from that report is incorporated into this EA in Appendix D. A monitoring plan has been developed and is referenced in Appendix E.

A key element of this Wēkiu Bug Mitigation Plan is restoration of Wēkiu bug habitat at and near the WMKO site. The habitat restoration portion of the Plan has been developed in consultation with the U.S. Fish and Wildlife Service (USFWS), and would restore previously disturbed habitat on the WMKO site and at the bottom of the Pu'u Hau 'Oki crater. The proposed restoration effort would encompass an area totaling about 0.028 hectares (0.069 acres) resulting in a habitat restoration ratio of about 3:1 relative to the amount of habitat area that would be disturbed by on-site construction and installation of Outrigger Telescopes 2 and 3. The intent is to restore the habitat in these areas to make it possible for the Wēkiu bug to establish resident populations within the restored areas. The restored habitat would be monitored by a qualified entomologist for about 18 months following completion of the proposed habitat restoration to determine if the bug reestablishes itself in those areas. In addition, as part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology, to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors.

Operation of the Outrigger Telescopes would have little, if any, impact on Wēkiu bug habitat. Many of the measures that would be implemented to protect Wēkiu bug habitat during on-site construction and installation would be carried into the facility operation phase. These include, but are not necessarily limited to, measures that: reduce generation of fugitive dust, maintain strict housekeeping practices to avoid accumulation of trash on the habitat, restrict access of observatory personnel to Wēkiu bug restoration areas, and ensure that foreign arthropods are not inadvertently introduced to the Mauna Kea summit environment.

Cultural Resources: In a letter dated May 3, 1999, the Hawaii State Historic Preservation Division (SHPD) stated that they "have come to believe that the cluster of cinder cones which merge and collectively form the summit of Mauna Kea is an historic property and that this single landscape feature probably bore the name Kūkahau'ula. This single landscape feature is now called Pu'u Hau 'Oki, Pu'u Kea, and Pu'u Wēkiu". In addition, the SHPD believes that the summit region of Mauna Kea is eligible for inclusion in the National Register of Historic Places as a historic district, and the summit cluster of cones has been given the State site number 21438. The SHPD also noted that, given the conclusion that Pu'u Hau 'Oki is part of a historic district, the proposed project would have an "adverse effect" on the historic property and historic district, but that these "adverse effects" can be mitigated if appropriate measures are adopted (SHPD 1999).

Because the proposed Outrigger Telescopes Project would be Federally-funded, Section 106 of the National Historic Preservation Act (NHPA) applies. Pursuant to NHPA, NASA undertook consultation with Hawaiian groups concerning the proposed project and its effects. NASA initially consulted with and invited the State Office of Hawaiian Affairs, and the following Native Hawaiian organizations—the Hawai'i Island Burial Council, the Royal Order of Kamehameha I, and Hui Mālama I Nā Kūpuna O Hawai'i Nei—to be Consulting Parties. Thereafter, two more Native Hawaiian organizations requested and were given Consulting Party status: Ahahui Ku Mauna and Mauna Kea Anaina Hou. In addition, NASA consulted with and invited the Office of Mauna Kea Management, the Mauna Kea Management Board, and Kahu Ku Mauna to also participate in the development of the Memorandum of Agreement (MOA).

As an integral part of the Section 106 consultation process, NASA prepared on-site and off-site cultural mitigation measures for consideration by the SHPD, the Advisory Council on Historic Preservation (ACHP), and the other participating Consulting Parties. On-site mitigation measures that were proposed include stabilization of the cinder cone slopes, prevention of accidental dispersal of debris during and after on-site construction, disposition of excavated material, and reduction of noise during on-site construction, installation, and operation of the

Outrigger Telescopes. Also included were monitoring and other measures that would prevent or minimize deterioration of the visual integrity (*i.e.*, shape and contour) of the cinder cone and its crater. One such measure also included the commitment to provide the Consulting Parties the opportunity to review and comment on the grading and site development drawings for the proposed project. As an off-site mitigation component of the Outrigger Telescopes Project, NASA, in consultation with the Office of Mauna Kea Management, will fund, out of funds for the Outrigger Telescopes Project, an initiative that deals with preservation and protection of historic/cultural resources on Mauna Kea and educational needs of Hawaiians.

A formal Section 106 meeting was held on February 1, 2001. In addition, NASA held another formal Section 106 meeting in Hilo on January 16 and 17, 2002. NASA held two Open House meetings in February 2001 in Hawai'i (Hilo and Kona) and held four Town Hall meetings in October 2001 (Kona, Waimea, and Hilo). The Open House and Town Hall meetings were attended by Native Hawaiian individuals, and organizations and members of the general public who stated their position, asked questions, expressed concerns and support, and learned more about the Outrigger Telescopes Project.

NASA representatives have met, formally and informally, with Native Hawaiian groups that have expressed interest in this project. Tables 5.1 and 5.2 in Chapter 5 of this Environmental Assessment provide a listing of the consultations/informal meetings that have occurred between NASA and interested parties concerning the Outrigger Telescopes Project.

The final cultural mitigation measures have been stipulated in the MOA (see Appendix C).

<u>Archaeological Properties</u>: No archaeological sites were located in the project area during past surveys, and none were uncovered during the construction of Keck I or Keck II. Review of past grading plans for the site indicated that the entire project area, with the exception of a small area near Junction Box-5, has been altered to such an extent that the probability of discovering human burials or other subsurface artifacts during on-site construction activities associated with the Outrigger Telescopes would be unlikely. No area is assumed to be devoid of archaeological properties, however, simply on the basis of its history. NASA has proposed mitigation measures that assume that such properties could possibly be found anywhere on the site. One such measure includes having a qualified archaeologist present on site to monitor excavation to minimize damage to inadvertently disturbed remains or subsurface artifacts. Operation of the Outrigger Telescopes would have no impact on known archaeological sites.

<u>Cultural Values/Traditional Cultural Practices</u>: Traditional cultural practices on Mauna Kea are associated with resource locations, trails, individual topographic features, burial locations, and cultural landscapes. Contemporary cultural practices include prayer and ritual observances, the construction of new altars; subsistence and recreational hunting; and collection of stone from quarry sites. Concerns include the importance of maintaining access to the summit area for spiritual purposes and maintaining the integrity of the spiritual and sacred quality of the summit landscape.

<u>Visual Aesthetics</u>: The existing Keck I and Keck II Telescopes, as well as the other existing telescope facilities within the Astronomy Precinct, are generally visible from within the summit area. The Outrigger Telescopes also would be visible from most locations within the summit area. Like the Keck domes, the Outrigger Telescope domes would be white. Proper design and grading practices—such as using natural materials obtained from the project site for fill and

surfacing—would minimize the visual impact. The dome ring wall and any necessary retaining walls would be colored to blend into the existing terrain.

Below the summit, the view of the existing astronomy facilities on the summit from the access road is typically blocked by the topography of the mountain. This would also be the case for the Outrigger Telescopes. Some of the existing facilities are visible from lower elevation areas such as Hilo, Honoka'a and Waimea. The proposed Outrigger Telescopes would be barely perceptible from areas where the Keck domes are visible.

Consideration of Alternative Sites. NASA developed two tiers of criteria to determine the location for the Outrigger Telescopes which would meet the scientific objectives. Eleven sites were considered. All of the alternative sites, other than the WMKO site, failed to meet one or more of the criteria and, therefore, were not evaluated further.

Tier 1 criteria were based on physical conditions for a site. The primary Tier 1 criterion was the presence of at least one large telescope (at least 8 meters (26 feet) in diameter) with which the Outrigger Telescopes can act as an interferometer. Other Tier 1 criteria involved having enough land available to achieve adequate separation, orientation of the telescopes, and site observing quality. Other than the WMKO site, only two other sites met the Tier 1 criteria (Cerro Paranal, Chile; Mt. Graham, Arizona). Tier 2 criteria included maximizing sky coverage and programmatic feasibility factors including technical, additional facilities, and cost. Only the WMKO site met all the Tier 1 and Tier 2 criteria.

No-Action Alternative. Under the No-Action Alternative NASA would not fund on-site construction, installation, or future operation of the Outrigger Telescopes Project proposed for the WMKO site at Mauna Kea. The potential environmental impacts described for the Outrigger Telescopes Project in this EA would not occur. If the Outrigger Telescopes are not constructed and installed at the WMKO on Mauna Kea, the facilities at the WMKO site would consist of the two existing 10-meter (33-foot) Keck Telescopes which are capable of functioning as the Keck-Keck Interferometer. NASA would be able to attain only two of the science objectives discussed in Section 1.3. The remaining four science objectives would not be met. In addition, the No-Action Alternative would result in economic losses to the State of Hawai'i of the estimated $10 to $11 million for the on-site construction and installation of six Outrigger Telescopes. Further, the incremental revenues that would be associated with operation of the Outrigger Telescopes Project would also be lost to the State. NASA's funding for the Wēkiu bug on-site mitigation, the autecology study, and the 18-month Wēkiu bug monitoring activities would not occur. NASA's funding for the on-site and off-site mitigation activities proposed by NASA in the Section 106 process also would not occur.

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ACRONYMS AND ABBREVIATIONS

ac	acre(s)
ACHP	Advisory Council on Historic Preservation
AU	astronomical unit
BLNR	Board of Land and Natural Resources
BMP	(construction) Best Management Practices Plan
Caltech	California Institute of Technology
CARA	California Association for Research in Astronomy
CDUA	Conservation District Use Application
CDUP	Conservation District Use Permit
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFHT	Canada-France-Hawai‘i Telescope
CFR	Code of Federal Regulations
CHARA	Center for High Angular Resolution Astronomy
cm	centimeter(s)
CMP	corrugated metal pipe
CO	carbon monoxide
CO_2	carbon dioxide
CSO	Caltech Submillimeter Observatory
CZM	Coastal Zone Management
dBA	A-weighted decibels
DLNR	Department of Land and Natural Resources (State of Hawai‘i)
DOH	Department of Health (State of Hawai‘i)
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMS	Emergency Medical Service
EMT	Emergency Medical Technician
FONSI	finding of no significant impact
ft	foot/feet
ha	hectare(s)
HAR	Hawai‘i Administrative Rules
HELCO	Hawaii Electric Light Company
Hg	mercury
HRS	Hawai‘i Revised Statutes
in	inch(es)
IRTF	NASA Infrared Telescope Facility
JB	junction box

ACRONYMS AND ABBREVIATIONS (Continued)

JCMT	James Clerk Maxwell Telescope
JPL	Jet Propulsion Laboratory
km	kilometer(s)
kV	kilovolt(s)
kVA	kilovolt-ampere(s)
kW	kilowatt(s)
lb	pound(s)
LBT	Large Binocular Telescope, Arizona
m	meter(s)
mi	mile(s)
MKAEC	Mauna Kea Astronomy Education Center
MKSS	Mauna Kea Support Services
mm	millimeter(s)
MOA	Memorandum of Agreement
mph	miles per hour
mt	metric ton(s)
N	newton(s)
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NO_x	nitrogen oxide
NPDES	National Pollution Discharge Elimination System
NRAO	National Radio Astronomy Observatory
NRHP	National Register of Historic Places
NSF	National Science Foundation
OEQC	Office of Environmental Quality Control (State of Hawai'i)
OMKM	Office of Mauna Kea Management
OSHA	Occupational Safety and Health Administration
PHRI	Paul H. Rosendahl, PhD., Inc.
PTI	Palomar Testbed Interferometer
SAAQS	State Ambient Air Quality Standards
SCBA	self-contained breathing apparatus
SHPD	State Historic Preservation Division
SHPO	State Historic Preservation Officer
SO_x	sulfur oxide
TOTS	Temporary Optical Test Sites
UBC	Uniform Building Code
UH	University of Hawai'i

ACRONYMS AND ABBREVIATIONS (Continued)

UH IfA	University of Hawai'i Institute for Astronomy
UKIRT	United Kingdom Infrared Telescope
U.S.C.	U.S. Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VIS	Visitor Information Station
VLBA	Very Long Baseline Array
VLTI	Very Large Telescope Interferometer, Chile
VOC	volatile organic compounds
WMKO	W.M. Keck Observatory

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USEFUL TERMS

'a'a—Hawaiian word meaning rough clinker lava, to blaze, to burn.

adaptive optics—an optical system that corrects for blurring or other optical effects of the atmosphere so that a ground-based telescope can form sharp images.

angular resolution—the level of detail that you can see; measure of how sharp is the view of the object being observed.

anticyclone—high pressure zone.

astrometric signature—the wobble of a star due to the gravitational influence of an unseen planetary companion.

astrometry—the precise measurement of the motions and positions of celestial bodies. Sometimes referred to as the measurement of stars.

'aumakua—Hawaiian word meaning personal or family gods; deified ancestral spirits who might take several shapes.

autecology—branch of ecology that focuses on individual organisms (or species) and how those individuals influence or are influenced by their environment.

cinder cone—steep conical hill of volcanic fragments that accumulate around and downwind from a vent. Can range in size from tens to hundreds of meters tall.

entomologist—a scientist who studies insects.

interferometry—the combining of light from 2 or more separate telescopes to produce greater angular resolution than that which could be attained from each telescope separately.

kea—white, clear, pale.

Keck Interferometric Array—any combination of some or all of the four Outrigger Telescopes with one or both of the Keck Telescopes.

Keck-Keck Interferometer—Keck I and Keck II used together as an interferometer (with no Outrigger Telescope combination).

Keck Telescope—either the Keck I or Keck II Telescopes.

Kupuna—Hawaiian word meaning Grandparent, ancestor, relative or close friend of the grandparent's generation, grandaunt, granduncle (Kūpuna – plural of Kupuna).

lens (fresh water)—a body of freshwater buoyantly overlying marine water.

light-year—the distance that light would travel in a vacuum in one year, 9.46 trillion kilometers or 5.8 trillion miles, used in measuring astronomical distances.

mauna—Hawaiian word meaning mountain, mountainous region; mountainous.

Outrigger Array—any combination of the Outrigger Telescopes alone.

Outrigger Telescopes—any of the six 1.8-m (6-ft) telescopes.

USEFUL TERMS (Continued)

permafrost—perennially frozen ground, occurring whenever the temperature remains below 0°C (32°F) for several years, whether the ground is actually consolidated by ice or not and regardless of the nature of the rock and soil particles of which the earth is composed.

pixel—smallest unit of an image on a television or computer screen.

proto-stellar disks—disks of dust and gas in space believed to be an early stage of star formation.

pu'u—Hawaiian word meaning any kind of protuberance from a pimple to a hill: hill, peak, cone, hump, mound, bulge, heap, pile, portion, bulk, mass, quantity, clot, bunch, knob.

seeing—the amount of degradation of the optical image by the Earth's atmosphere. Good seeing implies minimal degradation.

stellar debris disks—clouds of gas or other material remaining after a star is formed.

synoptic scale—pertaining to regional scales.

tephra—a rock type that is composed of fragmented volcanic products ejected from volcanoes in explosive events.

'ua'u—Hawaiian word meaning dark-rumped petrel, an endangered sea bird, considered by some an *'aumakua*.

vent—the opening at the Earth's surface through which volcanic materials (lava, tephra, and gases) erupt. Vents can be at a volcano's summit or on its slopes.

wēkiu—Hawaiian word meaning tip, top, topmost, summit.

CONVERSION FACTORS

Linear

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

Area

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

Volume

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

Weight

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

Energy

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

Pressure

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

Force

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

Radiation

1 becquerel (Bq) = 2.703 x 10^{-11} curies (Ci)	1 Ci = 3.70 x 10^{10} Bq
1 sievert (Sv) = 100 rem	1 rem = 0.01 Sv

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1 INTRODUCTION AND PURPOSE AND NEED

1.1 INTRODUCTION

This Environmental Assessment (EA) for the Outrigger Telescopes Project has been prepared by the National Aeronautics and Space Administration (NASA) to assist the decision-making process in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. §4321 *et seq.*) and NASA's policy and procedures (14 CFR Subpart 1216.3). The EA considers the Proposed Action—funding on-site construction, installation, and operation of six Outrigger Telescopes at the W.M. Keck Observatory (WMKO) site on the summit of Mauna Kea on the island of Hawai'i—its historic, cultural and environmental impacts, and alternatives. No final action will be taken on this proposal until the decision-making process under NEPA has been completed. On-site construction would not begin until all State and local permits and approvals have been obtained.

1.2 SUMMARY OF PROPOSED ACTION

NASA's Proposed Action is to fund the on-site construction, installation, and operation of six Outrigger Telescopes at the WMKO site located within the Astronomy Precinct of the Mauna Kea Science Reserve on the island of Hawai'i. The Mauna Kea Science Reserve is leased to the University of Hawai'i (UH) by the State of Hawai'i. The WMKO site is subleased to the California Institute of Technology (Caltech) by UH. The Keck Telescopes and WMKO site are operated and maintained by the California Association for Research in Astronomy (CARA), a non-profit corporation established by the University of California and Caltech. The WMKO site is the location of the two most powerful optical telescopes in the world—Keck I and Keck II.

It is expected that the on-site construction and installation of four of the six Outrigger Telescopes, along with on-site construction of the underground structures for Outrigger Telescopes 5 and 6, would begin in 2002, with start of operations expected in 2003. If funding is available, NASA intends to complete the on-site construction, installation, and operation of Outrigger Telescopes 5 and 6, with on-site construction and installation likely to begin in 2007.

1.3 PURPOSE AND NEED

The Outrigger Telescopes Project is a key element in NASA's Origins program. The NASA Origins program is directed at answering two basic questions: (1) How do galaxies, stars, and planets form (or, "Where do we come from?"); and (2) Are there other planets aside from ours, that have the conditions necessary to support life (or, "Are we alone?"). To find answers to these enduring questions, NASA's Origins program has outlined four goals:

- To understand how galaxies formed in the early universe.
- To understand how stars and planetary systems form and evolve.
- To determine whether habitable or life-bearing planets exist around nearby stars.
- To understand how life forms and evolves.

NASA's ability to meet these goals requires use of a technique known as interferometry. Optical interferometry is the science of combining the light from two or more widely-spaced telescopes to create an even sharper view of the object being observed than could be obtained from any one telescope separately.

NASA has defined the following specific ground-based interferometry objectives to help achieve the Origins program goals:

1. Detect the thermal dust emissions from dust clouds around other stars.
2. Detect the light from and characterize the atmospheres of hot, Jupiter-mass planets located within approximately 20 million kilometers (km) (12 million miles (mi)) of the stars they are orbiting.
3. Detect the astrometric signature (*i.e.*, the wobble of a star due to the gravitational influence of an unseen planetary companion) of planets as small as Uranus that are orbiting stars.
4. Make images of proto-stellar disks (*i.e.*, disks of dust and gas in space believed to be an early stage of star formation) and stellar debris disks (*i.e.*, clouds of gas or other material remaining after the star is formed).
5. Provide high resolution information about some faint objects outside our galaxy.
6. Make high resolution observations of objects within the solar system, including asteroids, comets and outer planets.

On March 12, 2001, the light from each of the two Keck Telescopes was combined, forming the Keck-Keck Interferometer. NASA can achieve the first two objectives listed above using the Keck-Keck Interferometer. In order to achieve the remaining four objectives, operation of four to six outrigger telescopes combined with one or more large telescopes is needed.

The addition of four Outrigger Telescopes to the Keck-Keck Interferometer would allow astronomers to obtain higher resolution images of astronomical objects by allowing the objects under study to be viewed at different angles. Adding a fifth and sixth telescope would almost double the resolution beyond that achievable using four outrigger telescopes. This further doubling of the resolution would provide much higher quality scientific data (*i.e.*, more data points), yielding much clearer images.

1.4 ENVIRONMENTAL PLANNING ACTIVITIES

1.4.1 State of Hawai'i Process

In response to a request from CARA to allow development of the Outrigger Telescopes on the 2-hectare (ha) (5-acre (ac)) WMKO sublease parcel, the University of Hawai'i Institute for Astronomy (UH IfA) prepared a draft EA in accordance with Chapter 343 Hawai'i Revised Statutes and § 11-200-9 of the Environmental Impact Statement (EIS) Rules (Chapter 200 of Title 11, Administrative Rules). The State draft EA was filed with the State Office of Environmental Quality Control (OEQC) on March 12, 1999, and circulated for public review.

Fifteen comment letters on the State draft EA were received during the 30-day review period. These included: five letters of support, two comments which required minor corrections to the text and/or tables, and eight letters with substantive comments related to the contents of the State draft EA, primarily cultural and biological. Each of the commenting parties received a response from UH IfA. The key issues that emerged were associated with the cultural resources on and use of Mauna Kea, and potential adverse effects on Wēkiu bug habitat. The Wēkiu bug is a candidate for listing under the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*).

1.4.2 Federal Environmental Review Processes

Federal NEPA Process. This Federal EA, prepared in accordance with NASA's policies and procedures, discusses proposed mitigation measures relating to cultural resources mitigation and Wēkiu bug mitigation. A letter informing potentially concerned agencies of NASA's NEPA process was transmitted in August 2000. The letter highlighted the major environmental issues that would be addressed in the NASA NEPA documentation, indicated that the Section 106 process had also been initiated under the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470 *et seq.*) (NHPA), and requested any comments or concerns. A copy of the letter, the distribution list, and responses received are provided in Appendix A. The major environmental issues associated with the proposed Outrigger Telescopes Project are historical/cultural resource issues (see Appendix B for the letter from the Department of Land and Natural Resources (DLNR) addressing the cultural significance of Pu'u Hau 'Oki and the summit region of Mauna Kea), and potential impacts to the Wēkiu bug (see Appendices D & E).

One of the key mitigation proposals is to restore Wēkiu bug habitat in a portion of the crater bottom of Pu'u Hau 'Oki and near Junction Box 5 (JB-5). This proposed habitat restoration would implement and satisfy the restoration element of the Wēkiu Bug Mitigation Plan. If additional suitably-sized cinder is available, habitat may be restored in an area near Outrigger Telescope 1.

NASA's Draft Environmental Assessment for the Outrigger Telescopes Project was completed and made available in December 2000 for review by Federal and State agencies, interested organizations, and the public. Copies of the Draft EA were mailed directly to all parties responding to NASA's August 2000 letter, as well as to others expressing interest in the Outrigger Telescopes Project. Copies were also made available to the public at libraries in the Hawaii State and Regional Library system, at a number of college and university libraries, and at two State offices. Notices regarding availability of the Draft EA were also published in widely circulated newspapers. A total of 21 comment letters on the Draft EA were received. In addition, NASA invited the public and other interested parties to attend NASA's Open House meetings in Hilo on February 5, 2001 and in Kailua-Kona on February 7, 2001. Some Open House visitors provided written comments. Environmental concerns expressed in the comments received included, but were not limited to, impacts to cultural resources, impacts to ground and surface water hydrology, use of hazardous materials, and Wēkiu bug mitigation and monitoring. All comments received on the Draft EA were considered by NASA in the process of completing this EA. All comments received during the Draft EA review process along with NASA's response can be found in Appendix I and Appendix J of this Final EA. NASA has also conducted numerous formal and informal meetings with Federal and State agencies, interested organizations, and the public over the intervening period since the Open House meetings. These include four days of Town Hall meetings, October 1 - 4, 2001, in Kailua-Kona, Waimea, and Hilo.

Section 106 Consultation Process. Aside from the NEPA process, the other Federal planning process for the proposed project is the Section 106 consultation process under the NHPA. By letter dated May 3, 1999, in response to the State draft EA, the Administrator of the State Historic Preservation Division (SHPD), State of Hawai'i Department of Land & Natural Resources (DLNR), stated that they have come to believe that the cluster of cinder cones—now known as Pu'u Hau 'Oki, Pu'u Kea, and Pu'u Wēkiu—is a historic property. The SHPD also indicated that they believe that the summit region of Mauna Kea is a historic district, and is eligible for listing on the National Register of Historic Places (SHPD 1999). The SHPD further stated that the proposed Outrigger Telescopes Project at the WMKO site, on Pu'u Hau 'Oki, within the Astronomy Precinct on Mauna Kea, would have an "adverse effect" on the historic property and the historic district; however, such adverse effect "can be mitigated if appropriate measures are adopted" (SHPD 1999) - see Appendix B. NASA agreed.

Thereafter, NASA commenced the NHPA process, when in July 1999 it authorized UH to initiate and conduct working level consultations on behalf of NASA in this regard. UH undertook interactions with State agencies and interested organizations and individuals to identify the nature of concerns relative to historic and cultural resources potentially affected by the Outrigger Telescopes Project. In August 2000, NASA formally provided copies of draft mitigation proposals to the State Office of Hawaiian Affairs, the Royal Order of Kamehameha I, the Hawai'i Island Burial Council, and Hui Mālama I Nā Kūpuna O Hawai'i Nei, and invited them to join with NASA and the SHPD in formal consultation under the Section 106 process of the NHPA. In September 2000, NASA formally invited the Advisory Council on Historic Preservation (ACHP) to join in the Section 106 process. The ACHP agreed to participate.

In addition, NASA consulted with and invited the Office of Mauna Kea Management, the Mauna Kea Management Board, and Kahu Ku Mauna to participate in the development of the Memorandum of Agreement (MOA). Two more Native Hawaiian organizations requested and were given Consulting Party status: Ahahui Ku Mauna and Mauna Kea Anaina Hou. A formal Section 106 meeting was held in Hilo on February 1, 2001. In October 2001, NASA distributed to the Consulting Parties a draft MOA for review and comment. NASA held another formal Section 106 meeting in Hilo on January 16 and 17, 2002. The cultural mitigation measures are stipulated in the MOA (see Appendix C).

Coastal Zone Management Act Process. Because NASA will be providing only Congressionally-appropriated funding for the proposed project, there are no Coastal Zone Management Act consistency determination implications (State Office of Planning 2000b).

2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

The National Aeronautics and Space Administration's (NASA) Proposed Action is to fund the on-site construction, installation, and operation of six Outrigger Telescopes at W.M. Keck Observatory (WMKO) site. It is anticipated the on-site construction and installation of four of the six Outrigger Telescopes, along with on-site construction of the underground structures for Outrigger Telescopes 5 and 6, will begin in 2002, upon issuance of all State and local permits and approvals, with start of operations anticipated in 2003. If funding is available, NASA intends to complete the on-site construction, installation, and operation of Outrigger Telescopes 5 and 6, with on-site construction and installation likely to begin in 2007. The proposed Outrigger Telescopes would be located adjacent to the twin Keck Telescopes on the existing WMKO site within the Astronomy Precinct, on the summit area of the Mauna Kea Science Reserve.

Alternatives to the Proposed Action that have been considered in this Environmental Assessment (EA) include: funding on-site construction, installation, and operation of the Outrigger Telescopes at an alternative site, and the No-Action Alternative. The No-Action Alternative is addressed in Section 2.2. Alternative sites considered included existing telescope facilities both within the United States and abroad. Section 2.3 provides an evaluation of these alternative locations, finding that none would be suitable for the Outrigger Telescopes for a variety of technical and programmatic reasons.

2.1 DESCRIPTION OF THE PROPOSED ACTION

NASA is proposing to fund on-site construction, installation, and operation of six Outrigger Telescopes at the WMKO beginning in 2002. However, NASA will not take final action on this proposal until the decision-making process under the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S.C. §4321 *et seq.*), has been completed.

The proposed Outrigger Telescopes would be strategically placed around the 10-meter (m) (33-foot (ft)) Keck I and Keck II Telescopes that are currently being operated by the California Association for Research in Astronomy (CARA) within the Astronomy Precinct of the Mauna Kea Science Reserve. Figure 2-1 illustrates the location of the Mauna Kea Science Reserve on the island of Hawai'i.

Related activities that would take place at Hale Pōhaku during the construction phase include use of the approved materials staging area and the existing construction camp.

2.1.1 Summit Area of the Mauna Kea Science Reserve and Hale Pōhaku

The proposed site is located within the Astronomy Precinct within the summit area of the Mauna Kea Science Reserve (Figure 2-2). The Mauna Kea Science Reserve, about 4,568 hectares (ha) (11,288 acres (ac)) in size, is leased by the State to the University of Hawai'i (UH). UH has, in turn, subleased parcels of the Mauna Kea Science Reserve in the summit area to various observatory facilities. The WMKO site is subleased by the California Institute of Technology (Caltech). The site is located within the Resource Subzone of the State Conservation District in an area defined as the "Astronomy Precinct" in the recently adopted Mauna Kea Science Reserve Master Plan (see Figure 2-3). Astronomy facilities are a permitted use in the Resource Subzone of the Conservation District. In accordance with the Mauna Kea Science Reserve Master Plan,

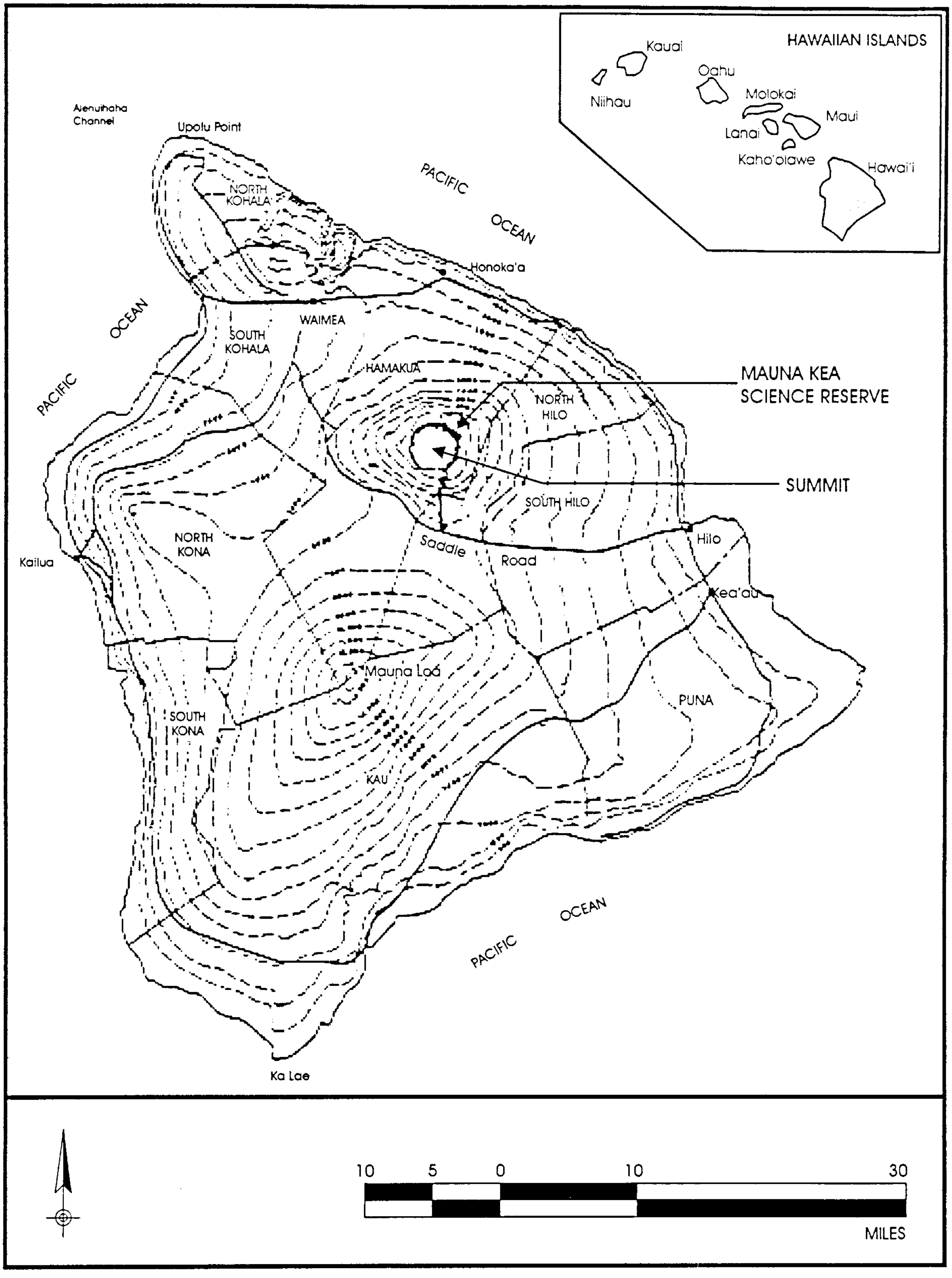


FIGURE 2-1. MAUNA KEA SCIENCE RESERVE ON THE ISLAND OF HAWAI'I

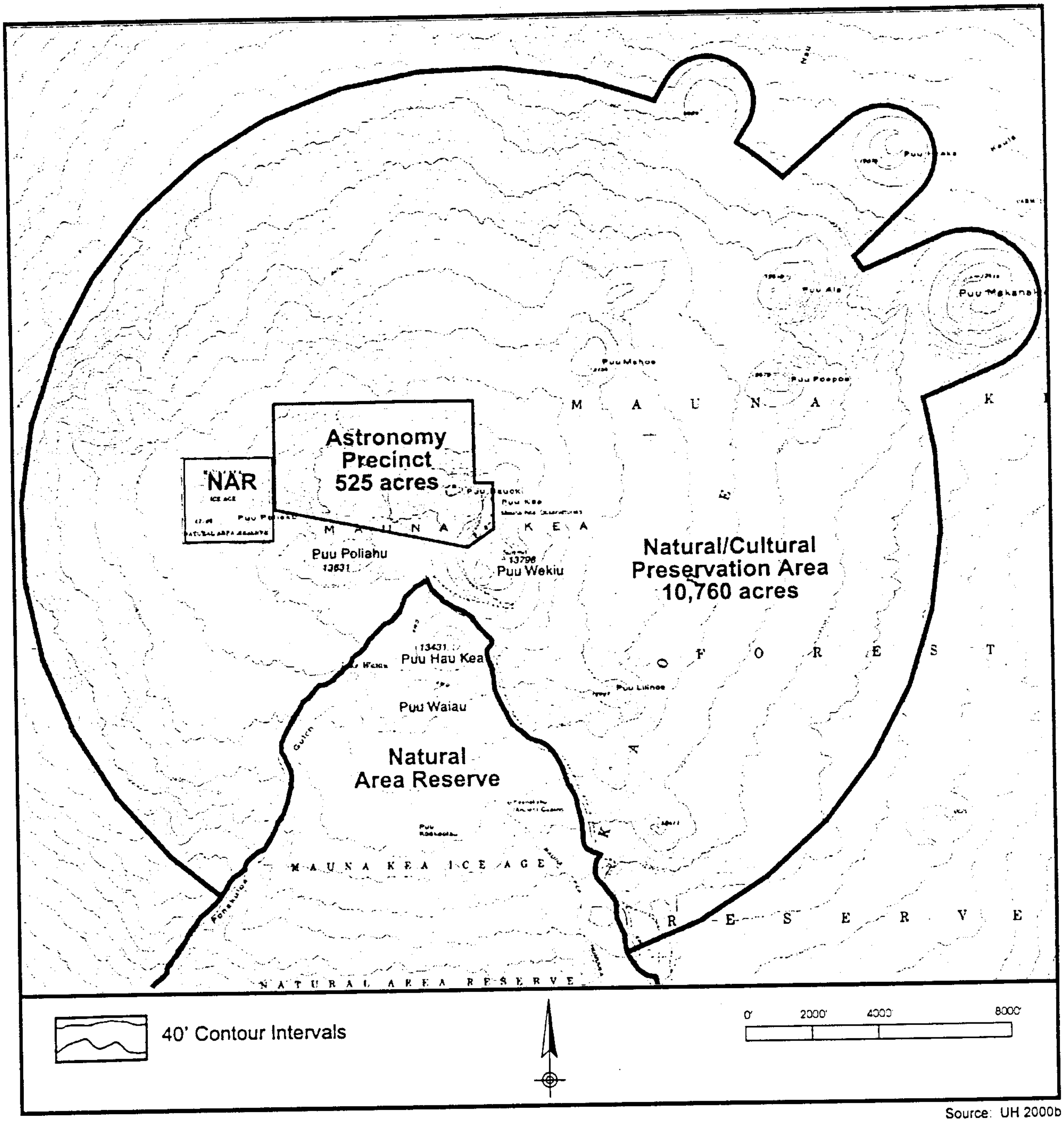
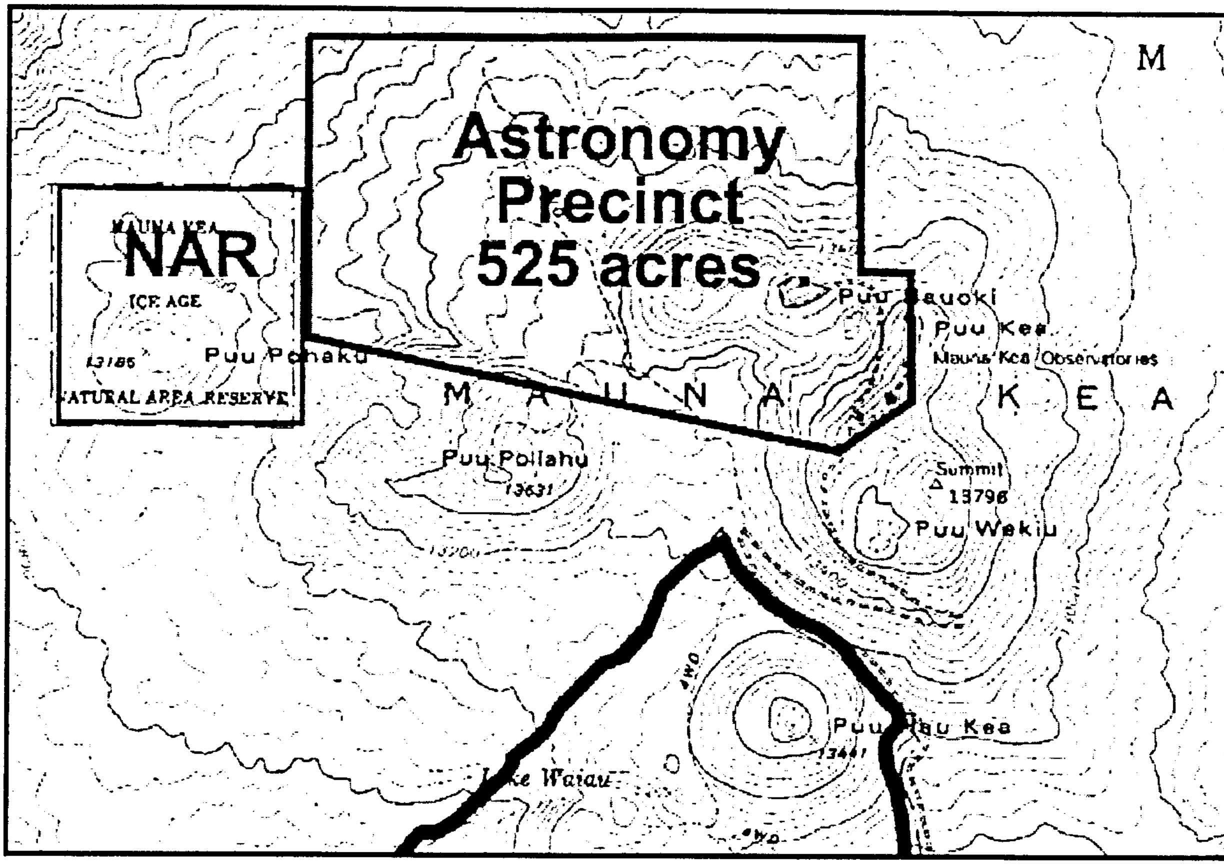


FIGURE 2-2. MAUNA KEA SCIENCE RESERVE, (INCLUDES THE ASTRONOMY PRECINCT AND THE NATURAL/CULTURAL PRESERVATION AREA)

all future astronomy development in the Mauna Kea Science Reserve would be allowed only within the Astronomy Precinct, totaling about 212 ha (525 ac).

In addition to Department of Land and Natural Resources (DLNR) review through the Conservation District Use Application process and approval of the Application by the Board of



Source: UH 2000b

FIGURE 2-3. ASTRONOMY PRECINCT

Land and Natural Resource (BLNR), future proposed development within the Astronomy Precinct will be subject to review and approval by the UH Board of Regents and President. All proposals also will be reviewed by the Office of Mauna Kea Management (OMKM), the Mauna Kea Management Board, and the Kahu Ku Mauna before any final decisions are made involving development within the Astronomy Precinct.

The second sub-area is the balance of the Mauna Kea Science Reserve leasehold, about 4,355 ha (10,760 ac) which has been designated as a Natural/Cultural Preservation Area (see Figures 2-2 and 2-3). This area will not be subject to any future development and will be preserved and protected for its natural and cultural values. Figure 2-4 illustrates the existing astronomy facilities within the Astronomy Precinct and their location relative to the other observatories and the Keck Telescopes.

Mauna Kea Science Reserve/Astronomy Precinct. One of the primary reasons that the Mauna Kea Science Reserve site has been selected as the proposed location for the Outrigger Telescopes is because of its superb conditions. It is one of the finest locations in the world for ground-based astronomical observations. Because of its location high on an island in the Pacific, the sky above the mountain is generally cloud-free. This gives Mauna Kea one of the highest number of clear nights in the world, an important characteristic for scientists who want to observe the planets and stars as often as possible. The stability of the atmosphere at Mauna Kea, free from disturbance

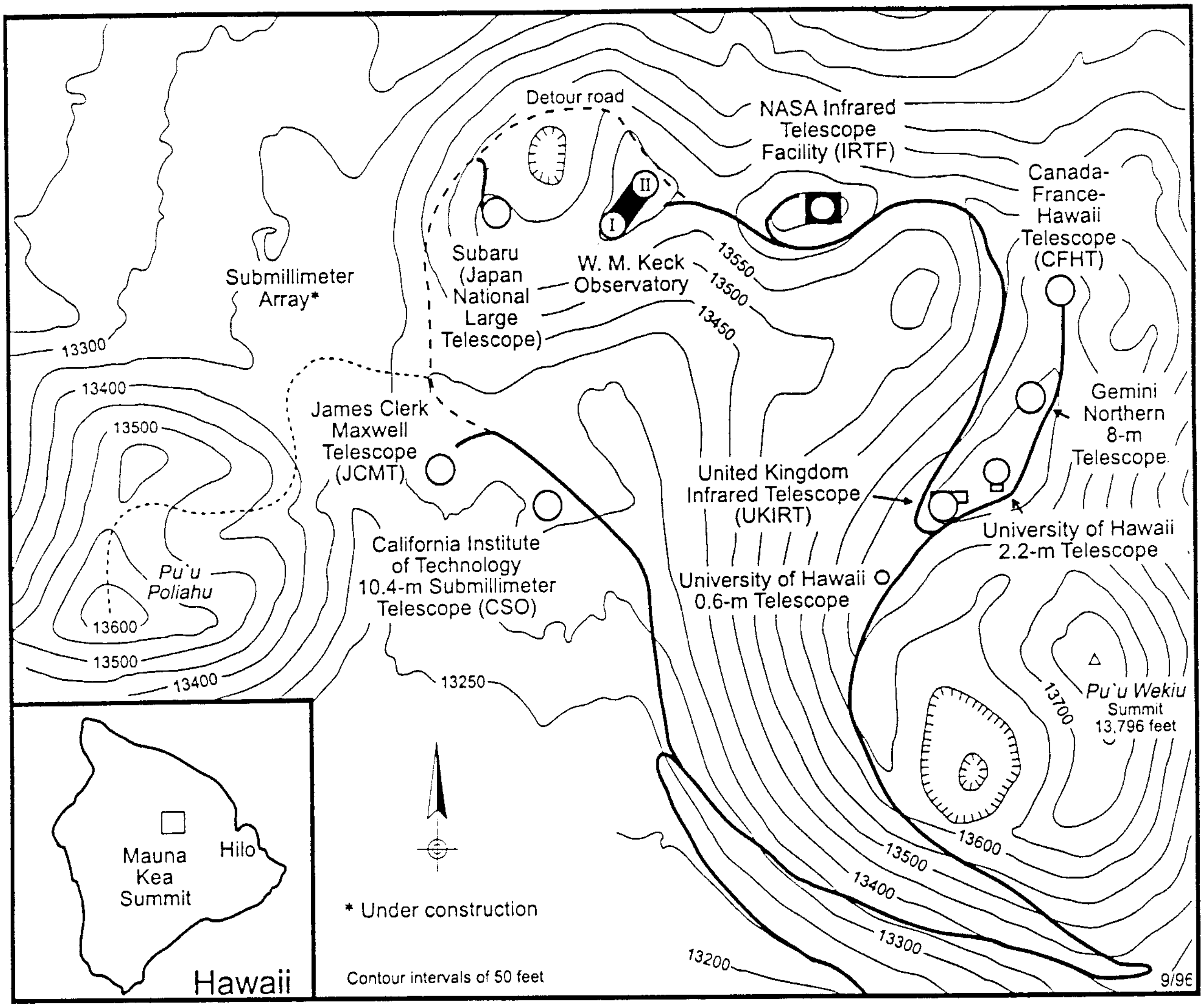


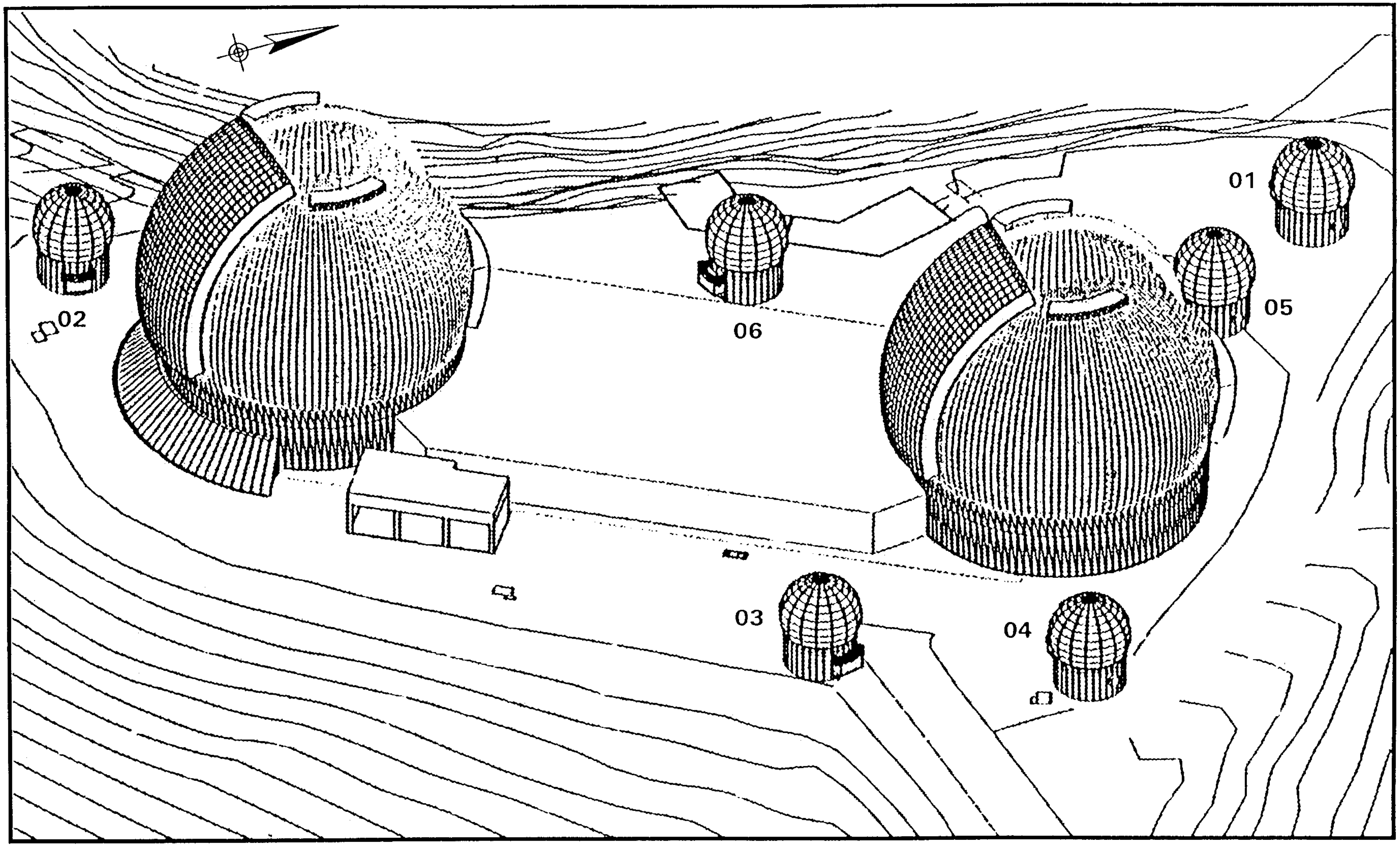
FIGURE 2-4. EXISTING OBSERVATORIES IN THE SUMMIT AREA OF THE MAUNA KEA SCIENCE RESERVE

caused by neighboring land forms, allows more detailed observations than available elsewhere. Finally, the summit's height above the tropical inversion layer provides summit skies that are pure, dry and free from atmospheric pollutants (UH IfA 1999).

In addition, the County of Hawai'i has a strong island-wide lighting ordinance to ensure an extremely dark sky, allowing observation of the faintest galaxies that lie on the edge of our observable Universe.

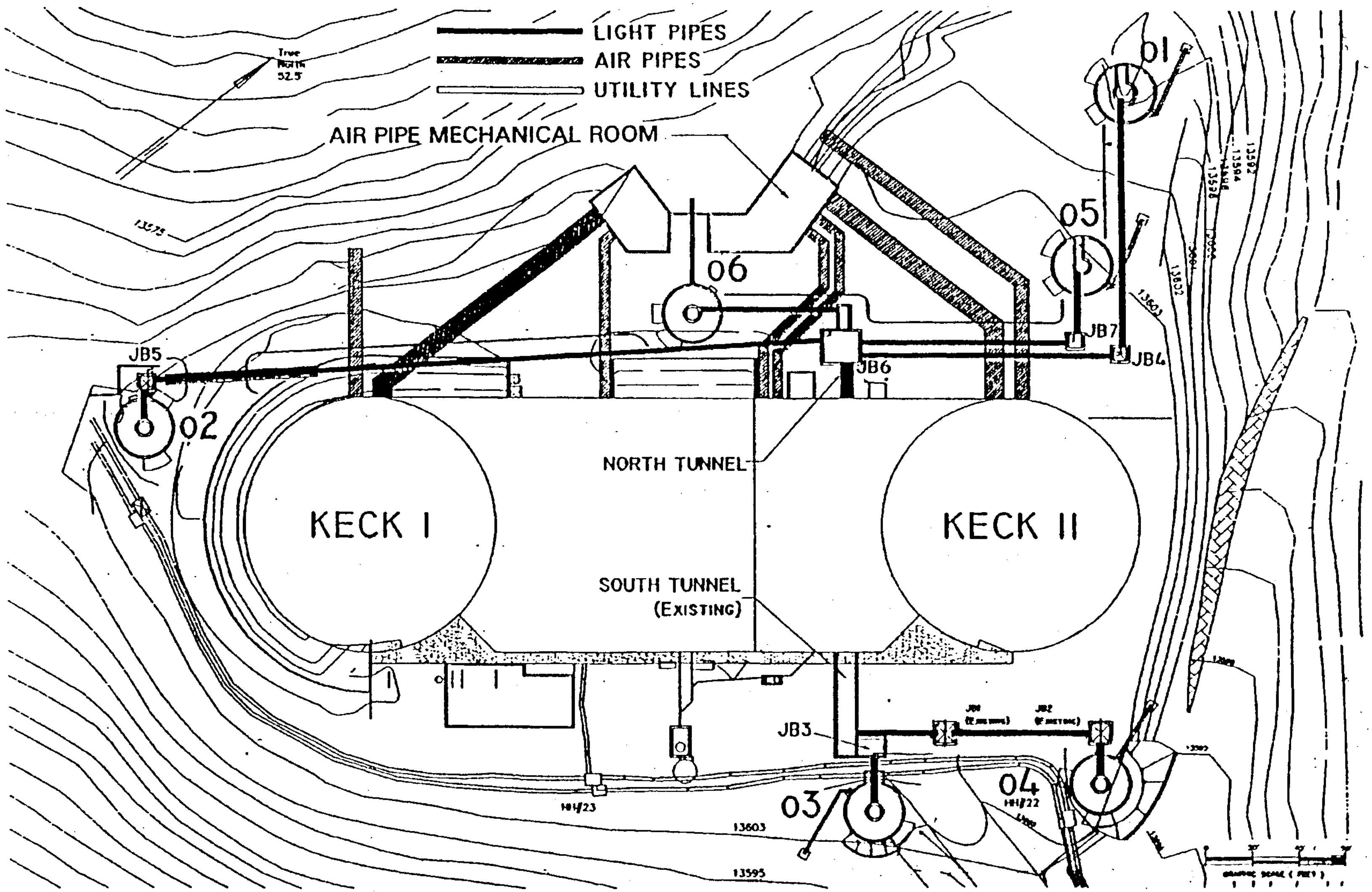
WMKO Site. The proposed Outrigger Telescopes Project would be located near the existing Keck I and Keck II Telescopes on the WMKO site. The WMKO consists of a total of approximately 2 ha (5 ac) on the summit area of Mauna Kea. Approximately 1.1 ha (2.8 ac) was leveled during construction of the Keck I and Keck II Telescopes. The six Outrigger Telescopes would be placed at strategic locations around the two Keck Telescopes, within the previously disturbed site.

Figure 2-5 shows a perspective view of the six Outrigger Telescopes relative to the Keck I and Keck II Telescopes. Figure 2-6 shows a plan view of the six proposed Outrigger Telescopes on



Source: UH IfA 2001a

FIGURE 2-5. PERSPECTIVE VIEW OF THE TWIN KECK TELESCOPES AND THE SIX OUTRIGGER TELESCOPES



Source: UH IfA 2001a

FIGURE 2-6. PROPOSED OUTRIGGER TELESCOPES ON THE WMKO SITE the WMKO site. Underground pipes, tunnels, and junction boxes that are proposed to provide the underground optical paths to connect the telescopes to instrumentation located in the beam-combining room in the basement of the Keck II Telescope building are also shown in Figure 2-6.

As proposed, the location of the Outrigger Telescopes would disturb habitat of the Wēkiu bug, a candidate for listing under the Endangered Species Act. Located on the summit area, a small amount of Wēkiu bug habitat (0.009 ha (0.022 ac)) adjacent to the WMKO site would be directly affected by on-site construction of the proposed project. Wherever practicable, engineering designs for the on-site construction and installation have attempted to minimize, reduce, or avoid impacts to the Wēkiu bug habitat. A natural resource management consulting firm has drafted a Wēkiu Bug Mitigation Report that contains recommendations designed to protect the Wēkiu bug and its habitat within and immediately surrounding the WMKO site (Pacific Analytics 2000).

Based on that report and its recommendations, a Wēkiu Bug Mitigation Plan was developed (see Appendix D).

Hale Pōhaku. Actions at Hale Pōhaku would involve temporary use of the approved materials staging area and temporary use of the construction camp (see Figure 2-7).

Construction Staging Area. The Outrigger Telescopes Project would temporarily use the existing construction staging area and temporary stockpile area located at 4,039-m (13,250-ft) elevation of the summit. This area was previously used for activities in connection with Subaru and Keck II Telescope projects (see Figure 2-8).

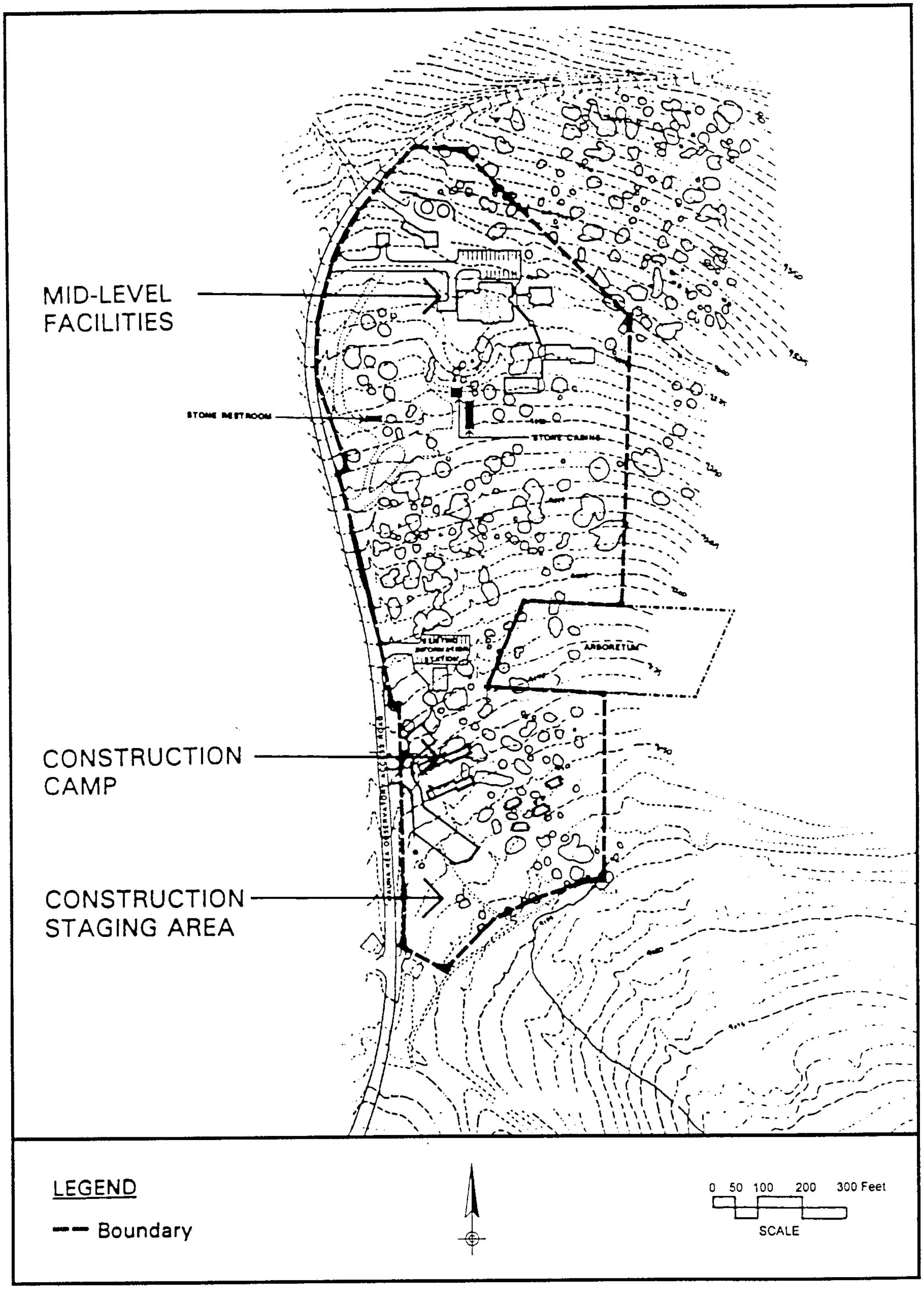
2.1.2 Proposed Facilities

The proposed facilities for the Outrigger Telescopes Project involve the Outrigger Telescopes, dome enclosures, and underground pipes and structures. The following section addresses the design of these facilities.

No substantial changes to the project are expected; the final design will not differ substantially from that stated in this EA. Some specifications are under design review and may change slightly in the final design. As required by the Conservation District Use permit (CDUP), final grading and construction plans will be submitted to DLNR for approval before the County of Hawai'i permits are obtained. In the unlikely event that any change results in any substantial changes in the environmental impacts, NASA will consider additional environmental documentation.

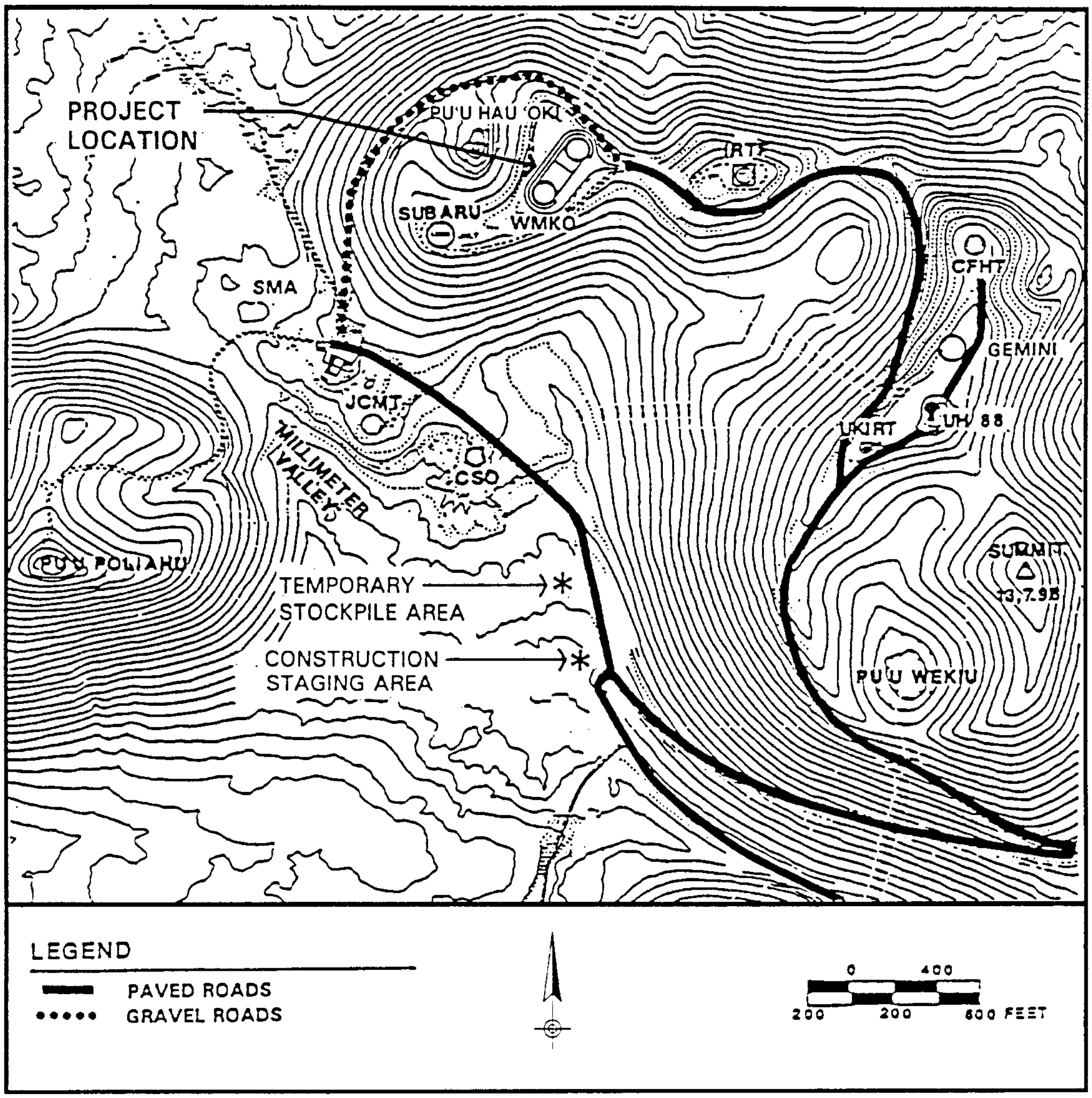
2.1.2.1 Outrigger Telescopes and Dome Enclosures

As proposed, each Outrigger Telescope would consist of a 1.8-m (6-ft) diameter, f/1.5 primary mirror, a secondary mirror, a tertiary mirror, a dual star module and a starlight beam on the telescope yoke. To protect it from the harsh conditions on the summit of Mauna Kea, each Outrigger Telescope will be enclosed by a dome enclosure that would be a maximum of 10.7-m (35-ft) high, 9.1 m (30 ft) in diameter at its widest point and 8 m (26 ft) at its base. These dome enclosures will be made up of two sections: a 7.9-m (26-ft) diameter cylindrical, fixed-in-place, corrugated metal-clad ring wall base, color-bond sealed "heritage red" to blend into the surrounding landscape, and, a white 9.1-m (30-ft) diameter (at its widest point) spherical dome



Source: UH IfA 2001a

FIGURE 2-7. HALE PŌHAKU



Source: UH IfA 2001a

FIGURE 2-8. LOCATION OF THE TEMPORARY STOCKPILE AND CONSTRUCTION STAGING AREA

which would rotate along the top of the ring wall on 16 wheels. Each proposed telescope and dome would be mounted on separate concrete piers for the purpose of vibration isolation. The domes would be large enough to accommodate both a telescope and a dual star module and have a slit width adequate for unobstructed viewing with a 1.8-m (6-ft) diameter primary mirror. The proposed height of the domes would be less than 10.7 m (35 ft) as measured from the level grade around each site, depending on what is required to reduce the impact of air turbulence near the ground.

2.1.2.2 Underground Structures and Pipes

Underground Telescope Instrument Rooms and Junction Boxes (JB). Each of the proposed telescopes would be supported by an underground telescope instrument room, which would act as a telescope pier. The mirror that injects the starlight beams into the underground light pipes would be housed in this underground telescope room. Five new junction boxes (JB-3, JB-4, JB-5, JB-6 and JB-7) will be constructed (see Figure 2-6). Each junction box would house the mirrors that redirect the starlight beams through underground pipes to the basement of the Keck II Telescope building, where the interferometer instrumentation would be located (see Table 2-1). Access to JB-3 and JB-6 will be through the South tunnel and North tunnel, respectively. An above-grade "roof hatch" will provide access to the inside of JB-2, JB-4, JB-5 and JB-7. The hatches will be marked appropriately with snow poles to provide a route for snowplows. An illustration of a proposed Outrigger Telescope and dome enclosure is shown in Figure 2-9.

TABLE 2-1. OUTRIGGER TELESCOPES JUNCTION BOXES

Junction Box	Estimated Exterior Junction Box Dimensions[a] Length x Width x Depth	Outrigger Telescope Served
2[b]	3 m x 3 m x 3.7 m (10 ft x 10 ft x 12 ft)	4
3	3.8 m x 2.6 m x 2.7 m (12.5 ft x 8.7 ft x 9 ft)	3
4	2.2 m x 2.2 m x 2.6 m (7.3 ft x 7.3 ft x 8.7 ft)	1
5	2.2 m x 2.2 m x 2.6 m (7.3 ft x 7.3 ft x 8.7 ft)	2
6	5.3 m x 4.9 m x 2.8 m (17.5 ft x 16 ft x 9.3 ft)	1, 2, 5, 6
7	2.2 m x 2.2 m x 2.6 m (7.3 ft x 7.3 ft x 8.7 ft)	5

Source: CARA 2000e

Note: The existing JB-1 would not be used by the Outrigger Telescopes.

a. Maximum dimensions.

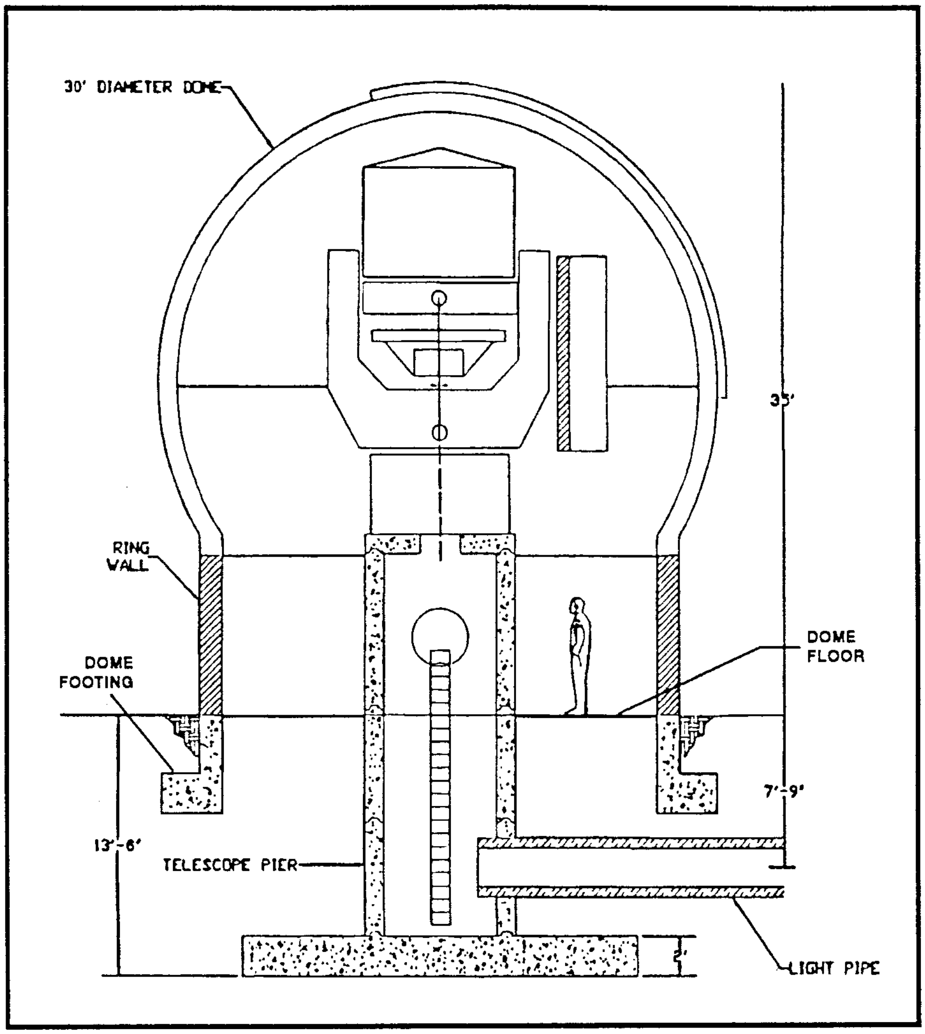
b. Previously constructed junction box.

Underground Pipes. Light pipes located on the north side of the facility would serve as conduits for the light beams from Outrigger Telescopes 1, 2, 5 and 6 to JB-6. From there, a 1.5 by 2.4-m (5 by 8-ft) North tunnel would serve to bring starlight beams into the basement instrumentation room. The pipes would be buried in trenches.

Two existing 1.2-m (4-ft) air pipes may have to be reinstalled 0.6-m (2-ft) deeper if they interfere with the light pipes. The 88.7-m (291-ft) long light pipe between JB-5 and JB-6 will be routed under the service road. It will either be installed in a culvert, in a trench covered by cinder or by some other method that will ensure that the pipe will not be damaged by vehicular traffic.

The existing 2.4-m (8-ft) wide by 2.1-m (7-ft) high by 20-m (67-ft) long (interior dimensions) underground tunnel on the south side of the facility and a proposed new junction box (JB-3) would provide a path for the starlight beams from Outrigger Telescopes 3 and 4 and would provide personnel access to JB-3. This tunnel already exists.

The light path from Outrigger Telescope 4 will be via an existing 36-inch (3-ft) light pipe from JB-2 to the South tunnel; the light path for Outrigger Telescope 3 will be via JB-3, which will be



Source: W.M. Keck Observatory 2001

FIGURE 2-9. ILLUSTRATION OF A PROPOSED OUTRIGGER TELESCOPE AND DOME ENCLOSURE

attached to the end of the tunnel. JB-1 and JB-2 were constructed in conjunction with the Temporary Optical Test Sites (TOTS) project. They will be retained and used to route the beams from Outrigger Telescope 4 into the existing South tunnel.

Smaller pipes, to be installed in the same trenches as the light pipes, will be used to route power and communication signals from the control room in the Keck basement to the Outrigger underground telescope instrument rooms and junction boxes.

Air pipes (up to 24-inch-diameter (2-ft)) will be installed to exhaust warm air away from the Outrigger Telescopes in order to minimize turbulence that could be created by plumes of air rising up in front of the enclosure slits. The warm air, which is caused by heat from the electronics and motors within the enclosures, could significantly degrade the images formed by the telescopes.

With the exception of Outrigger Telescope 2, the air pipes will be routed underground to the edge of the slope as follows: north about 18.3 m (60 ft) for Outrigger Telescope 1, north about

15.2 m (50 ft) for Outrigger Telescope 5, northwest about 15.2 m (50 ft) for Outrigger Telescope 6, south about 7.6 m (25 ft) for Outrigger Telescope 3 and north about 7.6 m (25 ft) for Outrigger Telescope 4. The air pipe for Outrigger Telescope 2 is planned to run above ground about 4.6 m (15 ft); its end will be mounted on the top of JB-5. A square pad (1.2 to 1.8-m (4 to 6-ft)) of either precast concrete or hardened-in-place cinder, will be installed at the end of each pipe. The purpose of the pads is to stabilize the pipes and to prevent potential damage from runoff.

2.1.3 On-Site Construction and Installation of the Outrigger Telescopes Project

2.1.3.1 Schedule

On-site construction work for the Outrigger Telescopes Project would start as soon as practical after all permits have been obtained. It is expected that the site work for all six telescopes and the installation and commissioning of the first four telescopes and their dome enclosures will be completed approximately 16 months after project start. The remaining two telescopes and their enclosures are not funded at this time. After their funding is secured, it would require an additional six months to install and commission them.

All four presently funded Outrigger Telescopes would be installed in their domes and integrated with the rest of the interferometry hardware by 2003 or early 2004. If the two additional telescopes—Outrigger Telescopes 5 and 6—are funded it would likely be 2007 before their on-site construction and installation would begin.

Until funding of Outrigger Telescopes 5 and 6 is secured, concrete work for those two telescopes would be limited to structures that are no higher than 18 cm (7 inches) above level ground. For reasons of safety, the unfinished underground telescope instrument rooms would be covered with steel plates and the area secured. Each telescope foundation area, including the 18-cm (7-inches) high ring wall footing and covered telescope instrument room, will then be covered with cinder from project excavations.

2.1.3.2 Estimated Excavation

Prior to undertaking underground work in the vicinity of power and communications cables, the contractor would install sheet piling as required by the Hawaii Electric Light Company (HELCO). This would protect the cables from inadvertent disturbance by construction equipment. The sheet piles would be removed and transported off the mountain when this phase of the on-site construction is finished.

As currently proposed, about 918 cubic meters (m^3) (1,200 cubic yards (yd^3)) of cinder would be excavated to install about 274 m (900 ft) of light pipe and air pipe trenches. About 1,835 m^3 (2,400 yd^3) of cinder would be excavated for telescope footings and underground telescope instrument rooms. Approximately 50 percent of the excavated material would be replaced on top of the tunnels and pipes and used for backfill around the telescopes. Excavated material not required for fill would be graded, and suitable sized cinder would be washed and used for restoration of the Wēkiu bug habitat. Any excavated cinder not used for backfill or restoration would be placed on the mountain at locations determined after consultation with the State Historic Preservation Division (SHPD) and OMKM.

2.1.3.3 Grading Plans for Outrigger Telescope Domes and Junction Boxes

Outrigger Telescope 1. The finished grade outside of the structure would be at an elevation of about 1.1-m (3.5-ft) lower than the existing level grade. There would be a small swale to divert surface water runoff away from the dome. The finished grade would require about 1.5 m^3 (2 yd^3) of fill.

Neither a retaining wall nor a truck access pad driveway would be required as the slope would be no steeper than about 12 percent. Figure 2-10 provides the proposed site plan for Outrigger Telescope 1.

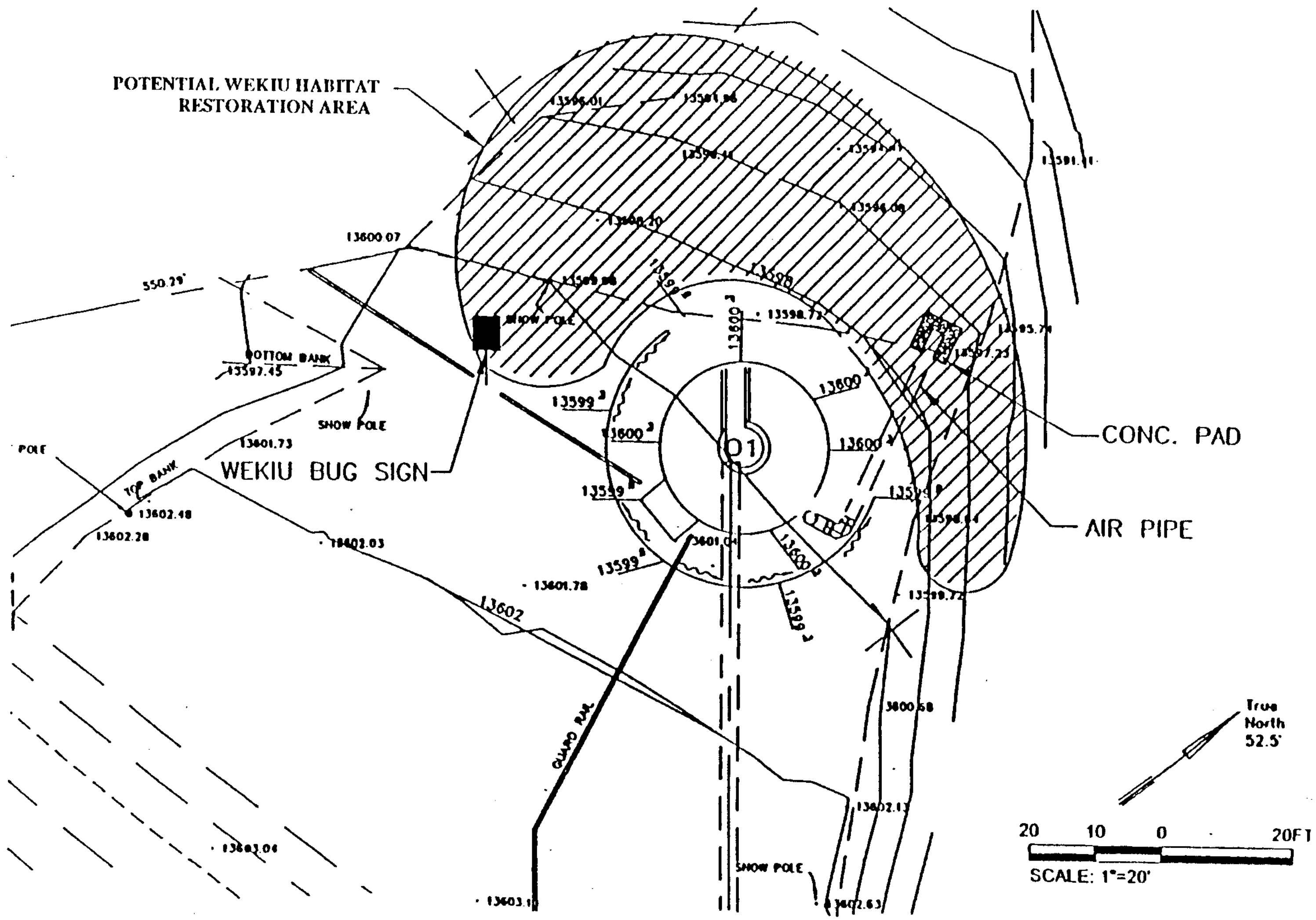
As part of the Outrigger Telescope on-site construction project, Wēkiu bug habitat restoration is being considered in the sloped area near Outrigger Telescope 1 if there is available cinder. A guardrail would be installed to protect Outrigger Telescope 1 and the light pipe. If the habitat is restored, the guard rail would protect the Wēkiu bug habitat in the sloped area from inadvertent damage due to trucks entering, leaving, and backing up within the dome area. As shown in Figure 2-10, if there is available cinder, habitat restoration would include filling a semi-circular area (0.032 ha; 0.08 ac) around Outrigger Telescope 1. Further details may be found in Chapter 4 and in the Wēkiu Bug Mitigation Plan (see Appendix D).

Outrigger Telescope 2 and JB-5. The proposed siting area for Outrigger Telescope 2 is on the existing graded pad of the main complex, and therefore, does not require extra fill to be placed near the slope. The junction box directly northwest of Outrigger Telescope 2 (JB-5), however, would be located close to the edge of the slope and would require structural support. Figure 2-11 shows the proposed site plan for Outrigger Telescope 2 and JB-5.

A 13-m (44-ft) long by 1.5-m (5-ft) high maximum (above grade) z-shaped retaining wall would be constructed to support JB-5. On-site construction and installation of an air pipe and retaining wall needed for slope stability at JB-5 near Outrigger Telescopes 2 would result in the loss of a small amount (0.003 ha (0.008 ac)) of the sloped cinder cone wall that contains Wēkiu bug habitat. Because JB-5 has been relocated to less than 0.9 m (3 ft) from Outrigger Telescope 2, any disturbance to the crater wall will be minimal. As part of project implementation, Wēkiu bug habitat will be restored. The retaining wall would be of solid concrete block construction and would be color-matched to the existing cinder.

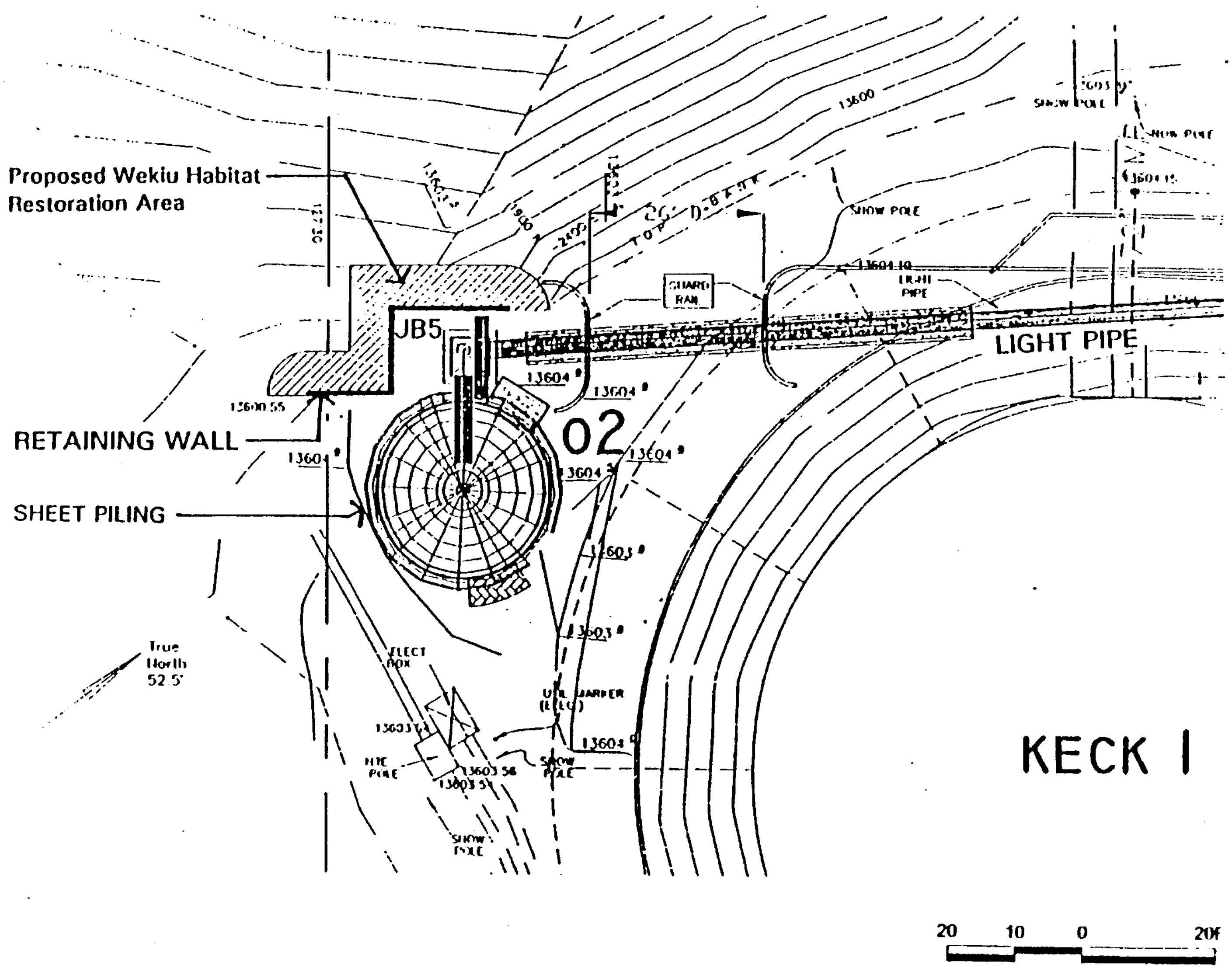
There was a proposal to use fill to provide slope stability at this location. The fill would have disturbed about 130 m^2 (1,400 ft^2) (or 0.013 ha (0.032 ac)) of Wēkiu bug habitat; this proposal has been rejected.

Outrigger Telescope 3. The proposed location for Outrigger Telescope 3 is on the existing graded area near the entrance to the WMKO. The finished grade outside the dome would be slightly elevated so that surface water would flow away from the dome. A cinder-colored concrete masonry block retaining wall would be placed about 1.8-m (6-ft) south of Outrigger Telescope 3 to provide slope stability. The retaining wall, color-matched to the existing cinder, would be a maximum of about 2.6-m (8-ft) high by about 11-m (36-ft) long. On-site construction and installation of Outrigger Telescope 3 would disturb a small amount (0.006 ha (0.015 ac)) of Wēkiu bug habitat. However, no Wēkiu bug habitat restoration can occur here because of the severity of the slope and the cinder necessary to restore the area would spill over onto undisturbed habitat. Figure 2-12 shows the proposed site plan for Outrigger Telescope 3.



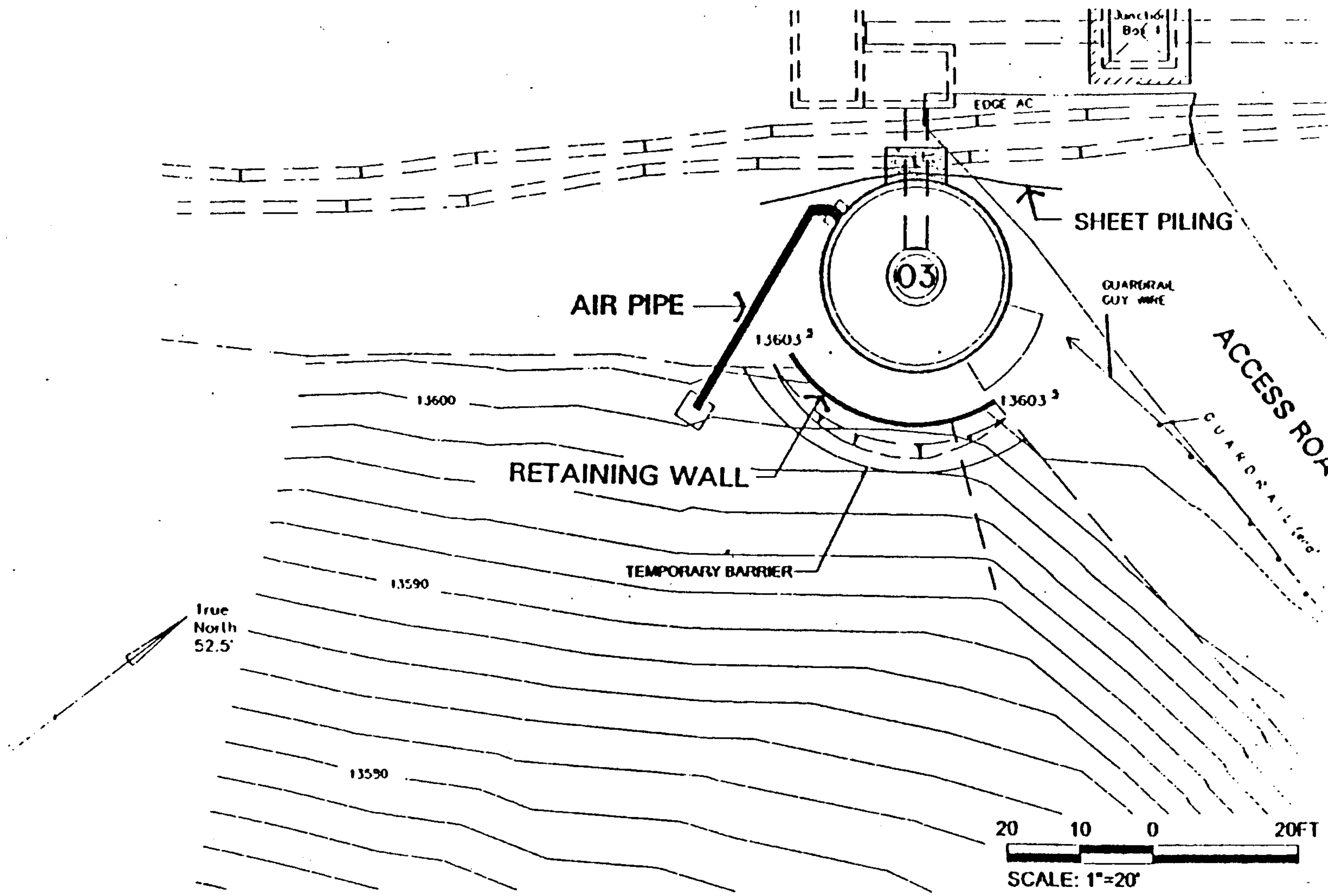
Source: UH IfA 2001a

FIGURE 2-10. PROPOSED SITE PLAN—OUTRIGGER TELESCOPE 1



Source: UH IfA 2001a

FIGURE 2-11. PROPOSED SITE PLAN—OUTRIGGER TELESCOPE 2



Source: UH IfA 2001a

FIGURE 2-12. PROPOSED SITE PLAN—OUTRIGGER TELESCOPE 3

Outrigger Telescope 4. This Outrigger Telescope is proposed to be located on the previously-graded area, near the entrance to the observatory site. The finished grade outside the structure would be slightly elevated so that surface water would flow away from the dome. About 42 m^3 (55 yd^3) of fill would be added to provide stability to the adjacent slope. The resulting new top of slope would be about 1.8 m (6 ft) from the edge of the Outrigger Telescope dome. On-site construction and installation of Outrigger Telescope 4 would not disturb any Wēkiu bug habitat.

A retaining wall would be built as a barrier to keep the fill from flowing onto the nearby access road. The retaining wall would be constructed of cinder-colored masonry blocks. The wall would be about 13.7-m (45-ft) long and 1.2-m (4-ft) high. A 56-m (185-ft) long retaining wall already exists on this side of the site to retain the slope underneath Keck II. Figure 2-13 shows the proposed site plan for Outrigger Telescope 4.

Outrigger Telescopes 5 and 6. On-site construction and installation for Outrigger Telescopes 5 and 6 would occur well within the area that was previously graded and leveled for construction of Keck I and Keck II. The finished grade around each Outrigger Telescope would be slightly elevated so that surface water will flow away from the enclosures. There would be no special engineering design applications required for Outrigger Telescopes 5 and 6 (see Figures 2-14 and 2-15). There would be no Wēkiu bug habitat disturbance from on-site construction and installation of Outrigger Telescopes 5 and 6.

2.1.3.4 Foundations and Footings

Based on current design concepts, the total amount of concrete needed for the tunnel, junction boxes, dome, and telescope foundations is estimated to be about 512 m^3 (670 yd^3). Concrete would be ready-mixed in Hilo or Waimea and delivered to the site by truck. Wherever possible, CARA plans to use pre-cast concrete for the junction boxes and telescope foundations.

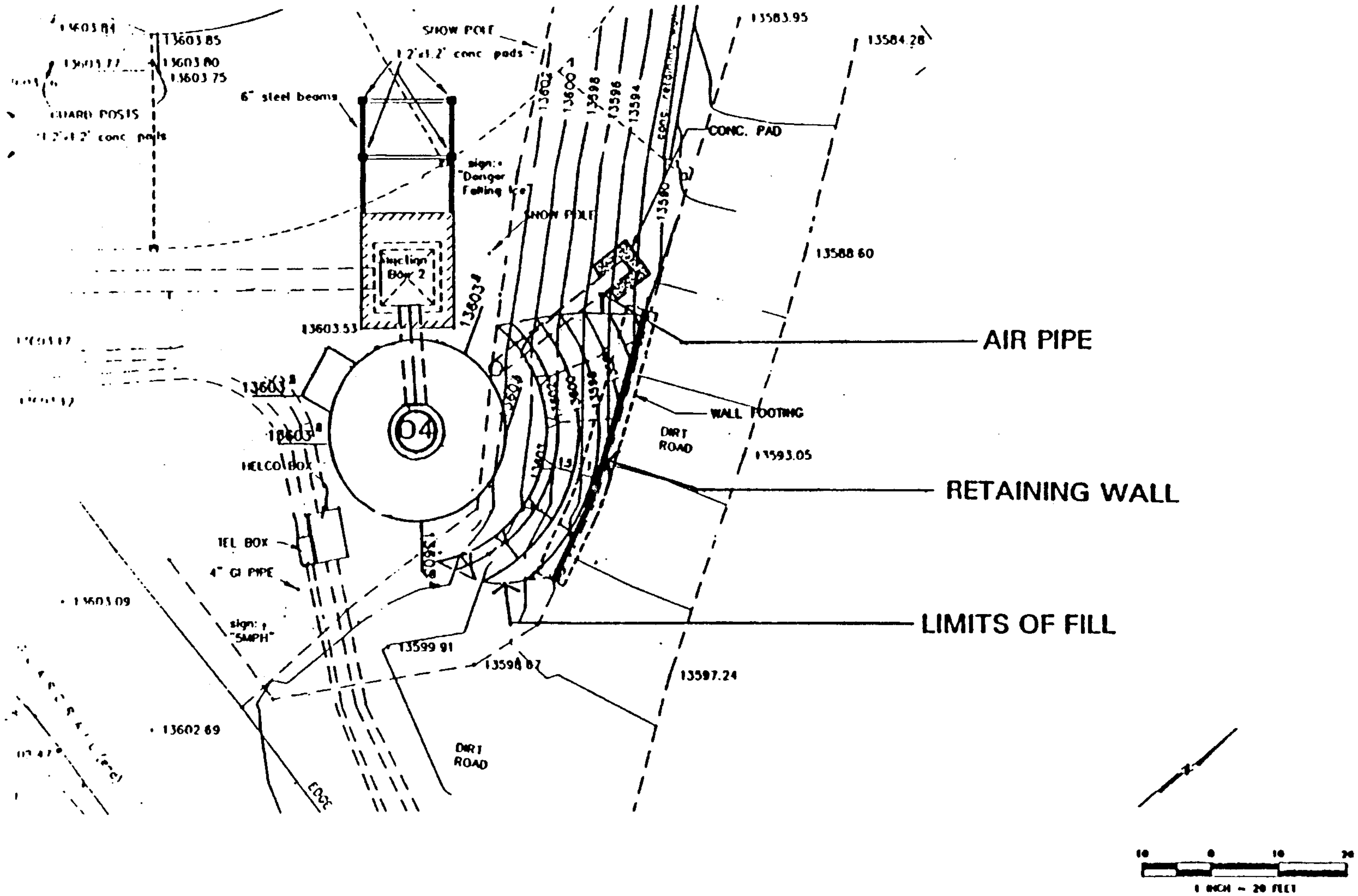
2.1.3.5 Signs

Up to six permanent signs will be located on the WMKO site, primarily along the Pu'u Hau 'Oki crater rim, to inform visitors of the historic/cultural significance of the crater and the need to protect the Wēkiu bug. One of the signs was previously approved and would be placed near the access point to Pu'u Hau 'Oki crater to protect the Wēkiu bug habitat restoration area.

Design of the signs will be consistent with the guidelines presented in the recently adopted Mauna Kea Science Reserve Master Plan, in that they will be small and unobtrusive and printed in black, blue, or dark earthtones. The signs will conform with criteria specified in HAR 13-5-22, that is: they will be no larger than 1.1 square m (m^2) (12 square ft (ft^2)) in area; they will not be lighted; they will be erected to be self-supporting; and, they will be no higher than 2.4 m (8 ft) above finished grade. Prior to installation, sign design and specifications will be submitted to both the Department of Land and Natural Resources and to the OMKM for approval.

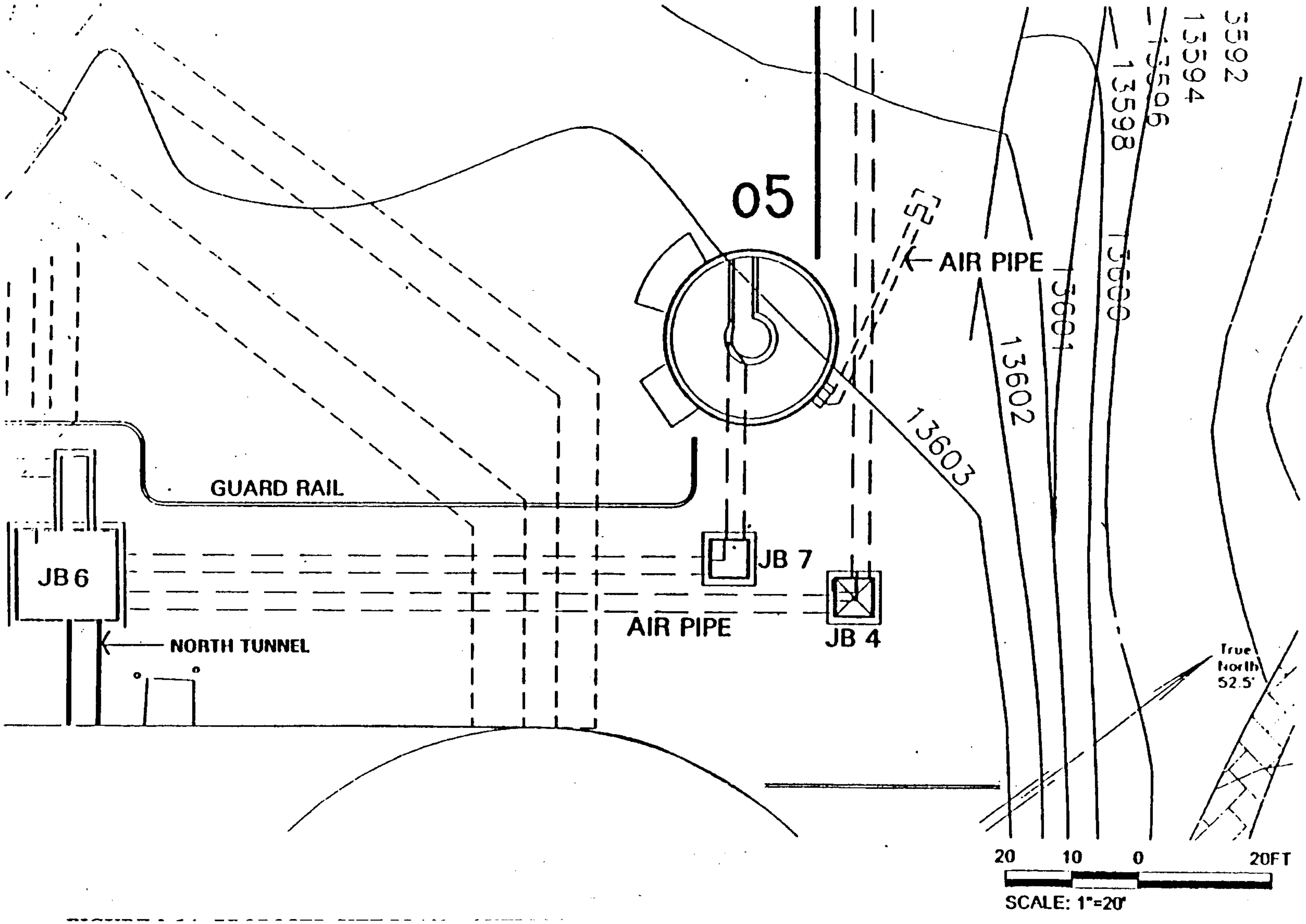
2.1.3.6 Installation of Telescopes and Dome Enclosures

The enclosure sections (ring wall base and spherical dome) will be prefabricated off-site and shipped to either Hilo or Kawaihae harbor in standard marine 12-m (40-ft) by 2-m (8-ft) containers. From there, the containers will be transported to an approved construction staging



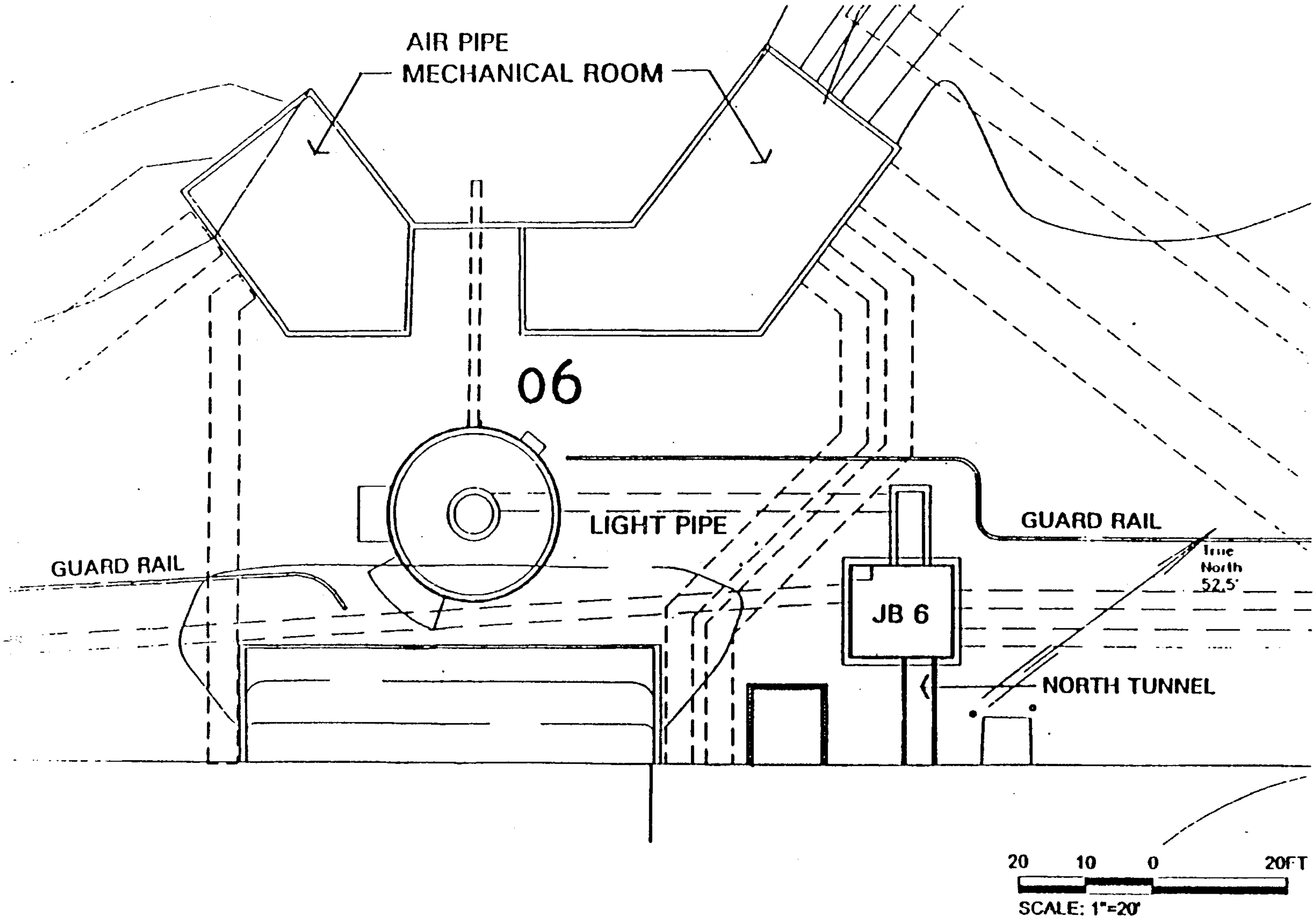
Source: UH IfA 2001a

FIGURE 2-13. PROPOSED SITE PLAN—OUTRIGGER TELESCOPE 4



Source: UH IfA 2001a

FIGURE 2-14. PROPOSED SITE PLAN—OUTRIGGER TELESCOPE 5



Source: UH IfA 2001a

FIGURE 2-15. PROPOSED SITE PLAN—OUTRIGGER TELESCOPE 6

area at either Hale Pōhaku or the summit, off-loaded and unpacked. The enclosure components will then be delivered to the project site on flat bed trucks. Each enclosure section (ring wall and dome) would be assembled on-site, the ring walls set on concrete foundations and the rotating domes placed on top.

The components of each Outrigger Telescope would be packed in up to ten plywood boxes and shipped to Hawai'i (Kawaihae or Hilo) on standard marine 12-m (40-ft) by 2-m (8-ft) open flat racks. These racks would be delivered to either the Hale Pōhaku or summit staging area, off-loaded and unpacked. Flat bed trucks would then bring the telescope components to the WMKO site.

After each enclosure is erected, its telescope would be assembled on a previously-constructed concrete pier. Large components would be lifted with a crane and placed in the enclosure through the enclosure shutter. When complete, the final component—the dual star module—would be hoisted through the dome shutter and installed on the telescope.

2.1.3.7 On-Site Construction Facilities/Equipment

A trailer to be used as a temporary office for construction management may be on site throughout the construction period. It is estimated that at various times during on-site construction—not necessarily at the same time—two excavators, a grader or bulldozer, two water trucks, two back-hoes, a loader, two or three dump trucks, a forklift, three or four cement trucks, two or three flat bed trucks, a crane of approximately 64-mt (70-ton) capacity, a compactor, and a vibrating hammer rig may also be present on site.

During on-site construction, a total of twenty 2 by 12-m (8 by 40-ft) containers, painted brown or green, could be present at the summit or Hale Pōhaku at one time. Materials and equipment stored in these containers would be unloaded at one or both of these approved staging areas and transported to the WMKO site. In addition, two or three flatbed trucks with cranes and two or three forklifts would be located at the staging area to support these activities.

If possible, all twenty containers would be unloaded at the approved summit staging area. If it is not feasible to store twenty containers at the summit, it will be necessary to unload some of them at the approved materials staging area at Hale Pōhaku (see Figure 2-7). If unloading does take place at Hale Pōhaku, up to ten containers, a forklift and one or two flat bed trucks would be present on the site to support these activities. This staging area was approved in CDUP HA-1819.

2.1.3.8 On-Site Construction Employment and Costs

Underground site work would require a maximum of 15 construction workers for approximately 9 months; a maximum of 12 workers would be required for about 17 months to assemble and test the enclosures and telescopes. Construction times would vary because of unfavorable weather conditions. Because enclosure erection and telescope installation will begin as soon as the site work for each telescope is completed, the site work crew and the enclosure/telescope erection crews will be on site at the same time for about three months of the construction period. Construction workers would either commute from off-mountain locations or use existing facilities at the Hale Pōhaku Construction Camp. Workers involved in dome assembly and telescope installation would most likely stay at Hale Pōhaku.

On-site construction and dome erection, and installation of four Outrigger Telescopes activities are estimated to cost approximately between $7 million and $8 million. The on-site construction and installation of the remaining two Outrigger Telescopes would probably cost about $2.5 to $3 million.

2.1.3.9 Construction Management

The Contractor would be required to follow the approved construction Best Management Practices Plan (BMP) during all on-site construction and installation activities. The BMP will include actions to minimize disturbance to the Wēkiu bug habitat and to avoid, reduce, or mitigate impacts to cultural resources. A draft BMP is provided in Appendix F. Specific areas of concern that are addressed by the BMP include but are not limited to:

- Designated lines of authority and responsibility.
- Education and training for construction workers to make them aware of the environmental sensitivity and historic/cultural significance of the site and the importance of strict adherence to the BMP and all State and Federal regulations in regard to discovery of burial sites and/or cultural artifacts.
- Precautions and actions to be taken before construction begins, including the review of grading and site development drawings by the Consulting Parties to help ensure that implementation would be conducted in a manner that minimizes or reduces impacts to natural and cultural resources on the project site.
- Inspections and mitigation to control alien arthropods in accordance with an approved Wēkiu Bug Mitigation Plan (see Appendix D of this EA).
- Actions to prevent or minimize disturbance of Wēkiu bug habitat by construction activities including, but not limited to, control of all trash, construction material, and cinder stored on the site.
- After consultation with SHPD and OMKM, a plan to ensure appropriate disposition of all excavated material not used for backfill or Wēkiu bug habitat restoration.
- Stipulations incorporated in the Section 106 Memorandum of Agreement (MOA) and relevant conditions attached to the CDUP.

The final BMP will be incorporated into the construction contract.

2.1.3.10 Construction Traffic

Daily construction worker traffic would add about 15 to 17 trips during the AM and PM peak periods, depending upon construction phase. The increase in traffic in the summit area during construction would be minimal, except for the assembly enclosure phase, as most heavy construction equipment would be stored on-site. Other traffic, generated by construction activities and originating off the mountain, would include service vehicles, water tankers, and fuel trucks.

In addition, at any one time as many as six container loads of dome enclosures and/or telescope components would travel from the harbor at either Kawaihae or Hilo to the summit area, be off-loaded at the staging area and delivered to the WMKO for assembly on the project site. Current plans would be to use standard-size trucks. However, if heavy trucks are used, their trips would be scheduled during off-peak hours so as not to interfere with normal traffic flow in Kawaihae, Waimea, or along the Saddle Road. CARA will coordinate with other road users to avoid traffic problems when non-standard size loads are transported from the staging areas to the WMKO site.

There are two alternative ways to reach the WMKO site within the summit area. The first is a continuation of the paved Mauna Kea Access Road which runs along the summit ridge from UKIRT to IRTF and then to WMKO. The second is the paved road through Millimeter Valley to its junction with the gravel "detour" road and then to the site. Two roads will serve to minimize conflicts between construction and observatory traffic. Construction traffic should avoid the "detour" road to minimize dust generation.

2.1.4 Operations for the Outrigger Telescopes Project

2.1.4.1 Employment and Economics

An estimated eight full-time personnel would be added to the WMKO staff; four would be hired when testing of the Outrigger Telescopes begins and four more when operations begin. It is expected that almost all of the observing would be done from the CARA base facilities in Waimea, thus only one or two additional people would be on the mountain at night. The daytime presence on the mountain will be increased by up to three people (UH IfA 2001a).

2.1.4.2 Traffic

It is estimated that new employees would generate two to three two-way vehicle trips per day and about one two-way vehicle trip per night along the Mauna Kea Access Road. The number of vehicle trips by service vehicles, such as water and fuel trucks, would not be expected to increase (UH IfA 2001a).

2.1.4.3 Infrastructure and Utilities

All utilities would be provided from existing WMKO services, which has all the necessary water, power, communications and sewage facilities. The existing water storage tanks (of 15 and 30 kiloliter (kl) (4,000 and 8,000 gallons (gal)) would be sufficient to accommodate the needs of the project. Commercial electric power is supplied to WMKO from the existing 12.47-kV Hawai'i Electric Company (HELCO) underground system. Power requirements are estimated to be a maximum of 30 kilowatts (kW) per dome. Peak electrical demand at the WMKO site is currently 440 kW, the operation of the Outrigger Telescopes would increase this by about 41 percent to 620 kW. If the Kecks and all six Outrigger Telescopes were operational, peak demand would be about 62 percent of service capacity (UH IfA 2001a). Voice and fiber-optic data transmission are currently provided by a local vendor; distribution cables will be installed in the same trenches as the light pipes. Wastewater will be disposed of by means of an existing DOH-approved septic tank and seepage pit.

2.1.4.4 Maintenance

During operations, the Outrigger Telescopes and domes would rotate on wheels which have ball bearings. The bearings would be encapsulated in a sealed track to prevent dust and other contamination from degrading the bearing performance and life. The bearings require periodic lubrication, which would be accomplished by injecting lubrication directly into the sealed bearing track.

From time to time during operations, Outrigger Telescope mirrors and equipment would require maintenance. At the present time, it is anticipated that each of the Outrigger Telescope mirrors would be cleaned once a year. Common cleansing solutions would be used to wash the mirror surfaces.

Periodically, the Outrigger Telescope mirrors would also require surface recoating. The process uses chemicals and water to remove the aluminum surface. Mirror recoating would take place in an area specifically set aside for this purpose within the existing WMKO facility. The rinse water from the aluminum removal and recoating process would be collected, removed, and transported off the site.

2.2 DESCRIPTION OF THE NO-ACTION ALTERNATIVE

Under the No-Action Alternative NASA would not fund on-site construction, installation, or future operation of the Outrigger Telescopes Project proposed for the WMKO site at Mauna Kea. The potential environmental impacts described for the Outrigger Telescopes Project in this EA would not occur. If the Outrigger Telescopes are not constructed and installed at the WMKO on Mauna Kea, the facilities at the WMKO site would consist of the two existing 10-meter (33-foot) Keck Telescopes which are capable of functioning as the Keck-Keck Interferometer. NASA would be able to attain only two of the science objectives discussed in Section 1.3. The remaining four science objectives would not be met. In addition, the No-Action Alternative would result in economic losses to the State of Hawai'i of the estimated $10 to $11 million for the on-site construction and installation of six Outrigger Telescopes. Further, the incremental revenues that would be associated with operation of the Outrigger Telescopes Project would also be lost to the State. NASA's funding for the Wēkiu bug on-site mitigation, the autecology study, and the 18-month Wēkiu Bug monitoring activities would not occur. NASA's funding for the on-site and off-site mitigation activities proposed by NASA in the Section 106 process also would not occur.

2.3 DESCRIPTION OF ALTERNATIVES CONSIDERED

NASA has reviewed a number of alternative telescope sites both within the United States and abroad as potential sites for placement of the proposed Outrigger Telescopes. All sites considered have some existing observatory infrastructure. In order to meet interferometry objectives 3 through 6 in Section 1.3, a number of screening criteria were identified. In performing this review, NASA has compared the known characteristics of each potential alternative site against the screening criteria of acceptable physical conditions and programmatic considerations discussed below.

2.3.1 Screening Criteria for Locating the Outrigger Telescopes

Tier 1 screening criteria set the minimum acceptable physical conditions for a site to meet the scientific objectives listed in Section 1.3 (specifically, objectives 3, 4, 5, and 6). A site which meets all of the Tier 1 criteria is then evaluated using the Tier 2 screening criteria. Tier 2 screening criteria comprise some, but not all, programmatic considerations other than United States foreign policies or security considerations. Sites which meet all of the Tier 1 and Tier 2 criteria would be considered potential alternatives. Table 2-2 identifies the screening criteria.

TABLE 2-2. SCREENING CRITERIA FOR THE ALTERNATIVES CONSIDERED

Tier 1 Screening Criteria	Tier 2 Screening Criteria
• One or more existing large telescopes • Adequate land available to provide sufficient baselines for imaging and astrometry • Site observing quality	• Maximizing sky coverage • Programmatic feasibility

Tier 1 Screening Criteria

- One or more existing large telescopes: Four Outrigger Telescopes and one or more large telescopes would be the required minimum number of telescopes to meet science objectives 4, 5, and 6 in Section 1.3. The size of the large telescope affects how much of the sky can be observed. This is because interferometry requires that there be a reference star close to the astronomical object being studied. With a smaller telescope, only brighter stars can be used as reference stars, and the amount of sky that can be studied is relatively limited. Larger telescopes allow fainter stars, which are more common, to be used for reference, enabling observations over larger portions of the sky. A reduction in sky coverage of up to 25 percent from that possible using a 10-m (33-ft) telescope as the large telescope would still allow for completion of science objectives 4, 5, and 6. This translates to a large telescope minimum size of 8m (26 ft).

- Adequate land available to provide sufficient baselines for imaging and astrometry: The number of telescopes and their relative separations and orientations are important in making high-resolution images of astronomical objects. The greater the number of different separations (called baselines), the greater the number of points (analogous to individual pixels on a computer screen) that are produced in the final image. Thus an interferometer consisting of two telescopes would have only one baseline and would have the ability to produce a detailed image of only a small portion of an object (analogous to only one pixel—the smallest unit of an image on a television or computer screen—in a picture; most of the picture would be black). Using a television as an analogy, it would be like looking at a TV screen in which just one pixel of the picture was lit, *i.e.*, the remainder of the screen is black and conveying no information about the picture being broadcast. If four additional telescopes were added to the interferometer (as with the proposed Outrigger Telescopes), and particularly if the four additional telescopes had different baseline orientations with respect to the interferometer, a total of 15 different baselines would be created. With the 15 baselines, each with a different length and orientation, detailed images of different portions of the object could be obtained (*i.e.*, the TV picture would now have 15 different pixels lit up). The information obtained characterizing the object would then be that much more detailed and would greatly increase the scientific value of the image. When two additional telescopes are added to bring the number up to six, the total number of baselines would increase to 28, almost doubling the amount of information (or pixels) that could be obtained about the object being studied, and in turn further increasing the scientific value of that information.

Without adequate land available to strategically place the Outrigger Telescopes at varying distances and at different baseline orientations, the ability of the interferometer to collect information from faint objects at a sufficient level of detail would be limited.

For the astrometry objective (objective 3 in Section 1.3) of the Origins program, an additional consideration is the ability for the Outrigger Telescopes to simultaneously form two long baselines that are nearly perpendicular to each other. Each baseline measures one component of a star's motion, say left to right for one baseline, and up and down for the other baseline. The minimum baseline separation is established from the requirement to be able to measure the astrometric signature of Uranus-sized planets. The longer the baseline, the better the measurement accuracy, in the same way that the ability to triangulate in surveying is improved with a longer measurement baseline. In order to accomplish objective 3, the minimum baseline separation for the Outrigger Telescopes must be at least 75 m (246 ft) in two nearly perpendicular directions.

There needs to be unobscured sky views from each outrigger telescope down to a zenith (or overhead) angle of 60 degrees in most directions—the notable exception would be in the direction of the large telescope, where some obscuration is inevitable. There would also need to be paths for installing beam lines from each outrigger telescope to the beam-combining laboratory to direct the star light for interferometric combination. The telescope piers also need to be reasonably coplanar or on the same level, so that the starlight feeds from each telescope to the beam-combining laboratory are approximately horizontal (*i.e.*, level) to +/– 3 degrees. For outrigger telescopes 50-m (164-ft) from the large telescope, this +/– 3 degrees constraint translates to a maximum outrigger telescope elevation difference of approximately +/– 2.6 m (+/– 8.5 ft).

- Site observing quality: Site observing quality has two components. The first component involves weather conditions near the observatory. Clear nights are required for scientists to conduct their observations; conditions such as cloud cover, fog, and rain obscure or prevent viewing. Light pollution from nearby cities also degrades performance of the telescopes' instruments. The second component of site observing quality is what astronomers refer to as "seeing." Seeing measures the stability of the atmosphere above an observatory. An unstable atmosphere is responsible for the twinkling of stars that is observed from most locations, and this same effect blurs the images that are produced with a telescope or interferometer. The best observing sites have a very stable atmosphere (*i.e.*, good seeing). Typically, the best sites are also at high altitudes, where they are already above much of the Earth's atmosphere.

Tier 2 Screening Criteria

- Maximizing sky coverage: Ideally, in order to maximize sky coverage, a powerful ground-based interferometer would need to be located in and collecting data from both the northern and southern hemispheres. Since the Earth is a sphere, it is impossible to locate one interferometer to achieve complete sky coverage. A complete search for distant planets and stars cannot be achieved from only one hemisphere and needs observatories in both hemispheres to maximize coverage of the heavens. There is a powerful European interferometer with large telescopes and outriggers under development in the southern hemisphere. Having a capability in the northern hemisphere would complement scientific data received from the southern hemisphere, and would maximize the opportunities to search for distant planets. A more complete search for distant stars and planets would not be possible without viewing from a site in the northern hemisphere. Placing the Outrigger Telescopes at a site in the southern hemisphere would provide a facility redundant with the European Array.

- Programmatic Feasibility: The feasibility of locating the Outrigger Telescopes at a site involves several issues including: (1) Would existing facilities need to be modified and are there engineering solutions to design the modifications; and (2) Would the cost of additional interferometer hardware, new facilities (such as adaptive optics on the large telescope, and a beam-combining laboratory), and other facility modifications be such that the project would not be economically viable.

2.3.2 Alternative Site Descriptions and Screening Criteria

This section identifies the potential sites and provides an evaluation against the two tiers of screening criteria shown above. No sites were considered that do not have some existing observatory facilities. Other possible sites on Mauna Kea were included if they were able to meet the primary criterion of a large telescope (8 m (26 ft)). However, all of the potential sites on Mauna Kea would have similar environmental impacts as the WMKO site.

2.3.2.1 Las Campanas, Chile

Description. The Carnegie Institution of Washington and others are deploying the twin 6.5-m (21-ft) Magellan Telescopes at their site at Las Campanas Observatory, Chile, at an altitude of 2,282 m (7,487 ft). This southern hemisphere site has good seeing, and the telescopes are located on an isolated peak at the site.

Screening Criteria Evaluation. The Las Campanas, Chile, site does not meet the Tier 1 screening criteria, as it does not have a large enough telescope to meet the minimum requirements for light-gathering capability, and there is not sufficient land on the site for the minimum 75-m (246-ft) baseline separation for the outrigger telescopes. The site also does not meet the Tier 2 screening criteria of maximizing sky coverage, as it is in the southern hemisphere, and there are also engineering problems associated with building the required beam-combining laboratory. Therefore, it is eliminated from further consideration.

2.3.2.2 Cerro Paranal, Chile

Description. The Very Large Telescope Interferometer (VLTI) is located in the southern hemisphere on Cerro Paranal, in northern Chile, at an altitude of 2,635 m (8,645 ft). It is under construction by the European Southern Observatory (ESO), a collaboration of several European organizations. Combining very high sensitivity with very high angular resolution, its four 8.2-m (27-ft) diameter telescopes and its three 1.8-m (6-ft) small (outrigger-like) telescopes can be used in several different modes. These interferometric combinations can ultimately give an angular resolution equivalent to a telescope with up to 200-m (656-ft) diameter.

When completed, this array will have similar capabilities to the Keck Interferometric Array, but located in the southern hemisphere. The site also has seeing comparable to Mauna Kea. Since the VLTI was designed to incorporate its own outrigger telescopes, there would be marginal scientific benefit from adding the proposed Outrigger Telescopes. In addition, the VLTI design is complete, making any additions of our proposed Outrigger Telescopes economically infeasible.

Screening Criteria Evaluation. The Cerro Paranal, Chile, site meets the Tier 1 screening criteria. However, on the basis of the Tier 2 screening criteria, it is eliminated from further consideration because it does not meet the criterion of maximizing sky coverage (southern hemisphere location) and programmatic feasibility (technical design and cost).

2.3.2.3 Cerro Pachon, Chile

Description. The Gemini South Telescope is a multi-national effort to build a 8-m (26-ft) optical/infrared telescope as a twin to the Gemini North Telescope located on Mauna Kea. These two telescopes are able to view the skies over both the northern and southern hemispheres. At an altitude of 2,700 m (8,860 ft), the Gemini South site has good seeing conditions. Gemini South is located on the cliff side of the Pachon ridgeline at the highest point. The Outrigger Telescopes could not be readily located on this site due to the steep terrain. Infrastructure costs would include building a beam-combining laboratory as well as an underground telescope instrument optics room. In addition, there is not adequate land available to build a support building.

Screening Criteria Evaluation. The Cerro Pachon, Chile site does not meet the Tier 1 screening criteria because of the lack of adequate land, attributable to the steep terrain. In addition, because the site is located in the southern hemisphere, it does not meet the Tier 2 screening criterion of maximizing sky coverage. Further, it does not meet the criterion for programmatic feasibility because there is inadequate space for a beam-combining laboratory. It is eliminated from further consideration.

2.3.2.4 Mt. Graham, Arizona

Description. The Large Binocular Telescope (LBT) is part of the Mt. Graham International Observatory near Safford, Arizona. The Large Binocular Telescope Project (LBTP) is an international collaboration among five partners (Italy, the University of Arizona, a consortium of five German Institutes, the Ohio State University, and the Research Corporation of Tucson in Arizona). The goal of the LBT project is to construct a binocular telescope consisting of two 8.4-m (28-ft) mirrors on a common mount. Its binocular arrangement will give the telescope a resolution power (ultimate image sharpness) corresponding to a 22.8-m (74.8-ft) telescope. At an altitude of about 3,270 m (10,700 ft), Mt. Graham has good seeing conditions.

One of the features of the LBT is that both mirrors are mounted on a single tracking mount—a configuration not compatible with outrigger telescopes. There is no clear engineering solution that would allow outrigger telescopes to be integrated into the overall design. An additional issue with Mt. Graham is that it is a heavily wooded site that would necessitate the removal of a large number of trees to provide unobscured views of the sky from outrigger telescopes, and to provide beam lines to the beam-combining laboratory. In addition, as the proposed Outrigger Telescopes are relatively small, and would be below the tree tops, additional trees would need to be removed in the vicinity of the telescopes to prevent cold air surrounding the trees at night (because of their color at infrared wavelengths, trees cool at night to temperatures below the air temperature), from compromising the seeing at the outrigger telescopes. Further, it is known that Mount Graham provides habitat for an existing population of a Federally listed endangered species.

Screening Criteria Evaluation. The Mt. Graham site meets the Tier 1 screening criteria. However, this site is eliminated from further consideration based on the Tier 2 criteria of programmatic feasibility. The binocular telescope design does not accommodate operating with the outriggers as an interferometer. Placing the Outrigger Telescopes at the Mt. Graham site would also require extensive new facilities (beam-combining laboratory) to be built. Finally, because of environmental impacts, the required tree clearing would be problematic.

2.3.2.5 Anderson Mesa, Arizona

Description. Located on Anderson Mesa outside Flagstaff, Arizona, at an altitude of 2,200 m (7,200 ft), the Navy Prototype Optical Interferometer is an array of 0.5-m (1.6-ft) telescopes. When the array is fully operational, it will have 10 telescopes with a total baseline of 440 m (1,440 ft). The site has adequate land, but seeing is only fair.

Screening Criteria Evaluation. On the basis of the Tier 1 screening criteria, the Anderson Mesa site is eliminated from further consideration because it does not have a large enough telescope to meet the minimum requirements for light-gathering capability.

2.3.2.6 Mt. Hopkins, Arizona

Description. At an altitude about 2,600 m (8,550 ft) located near Amado, Arizona, Mt. Hopkins has a telescope with a 6.5-m (21-ft) diameter mirror and is on a sharp ridge.

Screening Criteria Evaluation. On the basis of the Tier 1 screening criteria, the Mt. Hopkins site is eliminated from further consideration because this site does not have a large enough telescope to meet the minimum requirements for light-gathering capability, and the ridge does not provide sufficient space to achieve the requisite minimum baseline separation.

2.3.2.7 Palomar Mountain, California

Description. Palomar Observatory located in Pasadena, California, is owned and operated by Caltech and is used to support Caltech's scientific research programs. The principal instruments at Palomar are the 5-m (200-in) Hale Telescope, the 1.2-m (48-in) Oschin Telescope, and the 1.5-m (60-in) reflecting telescope (operated jointly by Caltech and the Carnegie Institution of Washington). Palomar Observatory is also the location of the Palomar Testbed Interferometer. The seeing at Palomar Observatory would be rated as fair.

Screening Criteria Evaluation. On the basis of the Tier 1 screening criteria, the Palomar site is eliminated from further consideration because it does not have a large enough telescope to meet the minimum requirements for light-gathering capability.

2.3.2.8 Mt. Wilson, California

Description. Located in the San Gabriel Mountains of California at an elevation of 1,742 m (5,700 ft), Mt. Wilson has two telescopes, the 1.5-m (60-in) and the 2.5-m (100-in) Hooker Telescope. There are also two interferometers on the site: the Center for High Angular Resolution Astronomy (CHARA) array with six 1-m (3.2-ft) telescopes, and the ISI (Infrared Spatial Interferometer) array, with three 1.65-m (5.4-ft) telescopes. Mt. Wilson has very good seeing.

Screening Criteria Evaluation. Based on Tier 1 screening criteria, the Mt. Wilson site is eliminated from further consideration, because it does not have a telescope large enough to meet the minimum light-gathering capability.

2.3.2.9 Mauna Kea (Gemini North and Subaru), Hawai'i

Description. The Gemini North Observatory to the east of the WMKO site, located on the summit area of Mauna Kea, has also been considered. The Gemini North site is approximately 0.8 ha (2 ac) in size, and houses a single 8.1-m (26.2-ft) optical/infrared telescope that saw first light in 1999. This facility is a twin to the Gemini South facility at the Cerro Pachon site discussed in Section 2.3.2.3.

The Subaru Observatory located on the summit of Mauna Kea has also been considered. Subaru is an 8.2-m (27-ft) optical/infrared telescope operated by the National Astronomical Observatory of Japan (NAOJ). The Subaru Telescope is located on an approximately 2 ha (5 ac) site to the west of the WMKO site.

Screening Criteria Evaluation. While both Gemini North and Subaru are located on Mauna Kea, they are both on narrow ridges, and lack flat land on which to locate the outrigger telescopes, and thus fail to meet the Tier 1 screening criteria. Because of the availability of the nearby WMKO which passes both Tier 1 and Tier 2 criteria, these sites were eliminated from further consideration.

2.3.3 Summary of Alternative Sites Comparison

Figure 2-16 graphically depicts the process used to compare the screening criteria with the potentially available sites.

2.4 SUMMARY COMPARISON OF PROPOSED ACTION AND THE NO-ACTION ALTERNATIVE

Table 2-3 compares the potential environmental impacts of the Proposed Action and the No-Action Alternative. Details summarized in this section can be found in Chapter 4.

ALTERNATIVE SITES CONSIDERED

Las Campanas
Chile

Cerro Paranal
Chile

Cerro Pachon
Chile

Palomar Mountain
California

Mt. Hopkins
Arizona

Mauna Kea (Gemini North and Subaru)
Hawaii

Mt. Wilson
California

Anderson Mesa
Arizona

Mauna Kea (WMKO)
Hawaii

Mt. Graham
Arizona

Tier 1 Screening Criteria

- One or more existing large telescopes
- Adequate land available to provide sufficient baselines for imaging and astrometry
- Site observing quality

SITES REMAINING AFTER TIER 1 SCREENING EVALUATION

Paranal
Chile

Mauna Kea
(WMKO)
Hawaii

Mt. Graham
Arizona

Tier 2 Screening Criteria

- Maximizing Sky Coverage
- Programmatic Feasibility: modification to existing facilities and need for adaptive optics (technical), and program costs

SITES REMAINING AFTER TIER 2 SCREENING EVALUATION

Mauna Kea
(WMKO)
Hawaii

FIGURE 2-16. ALTERNATIVE SITES CONSIDERED

TABLE 2-3. SUMMARY COMPARISON OF THE PROPOSED ACTION AND THE NO-ACTION ALTERNATIVE

Impact Area	Proposed Action	No-Action
Land Use	On-site construction and installation—Consistent with permitted uses within the Conservation District. Consistent with land use at Hale Pōhaku. Operation—Consistent with permitted uses within the Resource subzone of the Conservation District.	No change in baseline condition.
Climate/Meteorology/Air Quality	On-site construction and installation—The estimated emissions of all pollutants, including localized fugitive dust emissions, would be well below the significant thresholds for suspended particulate and combustion emissions. Operation—Slight increase in vehicular emissions, but no substantial impacts would be expected.	No change in baseline condition.
Noise	On-site construction and installation—No adverse impacts from on-site construction noise would be expected. Operation—No impact.	No change in baseline condition.
Geology, Soils, and Slope Stability	On-site construction and installation—No adverse impacts to geology or soils. Impacts to slope stability would be mitigated to ensure impacts to the crater would be minimized and that overall Wēkiu bug habitat is protected. Operation—No impact.	No change in baseline condition.
Hydrology and Water Quality	On-site construction and installation—No impacts would be expected to occur to the fresh groundwater lens or permafrost. No impacts to Lake Waiau. Operation—No impact.	No change in baseline condition.
Biological Resources	On-site construction and installation—Disturbance of Wēkiu habitat would be about 0.009 ha (0.022 ac). Project proposes a minimum habitat restoration at a ratio of about 3:1. Operation—Little, if any, impact.	No change in baseline condition. NASA would not fund Wēkiu bug mitigation and monitoring.

TABLE 2-3. SUMMARY COMPARISON OF THE PROPOSED ACTION AND THE NO-ACTION ALTERNATIVE (Continued)

Impact Area	Proposed Action	No-Action
Natural Hazards	On-site construction and installation—Risk from natural hazards would be extremely low.	No change in baseline condition.
Transportation	On-site construction and installation—Small increase in traffic along the Mauna Kea Access Road would be expected. No adverse impact. Operation—Minimal increase in traffic flow to summit area. No adverse impact.	No change in baseline condition.
Services, Facilities, and Waste Management	On-site construction and installation—Small increases; can be accommodated by existing facilities and services. Operation—Minimal increases; can be accommodated by existing facilities and services.	No change in baseline condition.
Cultural Resources	On-site construction and installation—The SHPD indicates project would have adverse effect both on the cluster of cinder cones, that has been determined to be eligible as an historic property and the summit region, an eligible historic district. Section 106 consultations have concluded in a Memorandum of Agreement. Operation—Interviewees within Native Hawaiian community consider the Outrigger Telescopes Project to have a negative impact on summit area cultural values.	No change in baseline condition. NASA would not fund On-site or Off-site mitigation activities proposed through the Section 106 process.
Socioeconomics	On-site construction and installation—Small increases in job opportunities and revenues to the State and County economies. Operation—Continued revenues to the State and County economies.	Decreased job opportunities and revenues to the State and County economies.
Visual Aesthetics	On-site construction and installation—Temporary visual intrusion to the cultural landscape. Operation—Outrigger Telescopes visible within Astronomy Precinct. Below summit and off-mountain, visual intrusion negligible. Interviewees within Native Hawaiian community consider the Outrigger Telescopes to have a negative impact on summit area cultural landscape.	No change in baseline condition.

3 AFFECTED ENVIRONMENT

This Chapter describes the environmental setting for the proposed Outrigger Telescopes Project and presents a brief summary of those elements of the environment that could potentially be affected by the Proposed Action. The environmental setting consists primarily of the summit area of Mauna Kea, located within the approximately 212-hectare (ha) (525-acre (ac)) Astronomy Precinct. The summit area is that portion of the Astronomy Precinct within which most of the existing astronomical observatories are located. The Astronomy Precinct itself comprises a small portion of the approximately 4,568-ha (11,288-ac) Mauna Kea Science Reserve.

3.1 MAUNA KEA REGION AND SITE

3.1.1 Regional Land Use

The island of Hawai'i is both the youngest and the largest in area of the Hawaiian Islands. As of 2000, the County of Hawai'i, which encompasses the entire island, had a resident population of approximately149,000; over half of them live on the eastern coast of the island in the Puna District and in the city of Hilo, the county seat and the largest city on the island (Bureau of Census 2000). The towns of Waimea and Hilo both serve as headquarters (also called base support facilities) for telescopes in operation or already under construction on Mauna Kea (see Figure 2-1).

Mauna Kea Science Reserve. The Mauna Kea Science Reserve (see Figure 2-2) encompasses an area of about 4,568 (ha) (11,288 ac) of State land situated above the 3,660-meter (m) (12,000-foot (ft)) elevation of Mauna Kea but excludes the parcels that make up the Mauna Kea Ice Age Natural Area Reserve.

The Mauna Kea Science Reserve is leased by the University of Hawai'i (UH) from the State of Hawai'i and is managed by UH. The lease states that the Mauna Kea Science Reserve is to be used "as a scientific complex, including without limitation thereof an observatory, and as a scientific reserve being more specifically a buffer zone to prevent the intrusion of activities inimical to said scientific complex" (State of Hawai'i 1968).

The Astronomy Precinct is centered near the middle of the summit plateau while the remainder of the Mauna Kea Science Reserve serves as a buffer area (see Figure 2-3). The support facilities at Hale Pōhaku were built for the acclimatization of those going to the top of the mountain and to house workers supporting construction activities.

The State Land Use Commission has established the boundaries of four State Land Use Districts throughout the State: these are Urban, Rural, Agriculture and Conservation. The Mauna Kea Science Reserve is located in the Conservation District. The State Board of Land and Natural Resources is responsible for the regulation of land uses within the Conservation District. It has established four types of subzones (general, resource, limited, and protective) based on the resource characteristics and has adopted regulations identifying permitted uses and permit requirements. The Mauna Kea Science Reserve is contained entirely within the Resource subzone (UH IfA 1999). Astronomy facilities are a permitted use in this subzone.

The Mauna Kea Science Reserve is regarded as one of the best sites in the world for optical/infrared and millimeter-wave telescopes. The site's excellent qualities for astronomical observation include its high altitude, atmospheric dryness and minimal seasonal variation.

3.2 CLIMATE/METEOROLOGY/AIR QUALITY

3.2.1 Climate/Meteorology

The Mauna Kea Science Reserve, located above the 3,660-m (12,000-ft) elevation of Mauna Kea, is well above the 2,130-m (7,000-ft) altitude of atmospheric temperature inversions for the area. The northeastern or windward flanks of Mauna Kea are subjected to extensive rainfall that is a consequence of warm, moisture laden surface air driven up the slopes of the mountain from northeast to southwest by the trade winds (see Appendix H). The trade winds are a consequence of the synoptic scale (*i.e.*, pertaining to regional scales) meteorology associated with the Pacific Ocean anticyclone (high pressure zone) that is centered to the north (summer) and northeast (winter) of Hawai'i (Erasmus 1986). Precipitation occurs as the air expands and cools as it moves up the slopes of the mountain, a process known as adiabatic expansion and cooling. Since cool air cannot hold as much vapor as warm air, the dew point temperature is reached and precipitation results. For example, the annual precipitation ranges from approximately 600 centimeters (cm) (236 inches (in)) at the Makahanaloa Station on the lower slopes (Juvik and Juvik 1998) to approximately 50 cm (20 in) at the Very Long Baseline Array Station at an altitude of 3,840 meters (12,599 ft) (Metcalf 2001). The summit is even drier in that Cruikshank (1986) reports an annual average precipitation of 15 cm (6 in) based on data from 1969 to 1977 for optical telescope sites located on the summit cones.

High precipitation values associated with trade wind induced lifting of surface air masses extend to approximately 2,000 m (6,562 ft). At that altitude the ascending air meets subsiding, warmer air associated with the Pacific Ocean anticyclone. This meeting of air masses produces an atmospheric inversion layer in which the surface air temperatures increase by a few degrees Celsius over only hundreds of meters of altitude. Above the inversion layer the air tends to become cooler with increasing altitude and to be dry and stable. In fact, the altitude of the inversion layer varies from between 1,500 to 3,000 m (4,921 to 9,843 ft), depending on weather systems and season. The upper slopes and summit of Mauna Kea are located above the inversion layer, providing a climate for these areas that is best described as a dry, cold tundra-like environment. For reference, Cruikshank (1986) reports an average maximum monthly temperature of 11° Celsius (C) (52° Fahrenheit (F)) in September and a minimum monthly average of –5° C (23° F) for February and March for data collected on the summit from 1969 to 1977. On most days, clouds, fog, and rain are kept beneath the inversion layer on Mauna Kea (Appendix H; see Figures 1 and 2). Particularly during the winter, storms from the southeast and southwest can reach the upper slopes and summit of the mountain. These storms are associated with a number of synoptic systems, including tropical cyclones. As a consequence, most precipitation above the inversion layer occurs during winter storms as snow, freezing rain, and rain. Typically the storm systems provide the majority of annual precipitation over a very small period of time (Appendix H; see Figure 4). Finally, fogs are common just below the inversion layer and fog drip from leaves provide a source of soil moisture for the upland Mamane-Ohia shrub systems and Koa-Ohia forests (Appendix H; see Figures 1 and 2).

Winds at the summit follow a diurnal pattern of prevailing west/northwest winds during the day, and east/northeast winds at night. Wind velocity usually ranges from 16 to 48 kilometers (km) (10 to 30 miles (mi)) per hour. During severe winter storms, winds can exceed 160 km (100 mi) per hour on exposed summit areas, such as the top of cinder cones (UH 2000b).

3.2.2 Air Quality

The existing meteorology, climate, air quality, ambient air quality standards, and estimated on-site construction-related emissions and impacts to air quality and mitigation measures are described in Dames & Moore (1999b).

Regulations. The National Ambient Air Quality Standards (NAAQS) are established by the Clean Air Act of 1970, as amended in 1977 and 1990. Under the Clean Air Act, States retain the option to develop more stringent standards. The NAAQS define the maximum levels of air pollution considered safe, with an adequate margin of safety, to protect the public health and welfare. The NAAQS are not to be exceeded more than once a year. The Hawai'i Department of Health (DOH) has developed the State Ambient Air Quality Standards (SAAQS). The SAAQS limit the time-averaged concentrations of specified pollutants dispersed or suspended in the ambient air of the State. Limiting concentrations specified in the SAAQS for a twelve-month period of a calendar quarter shall not be exceeded. Limiting concentrations specified in the SAAQS for 1-hour, 3-hour, 8-hour, and 24-hour periods shall not be exceeded more than once in any twelve-month period. The currently applicable State and Federal standards are shown in Table 3-1.

Air Quality Monitoring. The DOH has been monitoring ambient air quality in the State of Hawai'i since 1957. Before 1971, there was only one air monitoring station located on O'ahu. Today the air monitoring network has expanded to include twelve national and State and local air quality monitoring stations on O'ahu, Kaua'i and Maui. A number of non-DOH air quality monitoring programs have been undertaken on the island of Hawai'i, most aimed at understanding volcanic emissions and human health effects. Ambient air measurements of pristine conditions of selected parameters have been made at the Mauna Loa Observatory and would be the most comparable (Dames & Moore 1999b). The Mauna Loa data shows the following:

<u>Ozone</u>: Monthly averages range from 0.0243 to 0.063 parts per million (ppm), and the approximate range of hourly averages is from 0.015 to 0.08 ppm. No distinction was provided between baseline values and those collected during volcanic plume episodes. The highest hourly values, presumably collected during volcanic plume episodes would exceed the SAAQS, but not the NAAQS.

<u>Carbon Monoxide</u>: The long term (1994 to 1995) average is 0.0925 ppm, with a range of 0.054 to 0.164 ppm. The given averages are well below the SAAQS and NAAQS.

<u>Sulfur Dioxide</u>: The background average is less than 0.00001 ppm, again below the SAAQS and NAAQS annual average (Dames & Moore 1999b).

Mauna Kea Summit Area. Although air quality has not been sampled or monitored at the Mauna Kea Science Reserve, its geographic and meteorological isolation produces excellent air quality (Dames & Moore 1999b). The summit of Mauna Kea is well above the altitude of temperature inversions for the area. Air pollutants generated below this inversion layer (smog, smoke, dust, salt spray, etc.) do not result in air quality problems at the summit of Mauna Kea. Locally-generated atmospheric pollutants at the summit are primarily emissions from combustion engines and fugitive dust from construction activities and unpaved surfaces. Winds at the summit area would aid in the dispersion of air pollutants generated at the site.

TABLE 3-1. NATIONAL AND STATE AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	SAAQS[a]	NAAQS	
			Primary[b]	Secondary[c]
Ozone[d]	1 Hour	No Standard	0.12 ppm (235 μg/m³)	Same as Primary
Carbon Monoxide	8 Hour	5 mg/m³	9.0 ppm (10 mg/m³)	—
	1 Hour	10 mg/m³	35 ppm (40 mg/m³)	—
Nitrogen Dioxide	Annual (Arithmetic Mean)	70 μg/m³	0.053 ppm (100 μg/m³)	Same as Primary
Sulfur Dioxide	Annual Average	80 μg/m³	0.03 ppm (80 μg/m³)	—
	24 Hour	365 μg/m³	0.14 ppm (365 μg/m³)	—
	3 Hour	1,300 μg/m³	No Standard	0.5 ppm (1,300 μg/m³)
Particulate Matter (PM_{10})	Annual (Arithmetic Mean)	50 μg/m³	50 μg/m³	Same as Primary
	24 Hour	150 μg/m³	150 μg/m³	Same as Primary
Lead	Calendar Quarter	1.5 μg/m³	1.5 μg/m³	Same as Primary
Hydrogen Sulfide	1 Hour	35 μg/m³	No Standard	No Standard

a. Designated to protect public health and welfare and to prevent significant deterioration of air quality. Source: HAR 11-59-1.
b. Designated to protect the public health. Source: 40 CFR Part 50.
c. Designated to protect the public welfare from known or anticipated adverse effects including the effects on economic values and personal comfort (*e.g.*, protect against environmental damage, such as damage to soils, crops, wildlife, weather, climate and personal comfort). Source: 40 CFR Part 50.
d. The U.S. EPA promulgated a new Federal 8-hour ozone standard on July 18, 1997. The proposed revised standard is currently under judicial review. The State of Hawai'i has an 8 hour standard of 157 μg/m³ or 0.08 ppm.

3.3 NOISE

Background noise levels of the summit of Mauna Kea, and the W.M. Keck Observatory (WMKO) site, consist primarily of sounds associated with the wind and occasional vehicular noise. Therefore the summit of Mauna Kea normally has a low ambient noise level. Existing facility operations generate extremely low noise levels and there are no nearby sensitive noise receptors. Temporary construction-related noise is discussed in Section 4.1.3.

3.4 GEOLOGY, SOILS, AND SLOPE STABILITY

3.4.1 Geology

Geologic Overview. The geology of Mauna Kea has been mapped in detail (UH IfA 1999), and no tectonic faults have been observed. Mauna Kea is a dormant volcano that erupted about 4,400 years ago and hence cannot yet be labeled as extinct (Lockwood 2000). Many geologic features and structures found on the Mauna Kea Science Reserve are unique. The summit of Mauna Kea measures 48-km (30-mi) across and is studded with cinder cones that are some of the most pristine in Hawai'i. The primary geological activity shaping the summit terrain has been the interaction of molten lava and glacial ice during the Ice Ages (Lockwood 2000). Several main glacial features are present in the summit region, including glacial striations on bedrock outcrop and the glacially sculpted features of cinder cones and lava flows. The Mauna Kea Ice Age Natural Area Reserve is located between the 3,170 and 4,023-m (10,400 and 13,200-ft) elevations on Mauna Kea (see Figure 2-2). The main ice age features located in the reserve are Pōhakuloa Gulch (formed by glacial meltwater), glacial moraine, and meltwater deposits of fine sediments. The best examples of lava/ice interaction are found along the southern boundary of the Astronomy Precinct on steep slopes unstable for construction.

The small Lake Waiau is unique among the many natural features found on Mauna Kea. Lake Waiau is nearly circular, 91 m (300 ft) in diameter, and is situated on the summit platform of Mauna Kea at an altitude of approximately 3,970 m (13,020 ft). It is the highest lake within the boundaries of the Pacific Ocean basin and one of the highest lakes in the United States.

Glacial Features. The Astronomy Precinct includes well-preserved glacial features over much of its area including glacially polished and striated lava surfaces and glacial erratics. Well preserved examples of such features are also found in many other areas of the Mauna Kea Science Reserve and Mauna Kea Ice Age Natural Area Reserve. Within the Astronomy Precinct these features are largely restricted to high-standing outcrops which are not suitable for construction.

Sub-glacial Lava/Ice Contact Features. The steep cliffs at the southern edge and western boundaries of the Astronomy Precinct north of Pu'u Poli'ahu represent the margins of a lava flow that erupted beneath Mauna Kea's summit glacier about 30,000 to 40,000 years ago (Lockwood 2000). After the eruption ceased and the lava cooled, continued movement of the glacier eroded this contact zone, but the structures that remain are some of the best examples of lava/ice interaction found anywhere in the world (Lockwood 2000). These areas are very steep and consist of loose and unstable rock and would not be suitable for construction purposes (Lockwood 2000).

Volcanic Activity. Mauna Kea has not erupted within the period of known human settlement of Hawai'i (the last eruption occurred on the mountain's flank about 4,400 years ago). The most recent eruptive episodes in the area consisted of cinder cones, lava flows and tephra (a general term for cinders and/or ash formed by aerial expulsion of viscous lava from a volcanic vent). These were deposited below the summit at elevations of approximately 3,050 to 3,660 m (10,000 to 12,000 ft), some 4 to 4.8-km (2.5 to 3-mi) northeast and southeast of the project site. The volcano is considered to be dormant by volcanologists (Lockwood 2000). Although future eruptions are possible, Mullineaux and others have classified the summit and upper flanks as Zone 7 for lava flow hazards; Zone 9 is the least hazardous (UH IfA 1999). No volcanic earthquakes of the sort that would proceed an eruption have ever been detected beneath Mauna Kea and it can be assumed that no eruption is likely in the near future (Lockwood 2000).

3.4.2 Soils and Slope Stability

The WMKO site is located at an elevation of 4,146 m (13,603 ft) on the easterly edge of the topographic saddle forming the Pu'u Hau 'Oki cinder cone. This saddle is composed of a scoria, or volcanic cinder cone consisting of gravel- to sand-sized fragments of basaltic composition (HLA 1998). In the environment of Mauna Kea's summit, ice, frost heaving, and snowmelt have worked to wash and stratify the surface layer of the cones. Progressively larger rocks have been lifted to the surface and washed clean of ash, which in turn has accumulated in a layer 30 to 46-cm (12 to 18-in) below the surface. The sorting and washing of the surface cinder leads to the development of interstitial spaces and voids between the rocks.

The U.S. Natural Resources Conservation Service (formerly the U.S. Soil Conservation Service) describes the rock materials underlying the project site as "Cinder Land". The rock is very permeable and if properly compacted, is a viable source of construction material for foundations and roads.

Computer compilation of digital elevation data for the island of Hawai'i shows the average slope of Mauna Kea to be 7.0° (UH IfA 1999). Mauna Kea summit area gradients become steeper near the summit of the volcano, averaging 17.5° due to the presence of steep-sided cinder cones and caldera walls (Dames & Moore 1999a). At the western edge of the plateau the topography inclines down into the crater at a 35 to 50 percent slope. Slopes from the east edge of the plateau down the outside of the Pu'u Hau 'Oki vary from 40 to 50 percent. The slope breaks along both the east and west edges of the plateau are abrupt. The slope to north along the crater rim (proposed Outrigger Telescope 1 location) is more gradual, varying from 10 to 25 percent. No retaining wall or other barrier is currently in place along the plateau edges.

3.5 HYDROLOGY AND WATER QUALITY

Hydrology and Permafrost. A review and assessment were recently completed of the surface and ground water hydrology of the Outrigger Telescopes Project area with a focus on Pu'u Hau 'Oki and the proposed construction staging areas at Submillimeter Valley and Hale Pōhaku (Arvidson 2002) (see Appendix H). The results of that review have been used to update the description of surface and ground water hydrology found in the December 2000 Federal Draft Environmental Assessment (EA) for the Outrigger Telescopes Project.

Low precipitation rates, combined with high evaporation rates on the upper slopes and summit of Mauna Kea (see Section 3.2.1), drive a hydrologic system without perennial streams or extensive bodies of standing water. The saturated water table (surface below which pores and cracks are full of water) is far below the summit of the mountain (see Appendix H). This conclusion is consistent with past drilling activities at the summit, which showed only 10 percent pore water at the bottom of the 40-m (131-ft) maximum drill depth. In addition, long baseline electrical resistivity surveys along the Saddle Road between Mauna Kea and Mauna Loa suggest that the water table is as low as 610-m (2,001-ft) beneath the 1,980-m (6,496-ft) saddle elevation, suggesting that the water table level is many thousands of feet beneath the summit. The low water table elevation is a consequence of the low summit precipitation rates, combined with the high evaporation rates due to the low relative humidity.

Mauna Kea is estimated to have massive reservoirs of ground water (see Appendix H). Given the climatology and hydrology associated with the mountain, by far most of the input for these systems must be in the form of precipitation on the northeastern or windward slopes, below the inversion layer. For example, the Eastern Mauna Kea aquifer system is estimated to produce a sustainable yield of 1.47 billion liters/day (388 million gallons (gal)/day) whereas the Western Mauna Kea aquifer system is estimated to have a sustainable yield that is much less, only 79.5 to 212 million liters/day (21 to 56 million gal/day). This vast difference is a consequence of the geography of rainfall associated with trade winds and high precipitation on the windward slopes of the mountain. Further, the input from the summit and upper slopes must be very small in comparison to input from rainfall on the lower slopes.

The summit of Mauna Kea does exhibit numerous channels and gullies that extend down hill, connecting to larger gulches that have been cut into the slopes of the mountain (Appendix H; see Figure 3). Further, numerous small seeps and springs can be found on the upper slopes of Mauna Kea, largely emanating from permeable interfaces close to the contact between the glacial till deposits and volcanic materials (see Appendix H). In addition, Lake Waiau is a small pond located within Pu'u Waiau at the summit. Thus, the summit does have an active hydrologic system, but one dominated by ephemeral stream flow in response to storm-induced precipitation and rapid snow melt, shallow ground water flow and surface emanations as seeps and springs, and one small open body of water. The shallow ground water flow and the presence of Lake Waiau are both consequences of perched ground water systems in which subsurface flow from rainfall and snow melt on the summit is guided down-hill by the presence of impermeable substrates, including lava flows, clay layers, and perhaps permafrost zones. Except during storms and periods of rapid snowmelt the pore and cracks within the shallow subsurface are not saturated with water, except beneath Lake Waiau.

A detailed analysis of the topography and geomorphology of the summit and upper slopes (see Appendix H) shows that the following drainage basins exist:

- Pu'u Hau 'Oki is at the summit of Mauna Kea and forms the upper-most portions of drainage systems extending to the north into Ku'upaha'a Gulch and to the south into Pōhakuloa Gulch.
- The northern side of Pu'u Hau 'Oki is the upper portion of a drainage basin that empties into Ku'upaha'a Gulch on the northern side of the mountain.
- The southern side of Pu'u Hau 'Oki is the upper portion of a drainage basin that includes the Submillimeter Valley (construction staging site) and drains into Pōhakuloa Gulch on the southern side of Mauna Kea.
- Lake Waiau is fed by a small drainage basin that includes the inner walls of the cone and a portion of a nearby lava flow. Importantly, this small drainage system is isolated from the Pōhakuloa Gulch system that drains Submillimeter Valley and Pu'u Hau 'Oki, although overflow from the Lake into Pōhakuloa Gulch occasionally occurs during periods of high rainfall or snow melt. (The Lake was observed in 2000 and 2001 to have a green color due to the presence of algae, similar to a report by Gregory and Wentworth in 1937 (see Appendix H). This indicates that the algae are probably not due to human influence.)
- Hale Pōhaku is located on the southern slopes of Mauna Kea and is within a drainage basin that feeds a number of systems. This drainage basin is separate from the Pōhakuloa Gulch basin.

Currently, rainfall and snowmelt runoff from from paved surfaces at the WMKO site is directed into lined channels which conduct the water to collection basins where it is allowed to percolate into the cinder soils thereby preventing surface erosion or standing water problems (UH IfA 1999). The cinder soils are highly permeable, with water percolation through these soils at rates in excess of 51 cm (20 in) per hour (Dames & Moore 1999a). This permeability can be temporarily reduced at times during the winter when ice forms in the surface layers of the soil.

To estimate the mechanical load of sediment that may be naturally carried down-hill during storms and rapid snow melt a comparative analysis was conducted of the basins associated with Mauna Kea and a number of other basins of comparable size that have been monitored to estimate annual sediment transport rates (see Appendix H). This analysis indicates that on average the naturally occurring erosion of the Pōhakuloa Gulch basin probably proceeds at a rate of about 1 mm/year. Similar results were found for the other basins on the summit and upper slopes.

3.6 BIOLOGICAL RESOURCES AND THREATENED AND ENDANGERED SPECIES

This Section discusses the biological resources potentially affected by on-site construction, installation, and operation of the Outrigger Telescopes. For the purposes of this discussion, two areas will be discussed: (1) the summit area cinder cones; and (2) the areas of the Mauna Kea Science Reserve at elevations below the summit area cinder cones, and areas along the summit access road down to Hale Pōhaku. The summit area cinder cones of Mauna Kea, consisting of Pu'u Hau 'Oki, Pu'u Wēkiu, and Pu'u Kea, begin at an approximate elevation of 4,084 m (13,400 ft) and rise to about 4,205 m (13,796 ft) on Pu'u Wēkiu.

3.6.1 Biological Resources of the Summit Area Cinder Cones

The summit area cinder cones encompassing an area of approximately 100 ha (250 ac), consist of the three cinder cones, Pu'u Hau 'Oki, Pu'u Wēkiu, and Pu'u Kea. The WMKO site, the proposed location of the Outrigger Telescopes Project, is on Pu'u Hau 'Oki at an approximate elevation of 4,146 m (13,603 ft) within the summit area cinder cones. The summit area cinder cones are characterized by harsh environmental conditions that limit the composition of the resident floral and faunal communities found there.

No floral species have been found on the summit area cinder cones. Plants have been found only below the summit area cinder cones. The extreme temperatures and very dry conditions of the cinder cones, including limited precipitation, porous cinder substrates, and high winds, have apparently prevented establishment of even very hardy plants. The summit area cinder cones receive almost no rainfall, and snow accumulates only during a short winter season. Temperatures often drop below freezing at night. Solar radiation is extreme, and evaporation rates are high.

The only resident animal species found on the summit area cinder cones are arthropods. Eleven species of indigenous Hawaiian resident arthropods have been collected there: the Wēkiu bug (*Nysius wekiuicola*), lycosid wolf spiders (*Lycosa* sp.), sheetweb spiders (*Erigone* sp. A1 & B1), another sheetweb spider (Family Linyphiidae: species unknown), a mite (Family Aystidae: species unknown), another mite (Family Eupodidae: species unknown), springtails (Family Entomobryidae: 2 species unknown), another springtail (Class Collembola, family and sp. unknown), and a centipede (*Lithobius* sp.). An additional five arthropod species, non-indigenous to Hawai'i, are thought to be resident to the summit area cinder cones (Howarth and Stone 1982; Howarth and others 1999).

Loose packing of surface cinder on the summit area cinder cones makes numerous spaces that provide shelter for resident arthropods from adverse weather conditions, intense solar radiation, freezing temperatures, and predators. In addition, these arthropods have evolved distinctive adaptations in order to exploit the resources and live in this habitat (Howarth and Montgomery 1980).

One of the arthropods found on the summit area cinder cones, the Wēkiu bug, is a candidate for listing under the Endangered Species Act. This small insect, 3.5 to 5-millimeter (mm) (0.14 to 0.20-in) long, has made a remarkable adaptation in feeding behavior. Many true bugs, including most of those found elsewhere in Hawai'i, are herbivores and feed on seeds and plant juices. The Wēkiu bug is a predator. This evolutionary adaptation was probably influenced by the scarcity of plants on the summit area cinder cones. Wēkiu bugs use their straw-like mouthparts to feed on wind-carried insects blown up the mountain from the surrounding lowlands. These aeolian insects accumulate in protected pockets on the high-elevation cinder cones, and unlike Wēkiu bugs, are not adapted to the cold temperatures at the summit. Aeolian insects quickly become moribund in the cold and are thus easy prey for foraging Wēkiu bugs.

Wēkiu bug populations have been assessed twice, in 1982 and again in 1997/98. The 1982 assessment employed traps that resulted in the mortality of collected Wēkiu bugs (Howarth and Stone 1982). In 1997, three live trap designs were evaluated for survivability of captured Wēkiu bugs, effectiveness in capturing, and comparability to traps used in 1982. A modified pitfall live trap that included shrimp bait, cinder habitat, and a small water reservoir was selected for the 1997/98 assessment. While different trapping methods were used during the two assessments, the results were comparable (Howarth and others 1999). After sampling, the scientists conducting the 1997/98 assessment concluded that the Wēkiu bug population apparently experienced a 99.7 percent decline in comparable areas surveyed in both 1982 and 1997/98 (Howarth and others 1999). In the 1997/98 arthropod assessment, Wēkiu bugs were found on Pu'u Hau 'Oki as well as outside of the summit area cinder cones on Pu'u Māhoe and Pu'u Mākanaka (Howarth and others 1999). In a 1982 study, Wēkiu bugs were found from the summit area cinder cones down to an elevation of about 3,900-m (12,800-ft) below the summit area cinder cones (Howarth and Stone 1982). Although the lower elevations of the 1982 range were sampled in 1997/98, no Wēkiu bugs were found below about the 4,084-m (13,400-ft) elevation of the summit area (Howarth and others 1999). The 1982 range is estimated to have been about 1,214-ha (3,000-ac). The 1997/98 range is estimated to have been 120-ha (300-ac). The decline was evident in habitat previously disturbed by observatory construction, as well as in relatively undisturbed areas some distance from astronomy development. The 1997/98 trapping data indicated that Wēkiu bugs occurred in greater numbers in previously disturbed areas where habitat structure appears to have recovered. No Wēkiu bugs were found on roads or in graded areas near observatory buildings.

The causes of the Wēkiu bug population decline are not known. Hypotheses include climate change, a possible long-term downward trend in winter snowpack depth and persistence, introduction of predatory alien arthropods, mechanical habitat disturbance from road and observatory construction, recreationalist impacts, vehicle impacts, and the possible presence of environmental contaminants from human activities. The most likely cause would be a combination of some or all of the above factors.

3.6.2 Biological Resources of the Elevations Below the Summit Area Cinder Cones

Twenty-six species of lichens have been found on the lower elevations of the Mauna Kea Science Reserve below an approximate elevation of 4,084 m (13,400 ft). Apparently all are indigenous to Hawai'i (Smith and others 1982; Char & Associates 1999). Lichens reach their highest density and greatest diversity on the north and west facing rocks, sheltered from long periods of direct exposure to the sun. The most abundant lichen, *Lecanora muralis*, is distributed throughout the area below the summit cinder cones. *Candelariella vitellina* and *Lecidea skottsbergii* occur less frequently, and are found on small rocks and cobbles in cinder and colluvial material (Char & Associates 1999).

About 12 species of mosses have been collected from the lower elevation areas (Smith and others 1982). These mosses occur in shaded caves and crevices, and are usually associated with areas moistened by melting snow. Mosses have not been observed on the loose cinder of summit cinder cones (Char & Associates 1999). The most abundant mosses in the lower elevations below the summit cinder cones are species of the genus *Grimmia*. These silvery-gray species grow in semi-exposed snow run-off channels at the base of rocks. The bright green *Pohlia cruda* is the second most abundant moss. It occurs in deeply shaded and well-protected sites hidden from direct sunlight (Bartram 1933; Char & Associates 1999). None are found above approximately 4,084 m (13,400 ft).

Only six species of vascular plants grow on the lava plateau immediately below the summit area cinder cones extending from about an elevation of 4,084 m (13,400 ft) to about 3,960 m (13,000 ft) (Char & Associates 1999). Two are the common, cosmopolitan, introduced weeds, gosmore (*Hypochoeris radicata*) and dandelion (*Taraxacum officinale*). Neither are abundant in this habitat. Two endemic grasses occur in the lower elevations below the summit area cinder cones, *Agrostis sandwicensis* and *pili uka* (*Trisetum glomeratum*). They are abundant at lower elevations, but are found only infrequently above about 3,200 m (10,500 ft). None are found above about 4,084 m (13,400 ft).

Two ferns also are found on the lava plateau. *'Iwa'iwa* (*Asplenium adiantum-nigrum*) is the more abundant of the two indigenous species, and grows on cinder plains, lava flows, and in dry forests as low as about 610 m (2,000 ft) (Valier 1995). *Cystoperis douglasii* grows in open, exposed areas, typically on weathered rocks exposed to wind (Char & Associates 1999). This delicate fern is very rare, and is considered a species of concern by the U.S. Fish and Wildlife Service (USFWS) (1999). It does not occur above an elevation of about 4,084 m (13,400 ft).

At lower elevations of the Mauna Kea Science Reserve, near elevation 3,505 m (11,500 ft), the plant community is sparse and consists of lichens, mosses, ferns, and grasses. Occasional representatives of the alpine shrub community are found, including: *pūkiawe* (*Styphelia tameiameiae*) and *'ōhelo* (*Vaccinium reticulatum*). For the most part, the alpine shrub community is found below the lowest reaches of the Mauna Kea Science Reserve, at elevations below about 3,200 m (10,500 ft). This community is well developed at the Hale Pōhaku astronomy support facilities located at about an elevation of 2,804 m (9,200 ft). The subalpine *māmane* forest (*Sophora chrysophylla*) and the listed endangered Mauna Kea silverswords, *'āhinahina* (*Argyroxiphium sandwicense*) occur only below about 2,895-m (9,500-ft) elevation and are not found on the Mauna Kea Science Reserve.

The only fauna found at the lower elevations of the Mauna Kea Science Reserve between 4,084 m (13,400 ft) and 3,960 m (13,000 ft) are arthropods. Of the eleven indigenous Hawaiian resident species found on the summit cinder cones, most have also been found down to an elevation of 3,960 m (13,000 ft). The exceptions are two species of mites and two species of sheetweb spiders. The 1997-1998 arthropod assessment detected no Wēkiu bugs at these elevations below the summit area cinder cones (Howarth and others 1999), except for minor populations on Pu'u Māhoe and Pu'u Mākanaka.

One other indigenous Hawaiian resident arthropod was found in this lower elevation area, but was not observed on the summit area cinder cones during the 1997-1998 assessment. This is the summit moth (*Agrostis* sp.). Other indigenous arthropods may be resident on the lava plateau, but a thorough investigation has not been made.

Several species of birds native to Hawai'i are found in the *māmane* forest, including the endangered finch, *palila (Loxiodes bailleui)*. *Palila* occur only below an approximate elevation of 3,002 m (9,850 ft). The endangered seabird *'ua'u* (*Pterodrama phaeopygia sandwichensis*), a subspecies of dark-rumped petrel, once nested in the saddle area between Mauna Loa and Mauna Kea. Recent studies have found a few *'ua'u* in Kilauea crater, and colonies are suspected along the Mauna Loa summit trail, and on Mauna Kea below about 3,002-m (9,850-ft) elevation near Pu'u Kanakaleonui (Harrison 1990). None are thought to occur on the Mauna Kea Science Reserve.

Feral sheep, mouflon, goats, and cattle are found in small numbers in the *māmane* forest. These animals may occasionally wander up into the Mauna Kea Science Reserve, but the vegetation there is too sparse to support extended stays. Federal court rulings in 1979 and 1986 mandated removal of feral ungulates to allow regeneration of the *māmane* forest. Subsequent removal has eliminated most of these feral mammals (Stone 1989).

The Hawaiian bat, *'Ōpe'ape'a* (*Lasiurus cinereus*) is the only native land mammal living in Hawai'i today. Hawaiian bats roost in trees, and feed on a broad range of insects. *'Ōpe'ape'a* are most abundant near water and in the lowlands, but have been recorded flying at elevations of about 3,048 m (10,000 ft) flying over vegetation foraging for food. This endangered species has been seen in the *māmane* forest below the Mauna Kea Science Reserve, but is not thought to live above the tree line on Mauna Kea.

3.7 NATURAL HAZARDS

Seismic Activity. The island of Hawai'i is seismically active. Active faults and other tectonic features that are the source of this seismicity, however, are located well away from Mauna Kea. Much of the seismic activity is associated with active volcanism at Mauna Loa and Kilauea volcanoes. Recent geological maps of the Island show no known faults or active rift zones within several miles of the project site (UH IfA 1999). The area has been classified into ground fracture and subsidence hazard zone 4, the lowest risk zone on the Island (UH IfA 1999).

3.8 EXISTING USES AND TRANSPORTATION

3.8.1 Existing Uses of the Mauna Kea Science Reserve Summit Area

Astronomical Research. The Mauna Kea Science Reserve is one of the best locations in the world for ground-based astronomical observations. High on a Pacific island, the mountain is generally cloud-free, providing excellent clear nighttime viewing.

At the present time, 12 observatories are either in operation or under construction within the Astronomy Precinct. These include eight major optical/infrared telescopes, one 0.6-m (24-inch) telescope; two single-dish millimeter/submillimeter-wavelength telescopes; and a submillimeter array. The Very Long Baseline Array (VLBA) Antenna Facility is situated at the 3,719-m (12,200-ft) elevation of the Mauna Kea Science Reserve. All of the observatories are used for basic astronomical research. Table 3-2 lists the existing Mauna Kea Observatory telescopes;

TABLE 3-2. THE MAUNA KEA OBSERVATORIES

Telescope	Size	Primary Use	Sponsors	Year of Operation
Optical and Infrared Telescopes				
UH Telescope	0.6 m (24 in)	Optical	UH	1968
UH Telescope	2.2 m (7.2 ft)	Optical/Infrared	UH	1970
National Aeronautics and Space Administration (NASA) Infrared Telescope Facility (IRTF)	3.0 m (10 ft)	Infrared	NASA	1979
Canada-France-Hawai'i Telescope (CFHT)	3.6 m (12 ft)	Optical/Infrared	Canada/France/ UH	1979
United Kingdom Infrared Telescope (UKIRT)	3.8 m (12.5 ft)	Infrared	United Kingdom	1979
W.M. Keck Observatory (WMKO) (Keck I)	10 m (33 ft)	Optical/Infrared	California Institute of Technology (Caltech)/ University of California/California Association for Research in Astronomy (CARA)	1992
W.M. Keck Observatory (WMKO) (Keck II)	10 m (33 ft)	Optical/Infrared	Caltech/ University of California/CARA	1996
Subaru (previously called the Japan National Large Telescope)	8.2 m (27 ft)	Optical/Infrared	Japan	1999
Gemini Northern Telescope	8.1 m (26.2 ft)	Optical/Infrared	NSF/United Kingdom/ Canada/ Argentina/ Australia/ Brazil/Chile	1999
Millimeter/Submillimeter Telescopes				
Caltech Submillimeter Observatory (CSO)	10.4 m (34 ft)	Millimeter/ Submillimeter	Caltech/NSF[b]	1986
James Clerk Maxwell Telescope (JCMT)	15 m (49 ft)	Millimeter/ Submillimeter	NSF/United Kingdom/ Canada/ Netherlands	1986
Submillimeter Array[a]	Eight 6 m (20 ft) antenna	Submillimeter	Smithsonian Astrophysical Observatory/Taiwan	2003
Facility Outside the Astronomy Precinct				
Very Long Baseline Array (VLBA)	25 m (82 ft)	Centimeter Wavelength	NRAO/NSF[b]	1992

Source: UH IfA 2002

a. Under construction.
b. Acronyms: NRAO = National Radio Astronomy Observatory; NSF = National Science Foundation.

Figure 2-4 shows their location in the Mauna Kea Science Reserve (with exception of the VLBA located at too low an elevation to be shown on this figure).

Other Scientific Research. Mauna Kea has a number of interesting natural resources for scientists in various disciplines to study; geologists study the unique volcanic and glacial history of the mountain and health professionals study the effects of the altitude on the human body. Meteorologists study the weather and atmosphere; biologists study the endemic ecosystems found on Mauna Kea.

Cultural and Religious Uses. Because of Mauna Kea's prominence, isolation and extreme environmental conditions, Mauna Kea's place in the culture and history of the Hawaiian people is significant. The mountain has been attributed spiritual and cultural significance by the Native Hawaiian community. Cultural and religious practices are ongoing today. See Section 3.10 for more information about cultural and religious uses.

Recreation and Sightseeing. The seasonally snow-covered slopes of Mauna Kea, above the 3,050-m (10,000-ft) elevation, are used for skiing and snow play. Pigs, sheep, goats, and various game birds are hunted by rifle or archery at elevations well below the Astronomy Precinct. Hiking, sightseeing and photography are also popular uses of the mountain.

3.8.2 Existing Uses of Hale Pōhaku

Because the summit of Mauna Kea is 4,205-m (13,796-ft) high, it is inefficient and physically hazardous for people to travel directly from sea level to the summit and work without acclimatizing for a period of time at an intermediate elevation. Mid-elevation accommodations are provided at Hale Pōhaku (2,804-m (9,200-ft) elevation) for scientists, and support staff, so that they can acclimatize during their on-duty periods. Approved uses of the parcel include a mid-level facility for astronomers, an Information Station and parking for the public, a construction camp, and a staging area.

3.8.3 Transportation

The drive from Hilo or Waimea to the upper elevations of Mauna Kea takes 1 to 1½ hours. Access to the summit is from Saddle Road (Route 200) to Pu'u Huluhulu, and from there along a 9.7-km (6-mi) long, 6-m (20-ft) wide paved portion of the Mauna Kea Access Road to Hale Pōhaku, located at an elevation of 2,804 m (9,200 ft). From Hale Pōhaku, the Mauna Kea Access Road continues unpaved approximately 7.2 km (4.5 mi). The road is then paved again at an elevation of 3,597 m (11,800 ft) to the project site elevation of 4,146 m (13,603 ft) (see Figure 2-1).

In the fall of 1998, an average of 560 weekly trips were made to the summit (UH 1999). Table 3-3 estimates the type of traffic and the average number of weekly trips.

Hazards encountered during travel to and from the summit include brake failures on the steep summit road and weather-related accidents. On average, six accidents per year occur where a vehicle requires towing off the mountain (UH 1999).

TABLE 3-3. 1998 AVERAGE WEEKLY TRIPS TO THE MAUNA KEA SUMMIT

Traffic Type	Number of Trips per week
Construction personnel	150
Observatory day crews	150
Observatory night crews	85
Commercial tours	30
Mauna Kea Support Services personnel	20
Tourists and local traffic	125

Source: UH 1999

3.9 SERVICES, FACILITIES, AND WASTE MANAGEMENT

3.9.1 Water Supply

Water supply for Hale Pōhaku and the summit is trucked from Hilo in a 19-kiloliter (kl) (5,000-gal) capacity tanker truck. Two 152-kl (40,000-gal) water tanks are located at Hale Pōhaku. Currently 95 kl (25,000 gal) per week are trucked to the mid-level facility (MKSS 2000). An additional 57 kl (15,000 gal) per week are trucked to the summit to supply all the various facilities. At the WMKO, the water is stored in two tanks; 15 kl (4,000 gal) and 30 kl (8,000 gal). Typical consumption at WMKO is 11 kl (3,000 gal) per week for all purposes.

3.9.2 Wastewater Collection, Treatment, and Disposal

At this time all sewage disposal and treatment is handled by individual cesspools and septic/leachfield systems that serve each facility. There is no plan for construction of a sewer collection system to serve the summit area (UH 1999). WMKO wastewater is disposed of by means of a 4-kl (1,000-gal) septic tank and a 17-kl (4,500-gal) seepage pit, which operates in the same manner as a leach field. Wastewater enters the two-stage septic tank where bacteria digest bio-solids that settle to the bottom of the tank. The wastewater then flows from the septic tank into a 6-m (20-ft) deep seepage pit that drains into deep subsurface cinder. The remaining sludge is transported by a licensed waste disposal contractor from the summit to an approved waste treatment plant. The State Department of Health approved the WMKO wastewater disposal system.

3.9.3 Solid Waste and Hazardous Materials Handling, Storage, and Disposal

Some hazardous materials are used at the WMKO. In addition, the use of some materials results in the production of wastes. Hazardous materials stored and used at the WMKO include oil, lubricants, ethylene glycol, propylene glycol, hydrofluoric acid, paint and elemental mercury. CARA has procedures in place for the handling and storage of hazardous materials used at WMKO, including procedures for responding to any accidental releases of such materials.

All wastes generated at the WMKO facility, except domestic waste which is disposed of in a septic tank leachfield system, are disposed of off-site at appropriate disposal facilities. Waste lubricants, waste oils, waste paint, and liquid waste streams containing ethylene glycol and propylene glycol are containerized at the WMKO facility and transported by truck to WMKO headquarters in Waimea. The waste materials are picked up by licensed waste haulers.

Elemental mercury is used for the lateral restraint on the f/15 secondary mirror of the Keck Telescopes. Mercury is highly toxic. The mercury is contained within a rubber bladder that is located between the outer edge of the mirror and the cell that holds the 1.4-m (4.6-ft) diameter mirror. The mercury supports the mirror (keeps it centered) against gravity as the telescope moves from zenith (pointing up) to the horizon (CARA 2000c). Currently, 7.7 kilograms (kg) (17 pounds (lb)) are stored at the WMKO.

There are 5.9 kg (13 lb) of mercury in use for the lateral restraints on the secondary mirrors of Keck I and Keck II (2.9 kg (6.5 lb) in each of the two-f/15 mirror mercury bladders), resulting in a total of 13.6 kg (30 lb) of mercury stored and/or in use at the WMKO (CARA 2000c). As the mercury is being used in a rubber bladder, none of it is consumed through vaporization or other means. Elemental mercury would not be used for the Outrigger Telescopes.

The information available at the time of the issuance of the Draft EA indicated that no mercury spills had occurred at the site. Further investigation by CARA indicated that three mercury spills had occurred: (1) a 5-ml (1-teaspoon) spill; (2) a 100-ml (6.7-tablespoon) spill; and (3) a 5 to 10-ml (1 to 2-teaspoon) spill. All three spills occurred in 1995 during servicing of the Keck II Telescope. None of the mercury spills resulted in any of the mercury seeping into the ground or the septic system.

The WMKO has a mercury emergency response plan that describes safe handling procedures, protective equipment, and spill containment and clean-up procedures to be used in the event of a mercury spill. An authorized disposal company is used for the disposal of exposed/contaminated clothing and mercury-contaminated wastes following a clean up (CARA 1996).

Operation of the WMKO requires periodic maintenance cleaning, and recoating (re-aluminizing) of the telescope mirror segments and lubrication of the ball bearings throughout the facility. These maintenance activities and the compounds and materials used are discussed below.

Lubrication of Ball Bearings and Dome Weather Seal. Periodically, ball bearings throughout the facility are lubricated. During lubrication any excess lubricant is collected and removed to an appropriate waste container. Any lubricant that might be spilled accidentally during the lubrication procedure is cleaned up immediately.

The dome for each Keck Telescope has a weather seal. Each seal is a rubber skirt or flap that rides on an aluminum plate. To prevent sticking, in the past, the seal was lubricated with a silicon or graphite lubricant. As a result of the movement of the dome, over time (approximately eight years) lubricant has moved down the wall of the building. As a result, there was an accumulation of lubricant stains on the building walls. However, no lubricant has migrated to the cinder. In addition, the domes and building walls have been painted and the lubricant stains removed.

The weather seal on Keck Telescope I has been replaced with a system that does not require lubrication. CARA plans to replace the weather seal for Keck Telescope II with the same system.

Mirror Cleaning and Recoating. The WMKO 10-m (33-ft) mirrors each consist of 36 separate hexagonal mirror segments totaling 72 mirror segments for the Keck I and Keck II Telescopes combined. Mirror cleaning involves monthly use of CO_2 to clean the mirrors. Mirror cleaning also consists of occasionally washing several of the mirrors (primarily the secondary and tertiary mirrors) with a soap and water solution. This occurs approximately once every two years.

CARA's procedure requires the collection of effluents from mirror cleaning in containers and disposal off-site.

In addition, each Keck mirror segment is recoated (re-aluminized) every two to three years. Mirror recoating takes place inside the Keck Telescope building, in a room specifically designed and equipped for that purpose.

The first step in the recoating process is to use solutions containing copper sulfate, hydrochloric acid, and potassium hydroxide, and rinse water to remove the old aluminum coating.

The rinse water from the aluminum removal procedure contains small amounts of aluminum chloride, aluminum sulfate, copper chloride, copper sulfate, and potassium hydroxide; the rinse water is collected in containers and disposed of off-site. The last four compounds are listed under Section 102(a) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) by the U. S. Environmental Protection Agency (USEPA). Compounds on the table must be reported to the USEPA if released into the environment in an amount equal to or greater than the specified amounts. Assuming the Keck recoating facility processes its maximum capacity of four segments per month, the annual quantities of these chemical compounds that would be generated by Keck mirror segment recoating would range from less than 0.1 percent to about 4 percent of the reportable quantities under Section 102(a) of CERCLA (see Table 3-4). Therefore, even if all of the rinse water was spilled, no report would be required.

TABLE 3-4. COMPOUNDS RESULTING FROM MIRROR ALUMINUM REMOVAL AND REPORTABLE QUANTITIES

Resultant Compound	Amount per mirror segment (g)	Reportable Quantity (lbs)[a]	Total Quantity Per Year (g)	Percent of RQ
Aluminum Chloride	12	NA	576	NA
Aluminum Sulfate	15	5,000	720	0.03
Copper Chloride	2.5	10	130	2.90
Copper Sulfate	4	10	192	4.20
Potassium Hydroxide	9	1,000	435	0.096

Conversion Factors: 1 g = 0.0022 lb; 1 lb = 458.6 g

Source: Pacific Analytics 2000

a. Reportable Quantity (RQ) for hazardous substance under Section 102 of CERCLA.

3.9.4 Electrical Power and Communications

The Mauna Kea summit is presently served by a 69-kilovolt (kV) overhead transmission line to the Hale Pōhaku substation. This substation consists of two 3,000-kilovolt-ampere (kVA) transformers for a total capacity of 6,000 kVA. From the substation, there is an underground 12.47 kV dual loop feed system which loops around the Mauna Kea summit. The existing demand load at the substation is approximately 1,100 kVA, leaving approximately 4,900 kVA of surplus capacity. The existing peak demand load of the Keck Telescopes is approximately 440 kVA. In addition, a 250-kVA standby diesel-powered generator is located at Keck to provide minimal power needs such as dome closure in the event of a power outage. Diesel fuel for the generator is stored on site at the WMKO site in a 9.5-kl (2,500-gal) double-walled storage tank with a leak detection system. The existing WMKO electrical service provided by the Hawaii Electric Light Company has a 1,000 kVA capacity.

In recent years (1996 to 1998), the communications system serving the observatories at the summit has been upgraded, including the installation of a fiber optic communications system. This system provides communications links to provide real-time data flow between the summit and base facilities in Waimea and Hilo. Remote observing from outside Hawai'i via the Internet is also possible with the improved communications link.

3.9.5 Emergency Services and Fire Suppression

Emergency Services. An emergency preparedness and medical evacuation plan has been prepared by Mauna Kea Support Services (MKSS). This plan covers and applies to all observatories (including Keck I and Keck II) on the summit of Mauna Kea. The plan is updated as required and distributed to all facilities (MKSS 2000).

Because Mauna Kea is an isolated work location, many miles from the nearest professional Emergency Medical Service (EMS), the responsibility and primary source of first aid assistance are the employees at each observatory facility. There are no emergency medical facilities on the summit or at Hale Pōhaku. The plan recommends that each facility maintain a stock of emergency first aid supplies and that all employees have current first aid training and experience using the equipment available to them. In addition, the plan recommends that some staff members undergo emergency medical technician (EMT) training and that each facility should establish regular first aid drills, testing of emergency and safety equipment, and test driving of the emergency evacuation vehicle. If facility vehicles are inadequate and an accident victim needs to be transported to an EMS location or must meet an EMS vehicle, the emergency evacuation vehicle is available. This emergency vehicle is located at the Caltech Submillimeter Observatory for use by all observatories. The purpose of this vehicle is to provide a means of transporting an injured person down the mountain to an ambulance or helicopter at Saddle Road or Hale Pōhaku. The vehicle is equipped with first aid supplies and a cellular phone. EMS is available from both the Hawai'i County Fire Department and Pōhakuloa Training Area. Pōhakuloa is closer to Mauna Kea and can respond more quickly than the Fire Department. EMS personnel from the County and Pōhakuloa Training Area can be dispatched either by ambulance or helicopter. The nearest hospital is Hilo General Hospital.

Fire Suppression. The basic fire suppression equipment at the WMKO consists of hand-held fire extinguishers. These include carbon dioxide (CO_2) and dry chemical (A-B-C) types. WMKO is finalizing plans for installation of fire suppression systems for the Keck I and Keck II control and computer rooms, the interferometer control room, and the laser control room.

Presently, the fire alarm systems consist of manual pull stations located at the observatory exits. There are alarm bells in the domes and hallway. WMKO has plans to install a fire alarm system that will include supervised smoke, flame and heat detectors in all areas of the observatory with a voice annunciation system. Fire drills are conducted three times per year. Two self-contained breathing apparatus (SCBA) units are also located at the WMKO; annual training is conducted on their use (CARA 2000a).

3.10 CULTURAL RESOURCES

3.10.1 Resource Definition

Cultural resources include both historic properties and cultural values or traditional cultural practices.

Historic properties may be eligible for the National Register of Historic Places (NRHP) and may consist of archaeological sites (locations where human activity has altered the earth or left deposits of physical remains), historic districts (groups of significant archaeological, architectural, or landscape features), historic buildings, traditional cultural properties, and other evidence of human activity. Traditional cultural properties are associated with the practices and beliefs of a living community, are rooted in its history, and are important in maintaining the continuing cultural identity of the community (Parker and King 1998).

Historic properties are protected under the National Historic Preservation Act (NHPA) when they meet the eligibility criteria for listing in the NRHP.

Cultural values or traditional cultural practices include contemporary cultural practices or beliefs of particular ethnic or cultural groups. These values and practices are identified in ethnographic studies and other personal accounts (refer to Section 3.10.4).

3.10.2 Historical Setting

The first Hawaiians landed on the island's shores between 400 and 800 A.D. Early Hawaiians initially settled near the shore to make use of ocean resources (PHRI 1999). Later, forest resources were used, and nearby mountain tops, such as Mauna Kea, were considered sacred (PHRI 1999). Mauna Kea (White Mountain or Wakea's Mountain) is a dormant volcano on the island of Hawai'i. It is the highest point in the Pacific Basin, and the highest island-mountain in the world at 4,205-m (13,796-ft) above sea level. The broad volcanic landscape of the summit area is made up of cinder cones (*pu'u*) on a lava plateau.

From early times, local inhabitants attributed spiritual significance to, and relied on the volcanic stone resources of the mountain to manufacture tools. The adze quarry at Mauna Kea (Keanakāko'i) provided a dense volcanic basalt from which tools were fashioned (PHRI 1999). In association with the quarrying process, shrines were erected to the gods and shelters were built. Keanakāko'i experienced intensive use after 1400 A.D. Use declined with the introduction of metal tools following European contact (PHRI 1999). The Mauna Kea Adze Quarry National Historic Landmark, located within the Mauna Kea Ice Age Natural Reserve (1.6 to 4.8 km (1 to 3 mi) from the summit), is listed on the NRHP (NRIS 2000). Volcanic glass and dunnite/gabbro for cutting tools and octopus fishing gear sinkers were also collected (PHRI 1999) near Hale Pōhaku and at the periphery of the very broad area in which quarry material and flaked basalt are found.

By the early 1600s, the Hawaiian Islands were divided into political regions. The larger islands (*mokupuni*) were divided into districts (*moku*), and the districts divided into *ahupua'a*. *Ahupua'a* often consisted of valleys that spanned the top of the mountain ridge to the ocean, and contained most of the necessary subsistence resources (Maly 1999). Mauna Kea Science Reserve lies within the *Ahupua'a* of Ka'ohe, while the lower slopes of Mauna Kea are included in both Ka'ohe and Humu'ula.

Mauna Kea provided a number of resources, both physical and spiritual, for the Hawaiian people. The *māmane* forests contained an array of plant and animal resources used for food, canoe making, and other activities (Maly 1999). Shrines at the edge of the summit plateau may have marked the transition to a spiritual zone associated with the summit (PHRI 1999).

Europeans arrived in Hawai'i beginning in the late 1700s (PHRI 1999). New technologies, religion, animals, and diseases brought by Europeans dramatically changed Hawaiian culture.

European expeditions to Mauna Kea in the 1800s provided the earliest written descriptions of the mountain (Maly 1999). Cattle, sheep, and goats brought to the Island escaped to forested areas, multiplied, and were hunted by local residents. Stone adze making declined as metal tools were introduced, and general human activity on Mauna Kea declined (Maly 1999). In 1882, Dowager Queen Emma is reported to have ascended Mauna Kea on a journey of self-cleansing (Kanahele and Kanahele 1997; Maly 1998; Maly 1999; Cf. Ku Okoa 1882). The Mauna Kea Forest Reserve was established by the Board of Agriculture and Forestry in the early 1900s.

In the early 1960s, Mauna Kea was determined to be one of the best astronomical sites in the world. The atmosphere above Mauna Kea is extremely dry—which is important in measuring infrared and submillimeter radiation through the atmosphere—and cloud-free, so that the number of clear nights is among the highest in the world.

In the 1970s, four telescopes were developed on the mountain and infrastructure elements were added, including a camp for construction workers at mid-elevation (UH 1999). A Mid-Level facility for astronomers and a visitor's center were later completed. Two telescopes were completed in the 1980s and five telescopes, including Keck I and Keck II, were completed in the 1990s (see Table 3-2).

3.10.3 Previous Cultural Resources Investigations

Part of Pu'u Hau 'Oki was surveyed in 1982. No archaeological sites were recorded on the cinder cone, but 22 shrine sites were located outside of the *pu'u* (McCoy 1982). The 2-ha (5-ac) Subaru Observatory site was surveyed in 1990 (Robbins and Hammatt 1990). No archaeological sites were identified on Pu'u Hau 'Oki during this survey (UH IfA 1999).

Surveys of Mauna Kea Science Reserve outside the present project area include a 1984 survey of the east/southeast flank of Mauna Kea north of the adze quarry which identified 21 sites, all but one identified as shrines (McCoy 1984). A survey conducted for National Radio Astronomy Observatory antenna sites in the summit area recorded a total of three sites, possibly shrines (Hammatt and Borthwick 1988). The State Historic Preservation Division (SHPD) conducted a survey in 1995 to relocate and evaluate sites recorded in earlier surveys (UH 1999). Seventeen new sites were also identified during this survey. Two years later, a survey located 47 new sites, most identified as shrines (McCoy 1999).

Ethnographic research for the project region includes a report on the background of the Mauna Kea summit region (McEldowney 1982); a cultural synthesis of the Hāmākua District including the summit of Mauna Kea (Cordy 1994); a social impact assessment in association with the Saddle Road project (Kanahele and Kanahele 1997); a study of the potential effects of the proposed Mauna Kea Science Reserve Development Plan on Native Hawaiian cultural practices and beliefs associated with Mauna Kea (PHRI 1999); an oral history, consultation study, and archival research (Maly 1998; Maly 1999); and a historic and traditional cultural assessment for the Saddle Road project (USDOT 2000).

3.10.4 Summary of Oral Interview Findings

The following summary of findings, in cultural-historical documentation and oral history interviews for Mauna Kea on the island of Hawai'i, was prepared by cultural resources specialist, Kepā Maly (*Kumu Pono Associates*). This summary was prepared as a part of the development of this Environmental Assessment (EA) for the Outrigger Telescopes Project on Mauna Kea.

Between August 1996 to February 1999, Maly conducted two detailed studies on Mauna Kea (Maly 1998; Maly 1999). The first study conducted by Maly (1998) reported on findings of archival and historical literature research, and included previously unavailable translations of Native Hawaiian traditions of Mauna Kea and important survey documentation of features on the mountain (reported in the nineteenth century). The study was conducted at the request of Ms. Lehua Lopez, President, Native Lands Institute in partnership with various Hawaiian organizations and *Kumu Pono Associates*. The second study (Maly 1999) was conducted at the request of Group 70 International, as a part of the update of the Complex Development Plan of the Mauna Kea Science Reserve and Hale Pōhaku for the UH. The 1999 study reported the findings of a detailed oral history and consultation interview program, and also included a detailed overview of archival and historical literature pertaining to Mauna Kea and its place in Hawaiian cultural practices and beliefs.

Preparation of the following summary did not entail further archival literature research or the conduct of additional oral history/consultation interviews. As such, the summary represents findings and recommendations which apply to the whole of Mauna Kea. While the specific proposed Outrigger Telescopes Project was not the focus of the 1998-1999 oral history interview and consultation program, at several points this proposed project was raised in conversations, and some program participants had knowledge of the project. Perhaps of greater importance to this summary is the fact that most Native Hawaiian interviewees—as well as other interview/consultation program participants—addressed all forms of development (existing and future) in their comments regarding on-going uses of Mauna Kea.

Summary of Documentation. Mauna Kea is located on the island of Hawai'i. With its summit peak standing at 4,205-m (13,796-ft) above sea level, Mauna Kea is the highest peak in Hawaiian Islands and in the larger Pacific Basin. Because of its prominence on the landscape of Hawai'i, Mauna Kea is the focal point of a number of Native Hawaiian traditions, beliefs, customs, and practices. In the region of Mauna Kea—an area extending from around the 3,048-m (10,000-ft) elevation to the summit peaks at Pu'u Kūkahau'ula, and including a plateau-like feature above the 3,505-m (11,500-ft) elevation—and on its slopes extending down to an area once covered in dense forest growth (approximately the 2,700-m (9,000-ft) elevation), are many *pu'u* (hills) and other natural features, many of which are described in various traditions and historical accounts.

Perhaps as a result of its prominence, isolation, and extreme environmental conditions, Mauna Kea's place in the culture and history of the Hawaiian people is significant. This "cultural significance" extends beyond a physical setting, sites, or particular features which have been previously identified in archaeological site studies. Mauna Kea is a prominent feature on the cultural landscape of Hawai'i, and it has been, and continues to be, attributed with spiritual and cultural significance in the Native Hawaiian community.

While conducting research in archival literature, Maly reviewed primary sources, including, but not limited to: traditional Hawaiian accounts of the nineteenth and early twentieth centuries, published in Hawaiian language newspapers and manuscripts (some of which had not been previously translated) (Maly ms. 1992-1998); land use records, including the *Māhele* (Land Division) of 1848, Boundary Commission Testimonies, and historic survey records of the Kingdom of Hawai'i (c. 1860-1900); nineteenth century writings of native historians – Malo (1951), I'i (1959) and Kamakau (1961, 1964, 1976, and 1991); journals and manuscripts of historic period visitors and historians – Cook (in Beaglehole 1967), Ellis (1963), Douglas (1914), Stewart (1970), Bingham (1969), Remy (1865), Fornander (1917-1919 and 1973) and

Westervelt 1963; and secondary historical studies, including McEldowney and McCoy (1982), Cordy (1994), Kanahele and Kanahele (1997), Langlas (draft – February 1997).

Native Hawaiian traditions describe the "birth" of the Hawaiian Islands, and the presence of life on and around them, in the context of genealogical accounts. Hawaiian genealogies record that the island of Hawai'i was the first born child of Wākea (the expanse of the sky) and Papa-hānau-moku (Papa—Earth-mother who gave birth to the Islands). The same god-beings, or creative forces of nature who gave birth to the Islands, were also the parents of the first man (Hāloa), and from this ancestor, all Hawaiian people are descended (David Malo 1951:3; Beckwith 1970; Pukui and Korn 1973). It is also found in genealogical chants, that Mauna Kea is referred to as "*Ka Mauna a Kea*" (Wākea's Mountain), with the mountain being likened to the first-born of the island of Hawai'i (Pukui and Korn 1973). A *mele hānau* (birth chant) for Kauikeaouli (King Kamehameha III) (ca. 1813-1854), describes Mauna Kea in this genealogical context:

O hānau ka mauna a Kea,	*Born of Kea was the mountain,*
'Ōpu'u a'e ka mauna a Kea.	*The mountain of Kea budded forth.*
'O Wākea ke kāne, 'o Papa,	*Wākea was the husband, Papa*
'o Walinu'u ka wahine.	*Walinu'u was the wife.*
Hānau Ho'ohoku he wahine,	*Born was Ho'ohoku, a daughter,*
Hānau Hāloa he ali'i,	*Born was Hāloa, a chief,*
Hānau ka mauna, he keiki mauna na Kea...	*Born was the mountain, a mountain-son of Kea...*
(Pukui and Korn 1973: 13-28)	

A review of native traditions reveals that many of the traditions of Mauna Kea are directly attributed to the interaction of the gods with the land and people. In Hawaiian practice, elders are revered—they are the connection to one's past—and they are looked to for spiritual guidance. Because of its place in the Hawaiian genealogies, the landscape itself is considered sacred as it is believed to be home of the gods or ancestral deities.

Additionally, in Hawaiian culture, natural and cultural resources are one and the same. All forms of the natural environment, from the skies and mountain peaks, to the watered valleys and plains, and to the shore line and ocean depths are the embodiments of Hawaiian gods and deities. In both its genealogical associations and its physical presence on the island landscape, Mauna Kea has been, and remains a source of awe and inspiration for the Hawaiian people. Evidence of this sense of awe, is recorded in a traditional Hawaiian proverb which expresses the thought "***Mauna Kea, kuahiwi ku ha'o i ka mālie*" –** *Mauna Kea (is the) astonishing mountain that stands in the calm* (ref. Pukui 1983:2147).

One of the important cultural descriptors of knowledge of a landscape, and its significance in Hawaiian beliefs and customs, are place names. There are many place names on the landscape of Mauna Kea that remind us of the broad relationship of natural landscape to the culture and practices of the Hawaiian people. A number of the place names recorded for this mountain landscape are associated with Hawaiian gods. Other place names are descriptive of natural features and resources, or document events that occurred on the mountain. The occurrence of place names, extending from the shore line to the summit of Mauna Kea, is important in that it demonstrates the Hawaiian familiarity with the sites, features, and varied elevations of the mountain. Early traditional and historic accounts, as well as a number of historic survey maps from ca. 1862-1892, identify sites and features on Mauna Kea that bear the names of Hawaiian gods and goddesses who were intimately associated with the history of the mountain. This is particularly so in the summit region of Mauna Kea, where a number of landscape features are directly associated with Hawaiian gods and deity.

Summary of Oral Interviews. Between September 25th and December 21st, 1998, Maly conducted a total of fifteen tape recorded and supplemental oral history interviews with twenty-two participants. All but two of the interviews were conducted on the island of Hawai'i. Additionally three historic interviews (recorded between 1956 to 1967) were translated from Hawaiian to English by Maly and transcribed. With those interviews, representing three primary interviewees, the total number of interviewees represented in Maly's 1999 study totaled twenty-five participants. Most of the formal interview participants were of Hawaiian ancestry (many of whom had generational attachments to lands which lay on the slopes of Mauna Kea). Those interview participants who were not Hawaiian, had personal experience on Mauna Kea dating back to the 1920s.

Also, during the process of conducting the formal recorded interviews, Maly spoke with more than 100 individuals who were known to him, or were identified as: (*1*) having knowledge about Mauna Kea; (*2*) knowing someone who could be a potential interviewee; or (*3*) who represented Native Hawaiian organizations (in alphabetical order – *Hui Mālama I Nā Kūpuna o Hawai'i Nei*, the island of Hawai'i Council of Hawaiian Civic Clubs, *Ka Lāhui Hawai'i*, the Office of Hawaiian Affairs, and the SHPD) with interest in Mauna Kea. A number of those contacts resulted in the recording of informal documentation regarding Mauna Kea, or generated written responses as formal communications. Notes written up during various conversations, added information to the historical record of, and recommendations pertaining to Mauna Kea, and were cited in *Appendices B, C, and D* of Maly 1999.

The scope of work for this study focused on current and any proposed observatory development on Mauna Kea, neither interviewees nor consultant participants were asked about any other forms of development on Mauna Kea. The following points summarize key recommendations of interview and consultation program participants:

- All but one interview-consultation participant stated that they would prefer no further development of observatories on Mauna Kea. Of that same group, a few others expressed reservations about further development, but did not rule out the possibility. High visibility of observatory features and impacts on *pu'u* were raised as issues by many interviewees.
- Protection of the landscape and view planes (*e.g.*, *pu'u* to *pu'u* and cultural resources) needs to be addressed.
- The general consensus of all participants—often voiced with deep emotion—was that the State of Hawai'i and UH should be thankful for what they have been able to use, and they should use what they have wisely.
- Before trying to establish guidelines for Native Hawaiian use and practices on Mauna Kea, the State of Hawai'i and UH and other facilities users of Mauna Kea must establish and adhere to their own guidelines and requirements for use of Mauna Kea.
- When addressing the varied resources in the summit of the Mauna Kea, the State-University and other agencies and users must look beyond the summit. In a traditional Hawaiian context, Mauna Kea is comprised of two major land units that extend from sea level, through the mountainous region and on to the summit of Mauna Loa. Mauna Kea

is Hawai'i—there would be no Hawai'i had Mauna Kea not first been born. What occurs on the summit of Mauna Kea, filters down to, and has an impact on what is below.

The native system of *ahupua'a* management (which may be likened to an integrated resources management planning approach) needs to be incorporated into planning for any future activities on Mauna Kea.

- Complete work and studies that were required as a part of the original master plan, and keep commitments.
- Protocols for the collection of cultural data, data analysis, and any resulting recommendation should be stated, including recommendations that will be implemented. Archaeological sampling of sites should be limited and plans developed in consultation with knowledgeable cultural practitioners.
- Use of existing facilities and infrastructure needs to be monitored to ensure that further damage (*e.g.*, impacts to *pu'u*, view planes, cultural sites and practices, and geological resources) to the cultural-natural landscapes does not occur.
- A plan for access to, and use of, traditional sites and resources (*e.g.*, Keanakāko'i) needs to be formulated in consultation with native practitioners and families who share generational ties to Mauna Kea, and who still practice their culture and religion on Mauna Kea.
- The State of Hawai'i, UH, and other sub-lessees and users of the Mauna Kea facilities and resources should form a sustainable partnership with community members.

  Key participants in this partnership should include knowledgeable Native Hawaiian families who share generational ties to Mauna Kea, and other individuals known to be knowledgeable about Mauna Kea's various resources.

  Such a partnership should have more than an "advisory role," and would focus on formulating culturally sensitive management guidelines and protocols for users of Mauna Kea. Partnership programs could also implement further literature research and oral history documentation for Mauna Kea; develop site preservation and resource monitoring plans; and design educational-interpretive programs for Mauna Kea.
- Restore documented traditional Hawaiian place names to appropriate features and use them thereafter.
- Develop a plan for the restoration of the natural environment on Mauna Kea. For many interviewees, this includes maintaining hunting populations of introduced herbivores which can help keep alien plant species under check.
- Seek out and speak with members of the Hawaiian community who have generational ties to Mauna Kea, prior to undertaking any new projects. Then take their beliefs, practices, feelings, and recommendations into account in reaching management decisions.

3.10.5 Cultural Environment

Historic Properties. SHPD has stated that they "have come to believe that the cluster of cinder cones which merge and collectively form the summit of Mauna Kea is an historic property and that this single landscape feature probably bore the name Kūkahau'ula. This single landscape feature is now called Pu'u Hau 'Oki, Pu'u Kea, and Pu'u Wēkiu". This opinion is based on evidence that at least a part of the summit cluster was named for Kūkahau'ula, a figure who appears in legends about Mauna Kea as an 'aumakua (family deity) of fishermen (Maly 1998; Maly 1999). The names Kūkahau'ula, Lilinoe, and Waiau appear on an 1884 map of the region. In addition, Kūkahau'ula is given as the name of the highest peak in 1873. A detailed description of historically recorded names for the summit cluster is provided in the historic preservation plan for Mauna Kea (UH 2000b). NASA, in consultation with the SHPD, believes that this cluster of cones satisfies the criteria to be eligible for listing as an historic property in the National Register of Historic Places.

The SHPD has also stated that it intends to propose the summit region of Mauna Kea for inclusion in the National Register of Historic Places as a historic district, because "it encompasses a sufficient concentration of historic properties (*i.e.*, shrines, burials and culturally significant landscape features) that are historically, culturally, and visually linked within the context of their setting and environment" (SHPD 1999). Pu'u Hau 'Oki is a culturally significant landscape feature within the district. The boundaries of the district are recommended to coincide with the "extent of the glacial moraines and the crest of the relatively pronounced change in slope that creates the impression of a summit plateau surrounding the cinder cones at or near the summit (*i.e.*, generally above the 3,536 to 3,658-m (11,600 to 12,000-ft) contour)" (SHPD 1999).

Archaeological Properties. No individual archaeological sites have been identified within the proposed project area on Pu'u Hau 'Oki. Surveys prior to 1997 identified 93 archaeological sites within Mauna Kea Science Reserve. Seventy-six of the sites are shrines, four are adze manufacturing workshops with shrines, and three are markers. One burial site and four possible burial sites have also been identified outside the proposed project area, but within the Mauna Kea Science Reserve (McCoy 1999). Five sites are of unknown function.

Sites identified within Mauna Kea Science Reserve fall into several categories.

- <u>Shrines</u>: Shrines in the Mauna Kea Science Reserve are located on ridgetops or at breaks in the slope on the northern slopes near 3,962 m (13,000 ft), and on the eastern and southern slopes near 12,600 to 12,800 feet. Shrines have not been found on the tops of cinder cones (McCoy 1999).

- <u>Adze Quarrying and Manufacturing</u>: Although most of the sites associated with the Keanakāko'i quarry are located within the Mauna Kea Ice Age Natural Area Reserve, four adze manufacturing workshops have been found within the Mauna Kea Science Reserve. Each workshop also has one or more shrines (McCoy 1999).

- <u>Burials</u>: Within the Mauna Kea Science Reserve, one burial site has been identified on the summit of Pu'u Mākanaka (McCoy 1999). Four other possible burial sites also have been noted: one on the rim of Pu'u Lilinoe, and three on the rim of an unnamed cinder cone (McCoy 1999). In addition, oral histories refer to burials on the northern and eastern slopes of Mauna Kea (Maly 1999).

The Mauna Kea Ice Age Natural Area Reserve (NAR) to the south of the Science Reserve includes a number of sites such as those associated with Waiau, the Humu'ula Trail, and the Mauna Kea Adze Quarry.

Architectural Resources. No historic architectural resources have been identified within the Mauna Kea Science Reserve (PHRI 1999). The stone cabins at the Hale Pōhaku, south of the Science Reserve, are more than 50 years old and the SHPD considers them to be historic properties (SHPD 2001).

Cultural Values / Traditional Cultural Practices. Cultural values and traditional cultural practices include intangible resources that are important to a culture. Contemporary or neo-traditional cultural practices relate to current beliefs or practices.

Traditional cultural practices on Mauna Kea are associated with resource locations (*e.g.*, stone, water, hunting), trails, individual topographic features, burial locations, and cultural landscapes. A number of contemporary cultural practices have been identified. These include prayer and ritual observances, including the construction of new altars; subsistence and recreational hunting; and collection of stone from quarry sites within the Mauna Kea Adze Quarry (Maly 1998). The spiritual and cultural significance of Mauna Kea is described in detail in Maly (1998) and Maly (1999) as follows.

- Stone: Use of the Mauna Kea adze quarry complex (Keanakāko'i) was ongoing through the early 1800s until stone tools were replaced by metal tools. When local residents traveled to Mauna Kea in the 1930s and 1940s with their elders, the quarries were pointed out as one of the significant cultural features of the mountain.

- Water: The water of Waiau, in the Mauna Kea Ice Age Natural Area Reserve, has been associated with the god Kane and is considered important to the on-going practices of native healers and practitioners. Some families have been reported as taking the *piko* (umbilical cords) of their children to Lake Waiau.

- Hunting: Some families describe hunting on Mauna Kea, for both subsistence and recreation, as important.

- Trails: Oral historical evidence describes the use of trails, often by horseback, on Mauna Kea in the late 19^{th} and early 20^{th} century. Trails ascended Mauna Kea from most of the *ahupua'a* on its slopes. Many of the trails converged at Waiau. Interviews indicate that local elders traveled to Mauna Kea to worship in the summit region, to collect water from Waiau for healing, to procure stone for tool making, and to take cremated human remains to the summit or to Waiau.

- Topographic Features: A number of topographic features on Mauna Kea have cultural significance. Pu'u Kūkahau'ula (Pu'u Wēkiu, the summit peak of Mauna Kea) is identified as a repository of *piko* (umbilical cords) and of cremated remains, and is associated with navigational practices and historical surveys. Pu'u Poli'ahu and Pu'u Lilinoe are associated with Hawaiian goddesses considered to be ancestral to some Native Hawaiians local inhabitants.

- Burials: Oral histories describe burial sites in cinder cones and other natural features from about 2,134 to 3,658 m (7,000 to 12,000 ft) on Mauna Kea. Pu'u Mākanaka and the Kaupō vicinity are particularly noted as burial sites. In addition, modern use of the summit for the release of cremated remains has been reported in oral histories. While cremation of remains is not a traditional Hawaiian practice, taking a loved one's remains to a special landscape is an ancient Hawaiian custom that has adapted to allow for its continuation into modern times.

- Landscapes: Mauna Kea continues to be viewed as a place with spiritual and healing qualities. The summit of Mauna Kea has been referred to as *wao akua* (a region or zone of deities). It is so named because of the cloud cover which concealed from view the activities of the deities when they walked upon the land. It is the focal point of numerous traditional and historical Hawaiian practices and narratives. In earlier times, the area above the forest line was considered so sacred that one could not be pursued by enemies there. Some of the names for the mountain landscape are associated with Hawaiian gods, while others describe natural features and resources. The mountain region of Mauna Kea from about the 1,829-m (6,000-ft) elevation to the summit is considered a sacred landscape by some Native Hawaiians. Mauna Kea also has been described as the *piko* or origin point for the island of Hawai'i. According to Kanahele and Kanahele (1997), the three *pu'u* are named for three sister goddesses of water: Poli'ahu (snow); Lilinoe (mist); and Waiau (lake). Poli'ahu and Lilinoe are located within the Mauna Kea Science Reserve.

Navigational Traditions. Although the archival and historical literature does not refer to the features of Mauna Kea as being associated with navigational traditions, the deities associated with the mountain have celestial body forms and some were invoked for navigational practices.

3.11 SOCIOECONOMICS

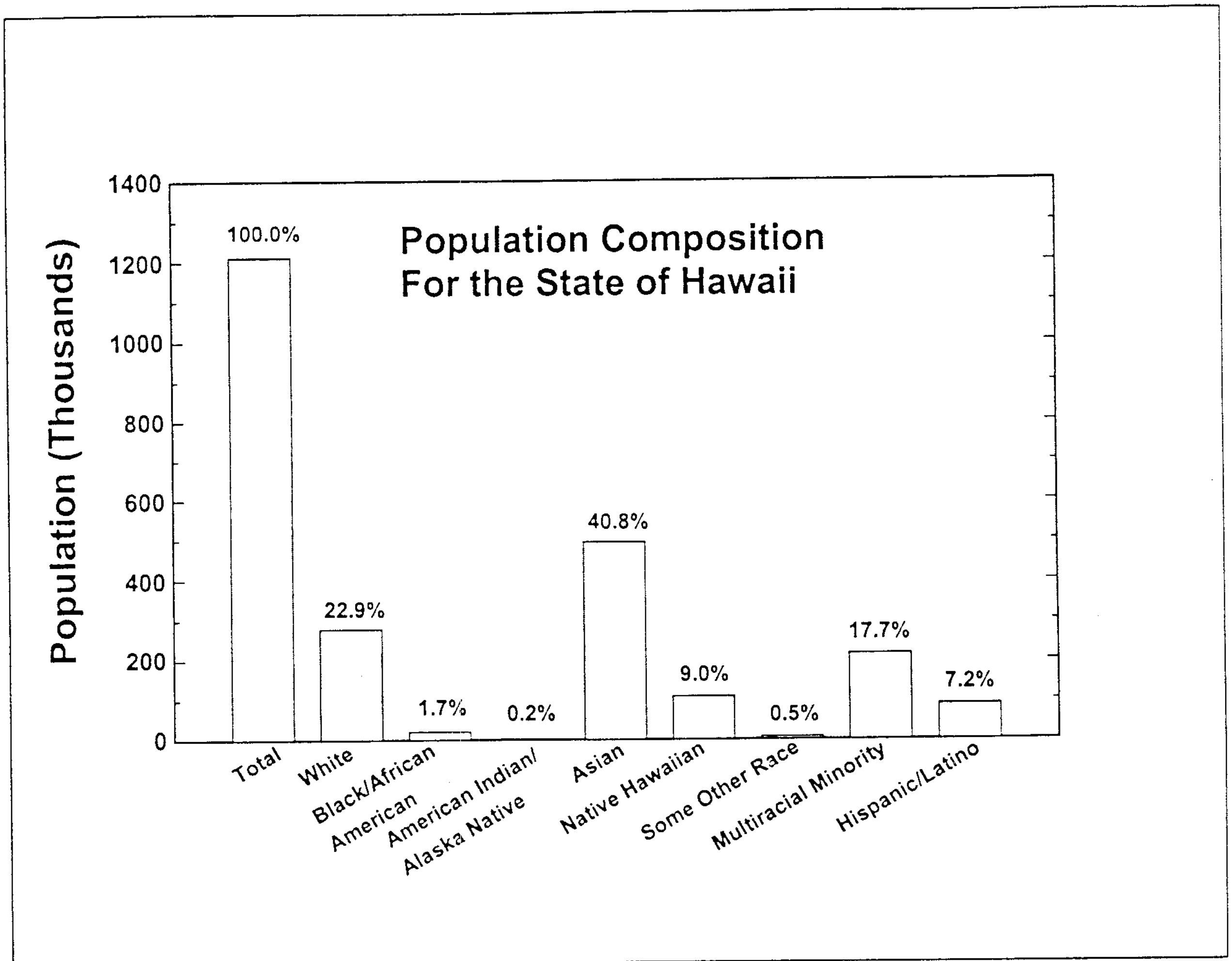
Introduction. Astronomy is an industry in Hawai'i and in particular on the island of Hawai'i because Mauna Kea offers exceptionally clear viewing conditions. The State and County have protected these conditions through the management of the summit of Mauna Kea and land use changes on the island of Hawai'i (*e.g.*, urban lighting) that could affect viewing.

Astronomers and scientific organizations throughout the world have responded by investing in observatories on the summit. In addition, UH has developed an undergraduate program in astronomy at Hilo and a graduate program at Manoa with the ability to create scientific instruments for viewing.

Demographics. Figure 3-1 shows the resident population for the State of Hawai'i determined in the decennial census of 2000 (USDOC 2000). The height of each bar in Figure 3-1 represents the population measured in thousands of persons. Percentages of the total population are shown above each bar. As indicated in the figure, over three-quarters of the population is composed of minority residents. Persons self-designated as Asian, Native Hawaiian or Other Pacific Islander, or multiracial (primarily Asian and Native Hawaiian) comprised approximately 67 percent of the total resident population.

Figure 3-2 shows similar information for the County of Hawai'i. Nearly 70 percent of the residents self-designated as Asian, Native Hawaiian or Other Pacific Islander, or multiracial comprised nearly 60 percent of the resident population of the County of Hawai'i.

The area surrounding Mauna Kea Science Reserve is relatively unpopulated. Figure 3-3 shows the population residing within 50 km (31 mi) of the reserve. Moving outward from the reserve, resident populations show relatively large increases as one approaches population centers in Waimea and Hilo.



Source: USDOC 2000

FIGURE 3-1. POPULATION FOR THE STATE OF HAWAI'I IN 2000

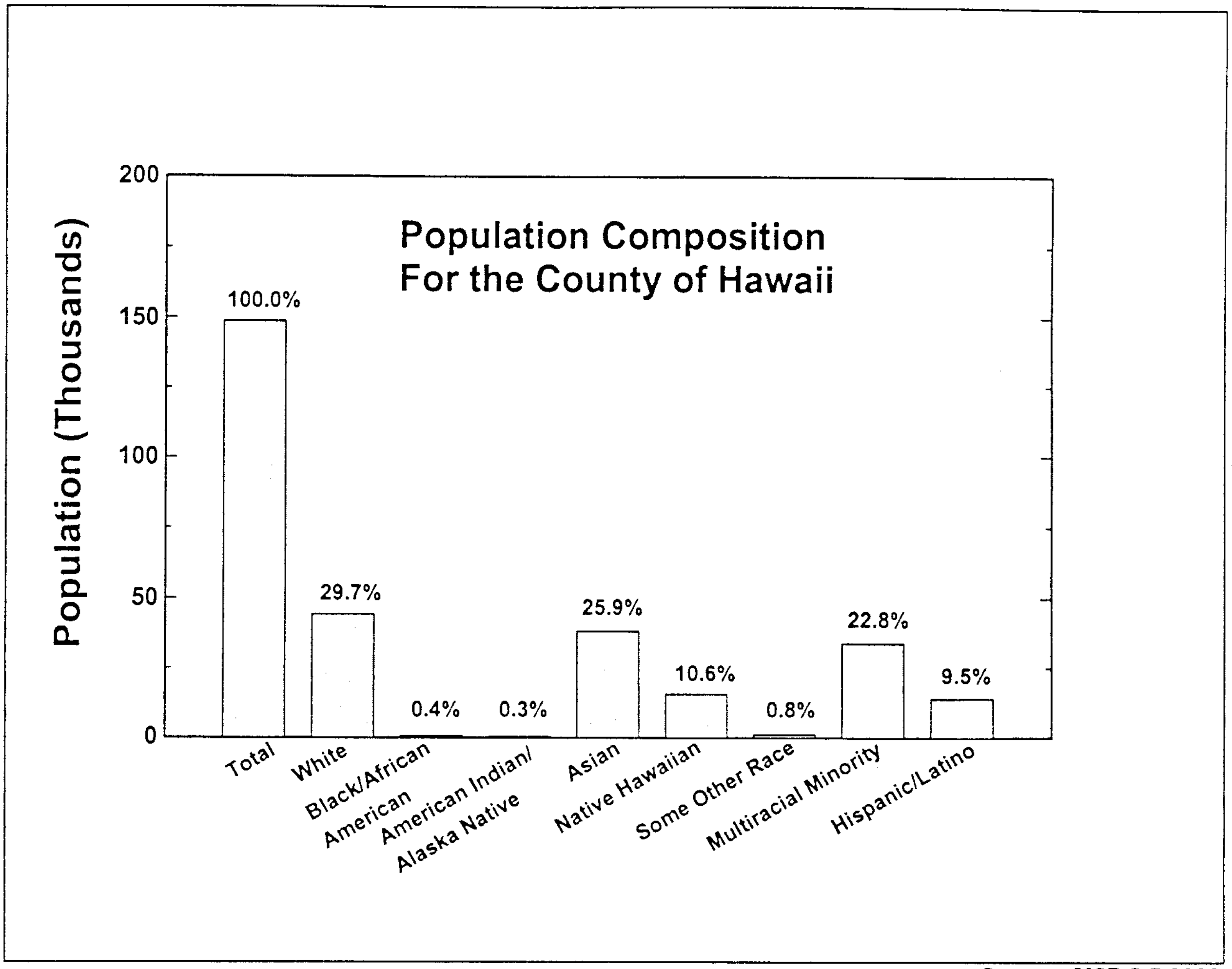
As shown in Table 3-5, population centers in Hilo and Waimea both experienced an overall increase in population during the decade between 1990 and 2000. During that decade, Waimea's population grew by approximately 18 percent, while Hilo's population grew by 8 percent.

Although the non-minority population in both areas declined, that decline was offset by growth in the minority populations. The enumeration conducted during Census 2000 showed that Waimea's population increased by approximately 1,000 to 7,028 residents. Waimea is the headquarters for the WMKO and since Waimea is a small town, approximately 7,000 residents in 2000, astronomy's role in the economic and demographic growth has been evident.

The summit of Mauna Kea and the Astronomy Precinct has a small transient population consisting of observatory staff and visiting scientists, but no permanent residents. In addition, tourist visits to the summit area and the Hale Pōhaku are increasing. Hikers and skiers also visit during favorable weather conditions.

Transient housing at Hale Pōhaku typically accommodates 30 visiting scientists and technicians.

The average visitor census for the County of Hawai'i increased during the 1980's and 1990's. The County of Hawai'i has attracted an increasing share of the State's visitors. In comparison



Source: USDOC 2000

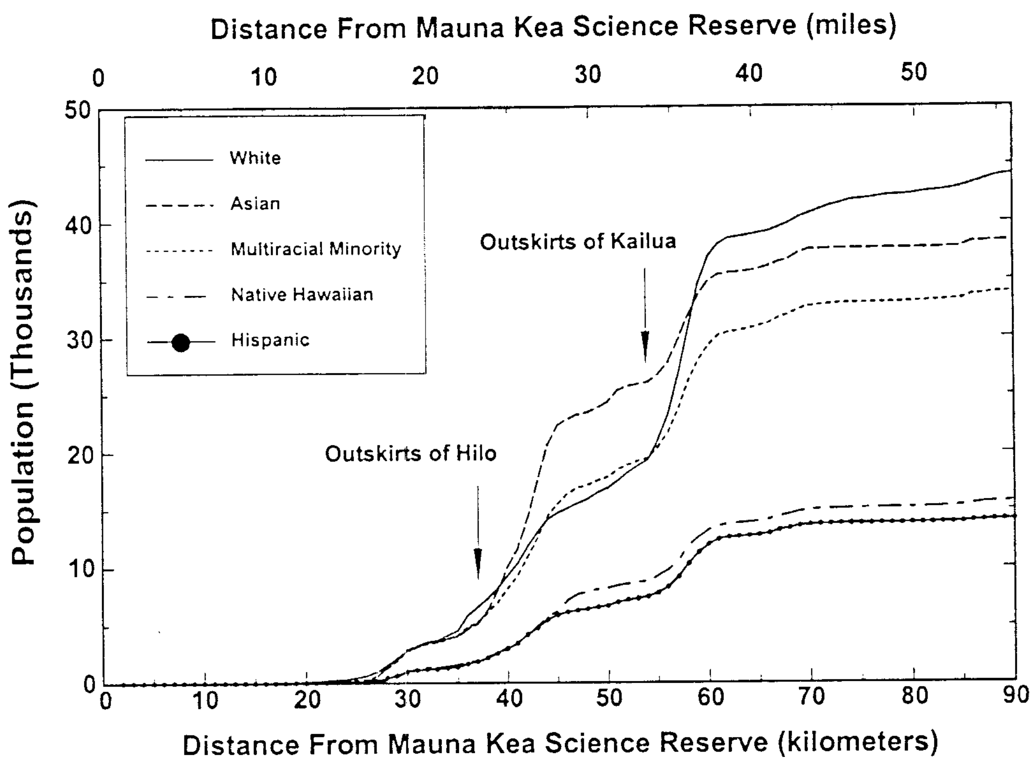
FIGURE 3-2. POPULATION FOR THE COUNTY OF HAWAI'I IN 2000

with 1999, visitor days for the island of Hawai'i declined by 3.7 percent in 2000 due to lower domestic and international arrivals. The average daily visitor census in 2000 was 21,831, approximately 4 percent less than the corresponding visitor census for 1999. Hale Pōhaku is visited by 100 or more visitors daily. Summit tours are increasing in number and growth in tourism on Mauna Kea is a large part of a trend towards active tourism on the island of Hawai'i.

Recreation Use. The Mauna Kea State Recreation Area is the only public park facility within the project vicinity. The Department of Land and Natural Resources (DLNR) Division of State Parks operates this facility. According to State Park records, the 15 cabins at Mauna Kea accommodated more than 12,500 user nights in fiscal year 1995-1996.

The Mauna Kea Support Services (MKSS), the UH-operated, observatory-funded organization that provides support services to the observatories, reports that 40,000 people per year make use of the Hale Pōhaku Visitor Information Station, which features astronomical and natural history exhibits and stargazing (UH 2000b). When Mauna Kea has snow, as many as 1,100 vehicles per day travel to the summit. Average traffic is about 100 vehicles per day.

Hunting is a long-standing tradition in Hawai'i. A number of censuses and ecological studies



Source: USDOC 2000

FIGURE 3-3. DISTRIBUTION OF POPULATIONS SURROUNDING THE MAUNA KEA SCIENCE RESERVE

have been conducted including work on the ecology and management of feral sheep on Mauna Kea (USDOT 2000). Census of feral sheep on Mauna Kea by DLNR in May 1997 counted 319 sheep. In the spring of 1997 DLNR initiated a program to reduce sheep numbers to below 150.

Economy, Employment, Expenditures, and Revenues. The average employed civilian labor force in the County of Hawai'i numbered 65,450 in 2000, an increase of 2,100 over the previous year. The County's average unemployment percentage declined from 8.7 percent in 1999 to 6.7 percent in 2000. Unemployment has been especially severe in areas where sugar plantations have closed such as Hamakua, North Hilo, and Kau Districts. The unemployment rate for the County of Hawai'i remains larger than that for the State of Hawai'i as a whole. During the same period, the State of Hawai'i's average unemployment rate declined from 5.6 percent in 1999 to 4.3 percent in 2000. Median household income in the County in 1997 was estimated to be $34,557, which is approximately $9,000 less than the median household income for the State as a whole.

TABLE 3-5. POPULATION TRENDS FOR HILO AND WAIMEA

Population	1990	2000	Percent Increase/Decrease
Hilo			
Minority	28,308	34,000	20.1
Non-Minority	9,420	6,759	-28.2
Total	37,728	40,759	8.0
Waimea			
Minority	3,718	4,964	33.5
Non-Minority	2,216	2,064	-6.9
Total	5,934	7,028	18.4

Source: USDOC 2001

From the construction of new astronomy facilities, to the employment of trained technicians, to the purchases made by visiting scientists, the astronomy industry has contributed substantially to the island of Hawai'i's economy. All of the telescopes on Mauna Kea have been built with funds coming from outside the State of Hawai'i. Typically, a minimum of one-third of the funds for construction and more than 80 percent of the operating funds are spent in Hawai'i, mostly on the island of Hawai'i. Currently the telescope facilities on Mauna Kea represent a total capital investment of over \$600 million dollars (not adjusted for inflation) and support nearly 500 direct operations jobs; the great majority of the jobs are located at base facilities in Waimea and Hilo (see Table 3-6). These jobs include astronomers, engineers and engineering technicians, software programmers, equipment technicians and administrative personnel.

Total economic activity (direct, indirect and induced) as a result of Mauna Kea observatories is estimated at \$130.9 million annually for the County and \$141.7 million annually for the State (UH 1999). Direct employment and expenditures associated with the operation of the telescopes in the Astronomy Precinct represent approximately \$61.1 million for the County and \$63 million for the State annually. Indirect economic expenditures occur when astronomy-related firms purchase goods and services from other firms. There are also induced expenditures by the astronomy workforce, which are spent in the local community. Construction costs for all facilities built total approximately \$826 million (converted to 1998 dollars). Roughly one fourth of the \$826 million, or over \$200 million was spent in the County of Hawai'i (UH 1999).

All jobs generated by observatory purchases from other firms and spending by the direct and indirect workforce results in about 750 jobs on the island of Hawai'i with a total payroll of about \$45 million, and with state-wide employment of about 820 jobs, generating a total payroll of approximately \$50 million (UH 1999).

Table 3-6 shows the capital and operating costs and employment generated by each telescope facility currently within the Astronomy Precinct.

3.12 VISUAL/AESTHETICS

The WMKO site at Pu'u Hau 'Oki is presently occupied by the two 10-m (33-ft) Keck Telescopes and associated domes and support structures and two temporary optical test mirrors (siderostats). The two Keck Telescope domes are each about 34-m (111-ft) high by 37-m (121.4-ft) wide, are white in color, comprising the most prominent visual feature at the WMKO

TABLE 3-6. MAUNA KEA OBSERVATORIES COSTS AND EMPLOYMENT BY FACILITY (2002)

Facility (mirror diameter in meters m=3.3 ft)	Capital Cost ($ million)	Annual Operating Cost ($ million)	County of Hawai'i Based Staff (No. of people)	Operational
UH 0.6-m Telescope (Optical)	0.3	a	a	1968
UH 2.2-m Telescope (Optical/Infrared)	5	1.3	8	1970
Canada-France-Hawai'i 3.6-m (Optical/Infrared)	30	6.2	50	1979
NASA IRTF 3.0-m (Infrared)	10	3.2	16	1979
United Kingdom 3.8-m (Infrared)	5	3.0	31	1979
James Clerk Maxwell 15-m Submillimeter	32	5.0	39	1986
Caltech 10.4-m Submillimeter	10	2.6	11	1986
WMKO (Keck I & II) 2- 10-m (Optical/Infrared)	170	11.0	115	1992/96
VLBA Antenna 25-m (Radio)	7	0.25	2	1992
Submillimeter Array 8 x 6-m[b]	80	6.0	36	2003
Subaru (Japan Nation Large Telescope) 8.2-m (Optical/Infrared)	170	15.0	70	1999
Gemini Northern 8.1-m (Optical/Infrared)	92	8.0	70	1999
Mauna Kea Observatories Support Services	Not applicable	2.4[c]	28	N/A
Total	611	61.6	476	—

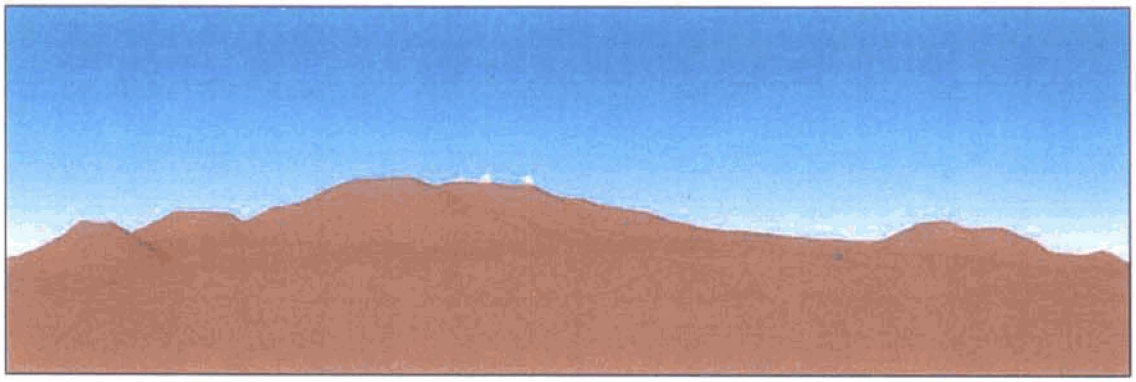
Source: UH IfA 2002

a. Combined budget and staffing with UH 2.2-m Telescope.
b. Under construction.
c. Not included in the total since derived from facility operating funds.

site. The two siderostats are much smaller structures located on the southeast side of the Keck II Telescope. Each siderostat consists of a small covered structure about 2.4-m (8-ft) wide by 4.9-m (16-ft) long and 3.1-m (10.25-ft) high. The siderostats will be removed.

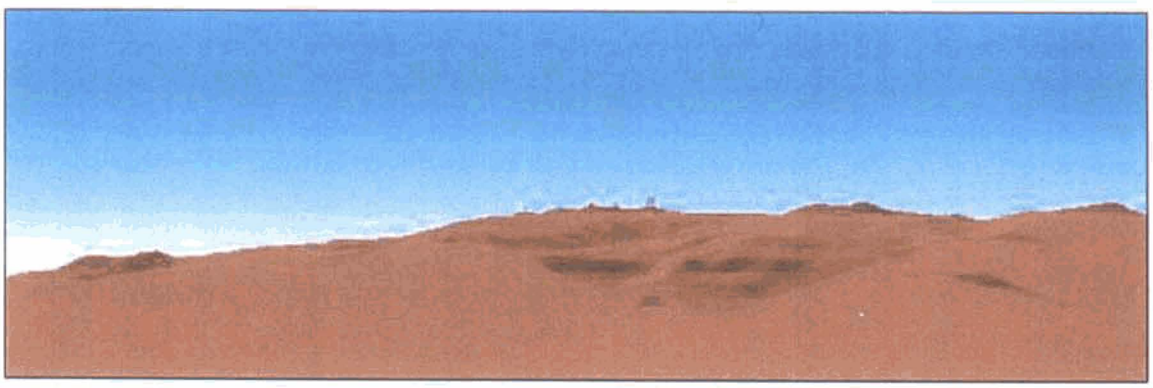
The existing Keck I and Keck II Telescopes, as well as the other existing telescope facilities within the Astronomy Precinct, are generally visible from within the summit area. Below the summit, the view of these facilities from the access road is typically blocked by the topography of the mountain (UH 2000b). Some of the existing facilities are visible from lower elevation areas such as Hilo, Honoka'a, and Waimea (see Figure 3-4). The twin Keck Telescopes are not visible from the city of Hilo. The proposed Outrigger Telescopes would be barely perceptible from areas where the Keck domes are visible.

The facilities at Hale Pōhaku consist of the astronomy support facilities and construction camp facilities, all of which are generally visible from the access road (UH 2000b). These facilities have been sited and constructed to follow mountain contours and colored to blend with the surrounding features. The single-story construction camp facilities are located to avoid the existing *māmane* trees. Materials and roof colors of the newer facilities were chosen to blend with the surrounding terrain.



Existing View from Hilo

Existing View from Honoka'a



Existing View from Waimea

Source: UH 1999

FIGURE 3-4. EXISTING VIEWS

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4 ENVIRONMENTAL CONSEQUENCES

4.1 POTENTIAL ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION

The National Aeronautics and Space Administration's (NASA's) Proposed Action is to fund the on-site construction, installation, and operation of six Outrigger Telescopes at the W.M. Keck Observatory (WMKO) site. It is anticipated the on-site construction and installation of four of the six Outrigger Telescopes, along with on-site construction of the underground structures for Outrigger Telescopes 5 and 6, will begin in 2002 (upon issuance of all State and local permits and approvals), with start of operations anticipated in 2003. If funding is available, NASA intends to complete the on-site construction, installation, and operation of Outrigger Telescopes 5 and 6, with on-site construction and installation likely to begin in 2007.

This Chapter presents information on the potential environmental impacts of the Proposed Action and the No-Action Alternative, which were highlighted in Chapter 2. The environmental impacts are examined for (1) on-site construction and installation, and (2) operation.

4.1.1 Regional Land Use

The State Land Use Commission has established the boundaries for four State Land Use Districts throughout the State: Urban, Rural, Agriculture, and Conservation. The Mauna Kea Science Reserve is located in a Conservation District. The County of Hawai'i Land Use Allocation Guide map also designates the area as conservation. The State Board of Land and Natural Resources is responsible for the regulation of land uses within the Conservation District. It has established four types of subzones (general, resource, limited, and protective), within the Conservation District based on the resource characteristics and adopted regulation identifying permitted uses and permitting requirements. The Mauna Kea Science Reserve is contained entirely within the Resource subzone. On-site construction, installation, and operation of an astronomy project such as the Outrigger Telescopes would be consistent with uses permitted in the Resource subzone.

The proposed on-site construction, installation, and operation of the Outrigger Telescopes would also be consistent with the recently adopted Mauna Kea Science Reserve Master Plan (UH 2000b).

A Coastal Zone Management Act compatibility determination does not apply to NASA's proposed action (State Office of Planning 2000b).

4.1.2 Climate/Meteorology/Air Quality

Small, but measurable, short-term air pollution impacts would occur during the on-site construction and installation of the Outrigger Telescopes and dome enclosures. Dames & Moore completed an analysis of the air quality impacts from on-site construction of the Outrigger Telescopes (Dames & Moore 1999b).

Short–term on-site construction effects would come from exhaust emissions from construction equipment and vehicles, and fugitive dust emissions from earthmoving activities.

On-Site Construction and Installation Impacts. The emissions associated with construction activities would be short-term in duration and would end once the Outrigger Telescope on-site construction is complete. Receptors of air emissions could include humans, ecological receptors and observatory equipment and optics that are sensitive to dust concentrations. Potentially affected persons include construction workers, scientists, staff and occasional visitors to the area.

Fugitive dust would be generated from excavation and vehicle movement on unsurfaced roadways. Dust would result from the excavation of approximately 918 cubic meters (m^3) (1,200 cubic yards (yd^3)) of cinder to install about 274 m (900 ft) of light pipe and air pipe trenches, and approximately 1,835 m^3 (2,400 yd^3) of cinder from excavation for telescope footings, dome foundations, and light tunnels.

Earthmoving activities would generate dust amounts that can be estimated based on the area disturbed and the period of construction. Underground site work for the six Outrigger Telescopes currently proposed would require about 15 construction workers for approximately 9 months. On-site construction and installation of the remaining two Outrigger Telescopes would likely begin in 2007, and would require about half the labor required for the initial four Outrigger Telescopes.

The EPA's recommended methodology (AP-42 Section 13.2.3 (USEPA 1995)) was used to estimate fugitive dust emissions given available information for construction equipment (Dames & Moore 1999b) and soil data (HLA 1991). Using updated information on the potential equipment needs for the Outrigger Telescopes Project and a revised installation schedule, the fugitive dust emissions of particulate matter (PM_{10}) from the Proposed Action are estimated to be 0.70 mt (0.77 tons) for the peak construction year. This estimate does not take into account for planned mitigation measures.

Table 4-1 summarizes the estimated maximum construction air pollutant emissions calculated and presented in the Dames & Moore analysis. The analysis used conservative assumptions. A maximum construction crew size of 15 workers during a nine month period with an additional 12 workers overlapping the construction work by six months to assemble and enclose the dome was assumed. Each worker was assumed to drive a private, light-duty, gasoline-fueled vehicle to the summit work site. This is a conservative assumption, because workers would likely car-pool. In addition, workers were assumed to commute about 120-km (75-mi) per day to and from Hilo or Waimea. This also may be conservative if workers remain at Hale Pōhaku during the workweek. It was further assumed that four heavy-duty, diesel trucks (cement, water, flatbed trucks, etc.) would make 1,000 trips (over the life of the project), the same distance to the project construction site. Other equipment would remain on-site and be used according to the schedule presented in the report (Dames & Moore 1999b). Emissions from equipment that were indicated to be operated more than nine months of the year in the Dames & Moore report (Dames & Moore 1999b) were reduced to account for the compressed operating schedule. Other equipment not originally considered in the Dames & Moore report were added using the same references as were used in the Dames & Moore report. Representative types of equipment were selected for the analysis and the total usage was estimated (Dames & Moore 1999b).

Carbon monoxide (CO) and nitrogen oxide (NO_x) emissions would be expected from on-site construction equipment and from vehicles of construction workers and motorized construction equipment traveling to and from the summit. Much of the vehicular emissions of CO and volatile organic compounds (VOC) would be emitted over the approximately 120 km (75 mi) of

TABLE 4-1. SUMMARY OF THE ESTIMATED MAXIMUM CONSTRUCTION AIR POLLUTANT EMISSIONS (IN TONS PER YEAR-TPY)

Sources	Carbon Monoxide (CO)	Volatile Organic Compounds (VOC)	Nitrogen Oxides (NO_x)	Sulfur Oxides (SO_X)	Particulate Matter (PM_{10})
Fugitive Dust Emissions	—	—	—	—	0.77
Equipment Emissions	2.29	0.56	4.63	0.41	0.58
Vehicular Emissions	8.57	1.03	1.26	Negligible	Negligible
Total	10.86	1.59	5.89	0.41	1.35
Significance Threshold	250	250	250	250	250

Source: Adapted from Dames & Moore 1999b

roadways between the Mauna Kea summit area and locations such as Hilo and Waimea, with much of this occurring below the typical inversion layer of about 2,134 m (7,000 ft). The impact of construction emissions would therefore largely be a regional effect as opposed to a site-specific impact. The estimated emissions of all pollutants including localized fugitive dust emissions are anticipated to be well below the significance levels of 250 TPY for suspended particulate and combustion emissions (Dames & Moore 1999b).

The installation activities associated with the Outrigger Telescopes primarily involve transport of the telescope dome enclosures and telescopes to the W.M. Keck Observatory (WMKO) site by flat bed trucks. The expected emissions from these activities, including localized fugitive dust and exhaust emissions from the trucks, would remain below the significance threshold for particulate and combustion emissions.

Summit wind velocity usually ranges between 16 and 24 kilometers (km) (10 and 15 miles (mi)) per hour with speeds exceeding 160 km (100 mi) per hour during severe storms (Dames & Moore 1999b). Dust ash and cinder disturbed during excavation could be carried by these winds and deposited on adjacent slopes. It is possible that excessive dust could impact Wēkiu bugs (a candidate for listing under the Endangered Species Act) and their habitat as well as existing telescope mirrors and other sensitive equipment. Dust control would therefore be imperative at the observatory site. Dust control measures that would be implemented are described under mitigation measures.

Operation Impacts. Air quality at the Astronomy Precinct and Hale Pōhaku would return to virtually the existing conditions once the Outrigger Telescopes Project on-site construction and installation is completed. There would likely be a slight increase in vehicular traffic and emissions associated with scientists and Outrigger Telescopes Project staff traveling on the unsurfaced section (roughly 7.2 km (4.5 mi)) of the roadway from Hale Pōhaku to the project site. Overall air quality at Mauna Kea would remain very good, due to the low intensity of use and the substantial winds that blow most of the time. The Outrigger Telescopes operation would not change these conditions.

Mitigation Measures. The short-term effects on air quality would be mitigated by requiring the construction contractor to strictly comply with the State Department of Health (DOH) Administrative Rules and the County of Hawai'i grading permit. In addition, the California Association for Research in Astronomy (CARA) has made a commitment to NASA that the following mitigation measures would be implemented and made part of any construction contracts.

Dust Controls: The potential exists for blowing dust from the on-site construction and installation of the Outrigger Telescopes to affect not only the existing telescope facilities at the WMKO site, but also Wēkiu bug habitat, historical/cultural resources, and potentially, biological habitat further downwind. The following dust control measures would be implemented.

1. Water will be applied to excavation sites and cinder stockpiles as required to minimize dust during earthmoving activities. Potable water for dust suppression would be transported to the site and applied as needed during trenching, bulldozing or other soil disturbance activities. The applied water would not be expected to cause any negative impact to the Wēkiu bug and may actually be beneficial (see Appendix D—Wēkiu Bug Mitigation Plan). It is possible that application of water to excavation sites could increase the amount of moisture available for Wēkiu bugs.

2. Dust generation will be minimized during construction to the extent practicable. Only small or contained areas will be affected at any given time.

3. Storms and accompanying high winds can arise quickly at the summit. These winds are capable of raising dust from recently exposed cinder and ash. Dust-generating activities would be suspended during periods of high winds, and water would be applied to recently exposed cinder and ash.

4. Application of environmentally-safe soil stabilizers may be applied to roads and parking areas to reduce dust during and after on-site construction. Environmentally-safe soil stabilizers would only be used in situations where the application of potable water is inadequate for dust control.

   Soil stabilizers will be applied under light wind conditions to prevent cinder dust drift due to wind into Wēkiu bug habitat. Products considered for use will be reviewed by an entomologist familiar with Wēkiu bug ecology prior to being considered for use.

5. Cinder or ash will be moved to temporary stockpile areas and, if needed, covered with tie-down tarps. Permanent placement of any excavated cinder fill and ash from the project area during on-site construction will be determined in consultation with the State Historic Preservation Division (SHPD) and the Office of Mauna Kea Management (OMKM).

Other mitigation measures would include requiring contractors to properly maintain construction vehicles and equipment to minimize combustion emissions. Engine emissions would be controlled by the use of functional emission devices as required by law. Equipment idling would be kept to a minimum when not in use.

4.1.3 Noise

On-Site Construction and Installation Impacts. On-site construction and installation of the Outrigger Telescopes would involve noise associated with excavation, trenching, grading, installation of sheet piling for utility protection, installation of junction boxes, construction of light and air pipes, the construction of telescope dome foundations, and the installation of telescopes and domes. The various construction phases of the project would periodically generate increased levels of noise. The actual noise levels would be dependent upon the mix and duration of construction equipment usage and the construction methods employed. The vibrating hammer, which would be used to install the sheet piling required for utility protection, would most likely be the loudest piece of equipment used during construction (approximately 95 A-weighted decibels (dBA) at 15 m (50 ft)). It is anticipated that the use of this equipment would be short-term, lasting one or two days in duration. There would be no blasting during the construction process. Noise from completion of on-site construction and installation of Outrigger Telescopes 5 and 6 would be comparable to the first four Outrigger Telescopes.

No substantial or long-term adverse effects from construction noise would be anticipated. Because of the location and distance of the Outrigger Telescopes, the on-site construction on the summit area of Mauna Kea would be far from potentially noise-sensitive fixed uses. The only people potentially affected during on-site construction and installation periods would be the scientists, staff, and visitors to the summit area. A small increase in traffic noise would occur at Hale Pōhaku.

Operation Impacts. There would be only slight noise from operation of the Outrigger Telescopes.

Mitigation Measures. Short-term noise impacts would be minimized through the use of construction equipment and vehicles with proper noise muffling devices in good working order. Impacts of high noise levels on construction workers would be mitigated by adherence to appropriate Occupational Safety and Health Administration (OSHA) standards. The construction contractor(s) would be required to strictly comply with State Department of Health Administrative Rules.

4.1.4 Geology, Soils, and Slope Stability

On-site Construction and Installation Impacts. Soil investigations in the Pu'u Hau 'Oki revealed volcanic cinder deposits to depths of at least 40 m (130 ft) (HLA 1998; HLA 1990). No special care or problems would be predicted for excavation of these soils for Outrigger Telescope foundations and underground facilities. No instances of surface or subsurface instability have been reported at or near the project site (Dames & Moore 1999a).

Initially, Outrigger Telescopes 3 and 4 and Junction Box (JB)-5 at Outrigger Telescope 2 were proposed for location within one to 1.5 m (3 to 5 ft) laterally from the edges of slopes that are 2:1 or steeper. Because the additional loads imposed by these structures could cause localized slope instabilities under static or seismic conditions, civil engineers with the consulting engineering firm of Harding Lawson Associates (HLA) conducted a slope stability analysis. HLA recommended geotechnical design criteria for the Outrigger Telescopes (HLA 1998). To provide a stable configuration under anticipated additional loadings, the HLA study recommends that the existing slopes be extended to provide a level setback distance from the edges of the domes to the edges of the new slopes. In lieu of extending existing slopes, the HLA report states that a retaining wall could be used to provide a stable configuration. HLA estimates that a minimum level set-back distance of 1.8 m (6 ft) from the edge of the domes to the edges of the new slopes would be required to provide a stable configuration. The HLA report provides foundation design criteria recommendations. The report recommends that all foundations should be supported on recompacted cinder. Isolated and continuous footing should be at least 46 and

30 centimeters (cm) (18 and 12 inches (in)) respectively. Ring wall footings should be designed for an allowable bearing pressure of (48,000 newtons (N) per square meter (m^2)) (1,000 pounds (lb) per square foot (ft^2)) for dead plus long term live loads. For total loads including wind and seismic, the allowable bearing pressure should be increased by 50 percent. The report also provides recommendations for resistance to lateral loads by friction and passive soil resistance.

Adherence to HLA design criteria should eliminate these risks. Proper construction in accordance with appropriate engineering specifications and recommendations contained in the HLA report and in current civil engineering design drawings and specifications would avoid the potential for slope stability risks and impacts (HLA 2000).

Utilizing the HLA recommendations several design and grading concepts for Outrigger Telescopes 3 and 4 and JB-5 that would provide the necessary slope stability while minimizing potential adverse effects to the natural and cultural resources of Pu'u Hau 'Oki, have been re-evaluated. The current design is described in Section 2.1.3.3. It should be noted that the current design has relocated JB-5 to less than 0.9 m (3 ft) from Outrigger Telescope 2. Thus JB-5 is now proposed to be located even farther from the edge of the slope (roughly 3.5 m (11.5 ft)) ensuring greater slope stability protection and greatly reducing Wēkiu bug habitat disturbance (see Section 4.1.6).

On-site construction and installation of Outrigger Telescopes 5 and 6 would occur well within the area that was previously graded and leveled for construction of Keck I and Keck II. There would be no special engineering design application required for Outrigger Telescopes 5 and 6.

The main objective of each design and grading concept has been to maintain the existing profile of Pu'u Hau 'Oki. Cost and engineering factors have also been considered in meeting this objective. In order to ensure protection of environmentally sensitive areas (*i.e.*, Wēkiu bug habitat), a natural resources specialist has been retained and has conducted reviews of the grading and site development drawings to ensure that appropriate mitigation measures would be incorporated to avoid impact to Wēkiu bug habitat during on-site construction. In addition, staff of the SHPD, as well as several Native Hawaiian organizations, have been afforded the opportunity to review the grading and site development drawings which minimize potential impacts to the integrity of the Pu'u Hau 'Oki cinder cone.

Material obtained from project excavations would be used for fill, or Wēkiu bug restoration habitat at the site. It should be noted that for this project all excavation material not directly used as fill or for Wēkiu bug restoration would be placed on the mountain at locations to be determined after consultation with SHPD and OMKM.

Mitigation Measures. CARA has committed to, and NASA would ensure that the following mitigation measures would be implemented during on-site construction and installation of the Outrigger Telescopes.

1. Under no circumstances during construction, installation, or operation will cinder or other materials be deliberately side-cast into Wēkiu bug habitat. Temporary barriers will be built along the slope breaks above the inner slopes of Pu'u Hau 'Oki crater.
2. Educational signs will be placed along the slope break above Wēkiu bug habitat, and at the service road adjacent to the crater floor. Attractive, non-intrusive, educational signs will be installed to inform people about the Wēkiu bugs, their habitat, and the historic/cultural

significance of the area. Signs will help prevent unintentional disturbance of habitat by workers and visitors.

3. Strict adherence to precautions and procedures outlined in the construction Best Management Practices Plan (BMP) would be required to maintain slope stability.

4.1.5 Hydrology and Water Quality

Pu'u Hau 'Oki is located at the high altitude portion of two drainage systems, the Pōhakuloa Gulch drainage basin from the summit to the southern side of the mountain, and the Ku'upaha'a Gulch drainage basin on the northern side (see Section 3.5). The Pōhakuloa Gulch system includes the septic system leach field located on the southern side of Pu'u Hau 'Oki (see Appendix H). This system also includes the Submillimeter Valley construction staging area and the washing zone for cinders (tephra) being prepared for Wēkiu bug habitat restoration.

Sediment at the summit and upper slopes is only transported mechanically by surface water systems during storms and periods of rapid snow melt, *i.e.*, when there is surface water flow (see Appendix H). To assist in evaluating the potential impact of on-site construction and installation activities on sediment transport from the summit area, the amount and type of cinder soils to be uncovered during construction was estimated and compared to the probable magnitude of naturally occurring sediment transport (see Appendix H).

As currently proposed, about 1,200 yd^3 (918 m^3) of cinder soil would be excavated on Pu'u Hau 'Oki to install light and air pipes and junction boxes. Another 2,400 yd^3 (1,835 m^3) of material would be excavated for footings, underground telescope instrumentation rooms, and Outrigger Telescopes 5 and 6. The total amount of cinder to be excavated would thus be 3,600 yd^3 (2,753 m^3). Approximately 50 percent of the excavated material (about 1,800 yd^3 (1,376 m^3)) would be used as backfill. The remaining 1,800 yd^3 (1,376 m^3) would be taken to the Submillimeter Valley for screening and grading in preparation for Wēkiu bug habitat restoration on Pu'u Hau 'Oki. Screened cinder of suitable size for Wēkiu bug habitat restoration would be washed. The remaining cinder would be placed on the mountain at locations to be determined after consultation with SHPD and OMKM.

No discernable increase in erosion and transport of mechanical sediment load by surface water flows would be expected as a consequence of construction, stockpiling, and cinder washing if the following guidelines are employed (see Appendix H). Cinder soils to be used as backfill should be protected in piles until used. Cinder soils to be stockpiled in other areas on the summit must be placed in regions away from ephemeral channels and in a manner that minimizes the surface area of exposed materials. The optimum configuration would be to maintain the same surface area/volume ratio for the stockpiled materials as existed before excavation.

Chemicals that may be accidentally spilled at the construction or construction staging sites would remain in the upper few meters of the surface until flushed by ephemeral saturated ground water flows generated by storms and rapid snow melts (see Appendix H). The reasons are that: (a) except for Lake Waiau, shallow subsurface materials at the summit are not saturated with water (*i.e.*, the system is within the vadose zone, the zone where water does not fully occupy pores in the cinder and cracks in rocks), except during storms and rapid snow melt events; and (b) the transport of dissolved materials within the vadose zone is extremely slow (10 to 1,000 times as slow) as compared to saturated flow. Thus, storms and rapid snow melts, which saturate the upper few meters of the surface, would be required for transport of dissolved materials down hill as ground and surface flows. Storms and rapid snow melt events are rare and most of these events occur during the winter season. Thus, surface and subsurface flow would be maximized during this season. Immediate response and clean up would mitigate any problems associated with entry into and transport by the ephemeral ground and surface water systems.

A modest increase 9,463 liters/month (2,500 gal/month) of sewage effluent associated with the WMKO facilities would be expected once the Outrigger Telescopes are in operation. The septic system for the WMKO facilities is on the southern side of Pu'u Hau 'Oki, *i.e.*, within the Pōhakuloa Gulch drainage basin. The small effluent discharge, combined with microbially-induced oxidation, would preclude the possibility of down hill contamination.

The Submillimeter Valley (construction staging area) is part of the drainage basin that feeds the Pōhakuloa Gulch (see Appendix H). Washing volcanic cinder in the Submillimeter Valley staging area for the Wēkiu bug habitat restoration would be the primary mode by which additional water would be introduced into the natural hydrologic system from the staging areas. Washing would be done with potable water and would add only very small amount of water to the upper portion of the Pōhakuloa Gulch drainage system. Assuming that about 18 percent of the excess excavated cinder screened and graded would be suitable for Wēkiu bug habitat restoration, about 248 m^3 (about 8,800 cubic feet (ft^3)) of suitably sized cinder would be washed. Assuming a ratio of one gallon of wash water per cubic foot (134 liters/m^3) of cinder, about two tanker truck loads (about 33,232 liters (about 8,800 gal)) of water would be required. With a 50- cm/year (20-inches/year) precipitation rate into the Submillimeter Valley above the washing station, approximately 222.5 million liters (58.7 million gal) of water would be added to that portion of the basin naturally. The water added for washing would thus comprise 1/6,700 of the annual water budget. More conservatively, if the average summit precipitation rate is assumed (15 cm/year (6 inches/year)) (Cruikshank 1986), then the ratio would decrease to 1/2,000 of the annual budget, still a small fraction. Screening and grading volcanic cinder in the Submillimeter Valley staging area for the Wēkiu bug habitat restoration would produce unsuitable cinder that is too fine-grained to be of use for Wēkiu bug habitat restoration (see Appendix H). Assuming an 82 percent rejection rate after screening and grading of about 1,376 m^3 (48,587 ft^3) of cinder, approximately 1,128 m^3 (39,830 ft^3) of unsuitable cinder would be produced. To minimize the erosion and transport of these materials the unsuitable cinder will be placed in locations away from ephemeral channels and in a manner that minimizes the surface area/volume ratio of the stockpiled material.

Hale Pōhaku (construction staging area) is located on the southern slope of Mauna Kea at an elevation of approximately 2,835 m (9,302 ft). It is within a drainage system that extends down slope to feed a number of channel systems. This system is not connected to the Pōhakuloa Gulch basin and thus is not connected to the WMKO facilities or the Submillimeter Valley.

Mitigation Measures. The following mitigation measures would be implemented by CARA and ensured by NASA during on-site construction and installation of the Outrigger Telescopes.

1. Adherence to dust control measures presented in the Wēkiu Bug Mitigation Plan (Appendix D) and conditions contained in the County of Hawai'i grading permit would minimize any potential for windblown dust.

2. Contractors will be required to minimize the amount of on-site paints, thinners, and solvents. Painting and construction equipment will not be cleaned on-site. Contractors will be required to keep a log of hazardous materials brought on-site and report spills immediately to a designated WMKO representative.

3. The amounts of such materials transported to the summit will be those required to support the current activity.

A small increase in surface runoff would result from additional impervious surfaces associated with the on-site construction of the Outrigger Telescopes. Existing drainage control features and those that would be installed with the addition of the Outrigger Telescopes (*e.g.*, building foundations and construction areas would be graded to drain away from any natural or artificial slopes, access roadways or other sensitive facilities), coupled with the highly permeable volcanic cinder soils, would easily accommodate increased surface runoff, and would preclude surface erosion and drainage impacts.

4.1.6 Biological Resources and Threatened and Endangered Species

On-Site Construction and Installation Impacts. As noted in Section 3.6, the environment of the high elevation summit area cinder cones including Pu'u Hau 'Oki is harsh. There are no floral species at the WMKO site. Consequently, on-site construction and installation of up to six Outrigger Telescopes would have no impact to this component of the natural environment of this summit area cinder cone.

Vegetation is also sparse within the elevations of the Mauna Kea Science Reserve below the summit cinder cones. Traffic along the Access Road in these lower elevation areas, particularly the heavy truck traffic that would be associated with the Outrigger Telescopes Project, may result in some dust deposition on roadside vegetation. This is expected to be short-term and temporary given that the increase in daily traffic would amount to only about 15 round trips each day, and heavy vehicular traffic would be confined largely to the mobilization and demobilization periods of the on-site construction and installation cycle. On-site construction and installation of the Outrigger Telescopes would not result in any adverse effect to vegetation at the approved construction laydown and storage areas.

The one Federally-listed plant species known to inhabit Mauna Kea above 3,132 m (9,000 ft) (the Mauna Kea Silverswords listed as endangered) would not be impacted by on-site construction and installation given that the only known population of this species occurs at the Wailuku river basin outside of the Mauna Kea Science Reserve, well away from the WMKO site. The fern, *Cystoperis douglasii*, considered a species of concern by the USFWS does not occur on the summit area cinder cones and is not expected to be affected by Outrigger Telescopes on-site construction and installation.

The area of the WMKO site, that was leveled for construction of the Keck I and Keck II Telescopes, is subject to daily use for WMKO activities including vehicle parking and foot traffic, and does not harbor substantial resident populations of any of the eleven resident Hawaiian arthropod species known to inhabit the summit area cinder cones (see Section 3.6). Most of the on-site construction and installation activity for four Outrigger Telescopes, and all of those activities for Outrigger Telescopes 5 and 6, would occur within that area (see Figure 2-6). Thus, on-site construction and installation of the six Outrigger Telescopes within that previously disturbed area of the WMKO site would not be expected to adversely impact any of the eleven species of resident Hawaiian arthropods known to inhabit the summit area cinder cones, including the Wēkiu bug, a candidate for listing under the Endangered Species Act.

On-site construction and installation of Outrigger Telescope 1 would occur on a gradually sloped portion of the leveled area that was previously graded and disturbed for construction of the Keck I and Keck II Telescopes (see Figure 2-6). No Wēkiu bugs were found in the leveled area during the 1997/98 sampling effort (see Section 3.6). On-site construction and installation of Outrigger Telescopes 2, 3, and 4, however would also involve activities on the previously disturbed sloped wall area of the cinder cone immediately adjacent to the leveled area of the WMKO site. While the sloped areas of the cinder cone wall adjacent to the WMKO site were previously disturbed during construction of the Keck I and Keck II Telescopes, Wēkiu bugs were determined by the 1997/98 survey (Section 3.6) to be inhabitants of the sloped cinder cone wall areas near Outrigger Telescope 2 and Outrigger Telescope 3.

On-site construction and installation of an air pipe and a retaining wall needed for slope stability at JB-5 near Outrigger Telescope 2, and at Outrigger Telescope 3 would result in loss of a small amount of the sloped cinder cone wall that is Wēkiu bug habitat in those areas. Specifically, at JB-5 near Outrigger Telescope 2, the air pipe and retaining wall would extend into and displace about 0.003 ha (0.008 ac) of the sloped area habitat (CARA 2001) (see Figure 2-10). At Outrigger Telescope 3 the air pipe and retaining wall would displace about 0.006 ha (0.015 ac) of the sloped wall area Wēkiu bug habitat (see Figure 2-12).

Outrigger Telescope 4 would require placement of its air pipe and a retaining wall within a steeply sloped portion of previously disturbed sloped cinder wall area on the north-eastern side of the WMKO site (see Figure 2-12). However, the 1997/98 arthropod sampling effort (Section 3.6) did not find any Wēkiu bugs in this area.

On-site construction and installation would not adversely impact fauna at lower elevations within the Mauna Kea Science Reserve including the endangered seabird, the *'ua'u*, suspected to occur at mid-elevations near Pu'u Kanakaleonui, and the two Federally endangered bird species, the *palila* and the *'akiapolā'au*, inhabiting the *māmane* forest below the Mauna Kea Science Reserve.

Operation Impacts. The Outrigger Telescope activities that potentially could adversely affect the environment would be additional traffic to and from the WMKO site, increases in hazardous materials use, hazardous waste management, housekeeping and trash management, and the potential introduction of alien arthropods to the summit area in shipments to the WMKO site. The area of the WMKO site, that was leveled for construction of the Keck I and Keck II Telescopes, is subject to daily use for WMKO activities including vehicle parking and foot traffic, and does not harbor substantial resident populations of any of the eleven resident Hawaiian arthropod species known to inhabit the summit area cinder cones (see Section 3.6).

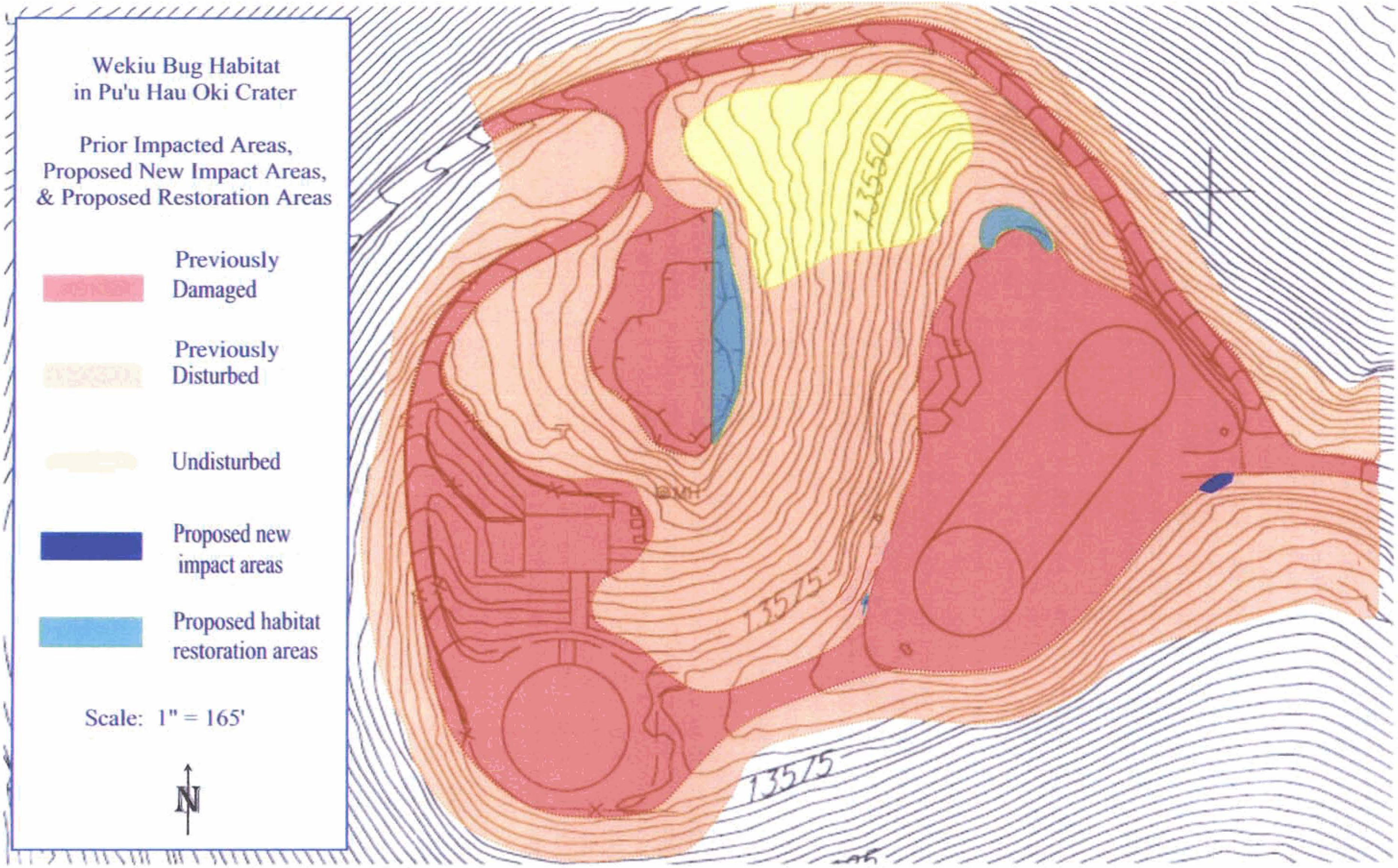
Applicable mitigation measures specified in the Wēkiu Bug Mitigation Plan would be implemented during Outrigger Telescopes operation (see Appendix D). Therefore, operation of the Outrigger Telescopes would have little potential for substantial adverse effects on species within the summit area and the Astronomy Precinct. Operations activities would also not adversely affect plant or animal resources within the lower elevations of the Mauna Kea Science Reserve. No Federally listed threatened or endangered species of plants or animals would be adversely affected by operation of the Outrigger Telescopes. The small amount of additional traffic to the summit that would be associated with Outrigger Telescope operation would generate negligible amounts of dust.

Mitigation Measures. Populations of the Wēkiu bug appear to have declined throughout the summit area when comparing 1982 and 1997/98 data for the same sampled areas (see Section 3.6). Given that: (1) on-site construction and installation of Outrigger Telescopes 2 and 3 would disturb and displace currently occupied Wēkiu bug habitat on the sloped area of the cinder cone wall; and (2) other on-site construction, installation, and operation activities could also impact the Wēkiu bug, the Wēkiu Bug Mitigation Plan (see Appendix D) has been designed to assist in reducing or avoiding those impacts. This plan includes measures to minimize habitat disturbance, control dust, hazardous materials, trash, and the potential for importation of alien arthropods during on-site construction and installation, as well as recommendations for Wēkiu bug habitat restoration as mitigation, to replace the habitat that would be displaced by on-site construction and installation of Outrigger Telescopes 2 and 3. Implementation of the plan would also reduce potential impacts on the other ten Native Hawaiian arthropods known to inhabit the summit area. A comprehensive monitoring plan has been developed to ensure contractor compliance to the Mitigation Plan and measure the effectiveness of restoration efforts. The Wēkiu Bug Monitoring Plan is referenced in Appendix E.

The Wēkiu Bug Mitigation Plan and its requirements will be incorporated into Outrigger Telescopes on-site construction and installation contracts, and compliance would be monitored and enforced by CARA. In addition, a qualified entomologist would periodically be on-site to review implementation of the proposed mitigation measures. Development of the Wēkiu Bug Mitigation Plan has also resulted in design changes to reduce the disturbance of Wēkiu habitat: Outrigger Telescope 1 has been relocated about 4-m (13.2-ft) closer to the Keck II Telescope than originally proposed; temporary barriers would be used during on-site construction and installation activities at JB-5 and Outrigger Telescopes 1 and 3 to prevent loose material from being sidecast and impacting Wēkiu bug habitat downslope; and JB-5 has been relocated to less than 0.9 m (3 ft) from Outrigger 2, minimizing disturbance to the crater wall. Retaining walls would be used at Outrigger Telescope 3 and JB-5 to further minimize habitat disturbance. The retaining walls would be constructed of cinder-colored masonry or reinforced concrete to blend with the surrounding land.

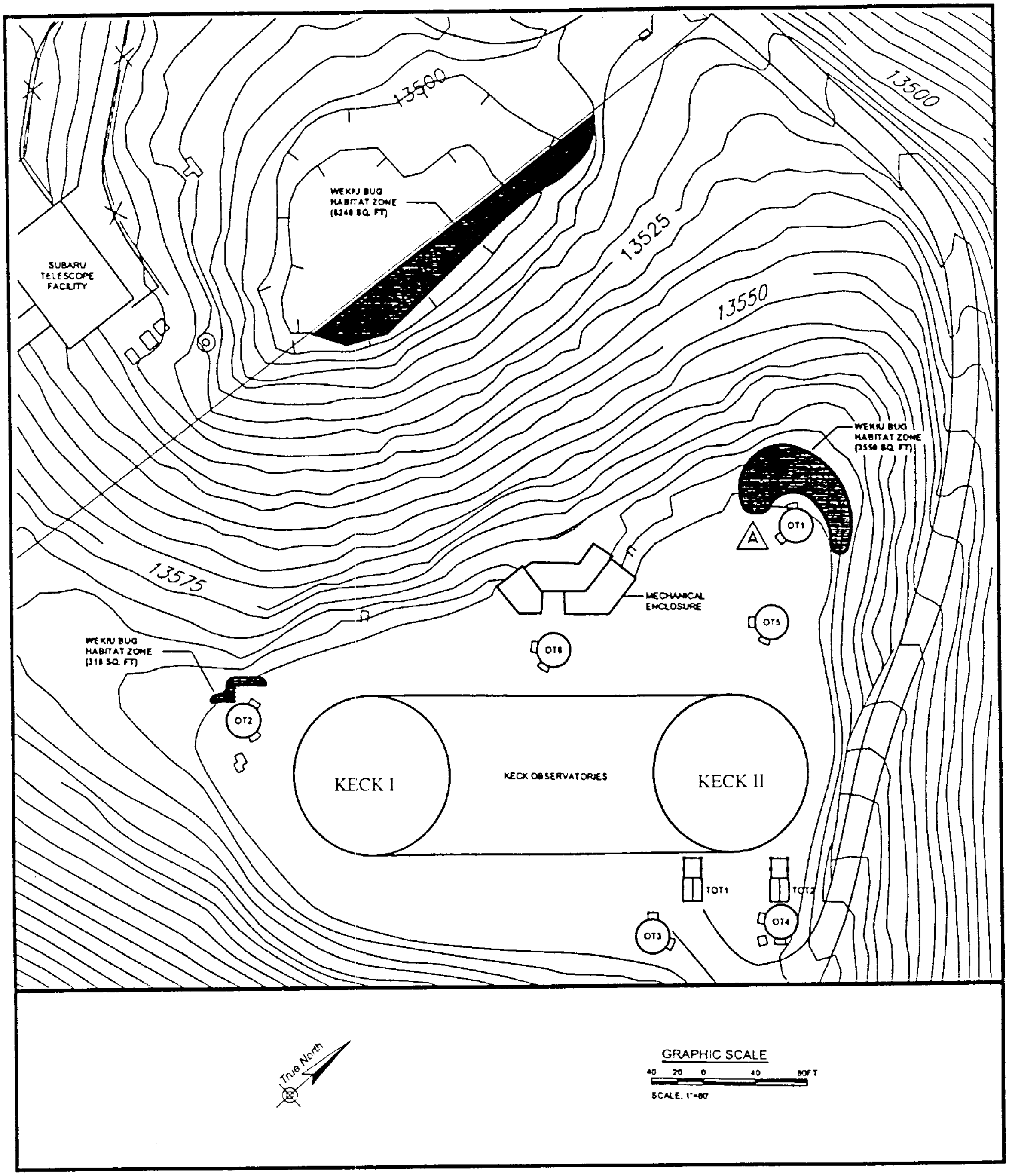
A key element of the Wēkiu Bug Mitigation Plan is restoration of Wēkiu bug habitat. The habitat restoration portion of this plan has been developed in conjunction with the USFWS, and would restore habitat on the WMKO site and at the bottom of the crater (see Figure 4-1). The proposed restoration effort would encompass an area totaling about 0.028 ha (0.069 ac) resulting in a habitat restoration ratio of at least 3:1 relative to the amount of habitat area that would be displaced by on-site construction and installation of Outrigger Telescopes 2 and 3. The intent is to make it possible for the Wēkiu bug to establish resident populations within the restored areas. The restored habitat would be monitored by a qualified entomologist for about 18 months following completion of the proposed habitat restoration to determine if the Wēkiu bug reestablishes itself in those areas. NASA and CARA have proposed Wēkiu bug habitat restoration within a portion of the crater bottom that was previously damaged by observatory construction on Puʻu Hau ʻOki (Figure 4-2).

The proposed restoration activity would use cinder excavated for the Outrigger Telescopes as the habitat restoration medium. All cinder not used for backfill or site grading would be screened to obtain suitably-sized cinder which would then be washed and spread at JB-5 in a layer about 30-cm (12-inches) deep. This is believed to be within the desired depth range for Wēkiu bug habitation (Pacific Analytics 2000). Additional screened and washed cinder would be spread at the crater bottom to accomplish the 3:1 commitment. If additional suitably-sized cinder remained, the restoration of the crater bottom area would continue possibly completing the 557-m^2 (6,000-ft^2) area. If additional cinder still remains, restoration may then occur north of Outrigger Telescope 1 until the supply of suitably-sized cinder is exhausted or the restoration of



Source: Pacific Analytics 2000

FIGURE 4-1. WĒKIU BUG HABITAT IN PU'U HAU 'OKI CRATER



Source: W.M. Keck Observatory 2001

FIGURE 4-2. PROPOSED WĒKIU BUG RESTORATION HABITAT FOR THE OUTRIGGER TELESCOPES PROJECT

Outrigger Telescope 1 is completed. As noted above, the restoration area would be monitored for establishment of Wēkiu bugs by professional entomologists.

Placement of any excess excavated material at other locations on Mauna Kea from on-site construction and installation of all of the Outrigger Telescopes (1 through 6) would be undertaken only after consultation with the SHPD and OMKM (see Appendix C, Memorandum of Agreement).

The habitat restoration protocol has been based on the best scientific information available about the habitat needs of the Wēkiu bug. The protocol is based on the following information.

1. Wēkiu bugs appear to prefer habitat made of loose cinder 1.3 centimeters (cm) (½ inch) in size or larger. In past studies (Howarth and Stone 1982; Howarth and others 1999), the highest concentration of Wēkiu bugs were collected in habitat consisting of 25 to 38 cm (10 to 15 inches) of 1.3 cm (½ inch) size or larger cinder, with an impenetrable ash layer below the cinder. This information leads us to conclude that restored habitat consisting of 30 to 46 cm (12 to 18 inches) of loose 1.3 cm (½ inch) size or larger cinder will be acceptable to Wēkiu bugs.

2. Wēkiu bug habitat occurs on undisturbed portions of crater floors in summit cinder cones (Howarth and Stone 1982; Howarth and others, 1999). In 1982, 6,230 Wēkiu bugs were collected on the crater floor of Pu'u Wēkiu and 430 Wēkiu bugs were collected on the crater floor of Pu'u Hau 'Oki. During the 1997/98 arthropod assessment, Wēkiu bugs were found on the crater floor of Pu'u Wēkiu and Pu'u Hau 'Oki, and on the inner slopes of Pu'u Hau 'Oki adjacent to the crater floor. Since suitable habitat does not exist on the crater floor of Pu'u Hau 'Oki, Wēkiu bugs from the adjacent inner slopes apparently migrate to the crater floor. This information leads us to conclude that Wēkiu bugs would likely occupy restored habitat on the floor of Pu'u Hau 'Oki.

3. Given sufficient time, Wēkiu bug habitat appears to recover from disturbance. Of all sites sampled during the 1997/98 arthropod assessment, habitat on the slopes below W.M. Keck Observatory that was disturbed during construction contained the highest concentration of Wēkiu bugs. This information leads us to conclude Wēkiu bugs would eventually occupy that restored habitat.

Given the information above, it is believed that habitat restoration will succeed in expanding the current Wēkiu bug population. As part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology, to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors. New information may be used to modify the habitat restoration protocol to increase its effectiveness.

The Wēkiu Bug Monitoring Plan is referenced in Appendix E and is briefly described below.

The Wēkiu Bug Monitoring Plan was developed to aid in the protection and enhancement of the Wēkiu bug population, and is consistent with the goal of good stewardship of the natural environment on the summit of Mauna Kea. The Monitoring Plan specifies methods for measuring the results of actions undertaken in the Wēkiu Bug Mitigation Plan, and the subsequent changes in the Wēkiu bug population and habitat. Two types of monitoring will be implemented: compliance and effectiveness monitoring. Compliance monitoring investigates the extent to which contractors, operators, managers, and visitors comply with Wēkiu bug protection guidelines and rules. Effectiveness monitoring investigates the changes in Wēkiu bug habitat and population that happen concurrently and subsequently to construction of the Outrigger Telescopes. This includes monitoring of habitat restoration efforts. The Wēkiu Bug Monitoring Plan specifies tasks, schedules, and methods for both types of monitoring.

The Compliance Monitoring section is based on the commitments made in the Wēkiu Bug Mitigation Plan to protect Wēkiu bugs and their habitat. Compliance Monitoring will measure adherence to guidelines set for slope stability and habitat protection, habitat restoration, control of dust and trash, avoiding spills of hazardous materials, and cleaning construction equipment and material before transport to the summit. Monitoring for compliance with guidelines will give the operators, oversight agencies, and the public the information necessary to ensure that natural resources are protected during the Outrigger Telescopes Project.

Effectiveness monitoring will investigate the changes in the Wēkiu bug population and habitat that happen concurrently with construction and operation of the Outrigger Telescopes. Effectiveness monitoring measures the success of the environmental controls adopted and mitigation treatments undertaken in conserving the Wēkiu bug.

4.1.7 Seismic Activity

Several strong earthquakes have historically occurred in the Hawaiian Islands. These seismic events appear to be associated with displacement along faults on the Molokai fracture zone and the rifts and deep slump zones on the flanks of the Mauna Loa and Kilauea volcanoes (Kingery 2000).

The largest recorded earthquake in Hawaii was the Great Ka'u Earthquake on April 2, 1868, estimated at magnitude 7.9 (USGS 2000). This event was centered near the southern end of the island of Hawai'i, and destroyed over 100 homes. Eighty-one lives were lost. A magnitude 7.2 earthquake occurred beneath Kalapana in the southeastern portion of the island of Hawai'i on November 29, 1975, and caused land subsidence and seaward displacement of the coast as much as 8 m (26 ft) (Lipman and others 1985).

4.1.8 Existing Uses and Transportation

4.1.8.1 Existing Uses

The Mauna Kea Science Reserve has been designated in the recently adopted Mauna Kea Science Reserve Master Plan as a multi-use resource, and presently supports a variety of scientific, cultural, and recreational uses (UH 2000b) (see Section 3.8.1). The Outrigger Telescopes, located in the Astronomy Precinct of the Mauna Kea Science Reserve, would lie within that area of the Reserve designated for astronomy activities and would be consistent with that use.

4.1.8.2 Transportation

On-Site Construction and Installation Impacts. Traffic to the summit area would be associated with on-site construction and installation, service vehicles, telescope personnel, cultural practitioners, Mauna Kea Support Service personnel, and visitors. At a maximum, the construction worker traffic is expected to add 15 trips during the morning and evening peak periods. Additional construction traffic, service vehicles, heavy truck loads, flat bed trailer loads of telescope components from Hilo or Waimea for assembly on the project site would also be expected (UH IfA 1999).

This increase in traffic in the area during on-site construction and installation would be minimal as most heavy construction equipment would be stored on site during the construction period. Some delay of traffic on the Mauna Kea Access Road could be expected when the telescopes and domes are trucked up the mountain. This traffic would only occur intermittently and thus should not regularly interfere with normal traffic flow. While construction vehicles are slow and difficult to maneuver, they would not be expected to have any long-term impact on either the road or overall traffic flow.

The potential impact of on-site construction and installation of Outrigger Telescopes 5 and 6 would be comparable but proportionately less. No long term impact on either the Mauna Kea Access Road or overall traffic flow would arise from on-site construction of Outrigger Telescopes 5 and 6.

Mitigation Measures. Transport of major observatory components would cause a short-term disruption of traffic along the route. In order to minimize negative effects, appropriate traffic control measures would be taken, and all trips of heavy oversized loads, such as those transporting the telescope components, would be scheduled during off-peak hours so as not to interfere with normal traffic flow in Kawaihae, Waimea, or along the Saddle Road.

Operation Impacts. An estimated 2 to 3 two-way vehicle trips per day and about 1 two-way vehicle trip per night along the Mauna Kea Access Road would be required during the operations phase of the Proposed Action. No mitigation measures would be required for this slight increase in traffic.

4.1.9 Services, Facilities and Waste Management

4.1.9.1 Water Supply

On-Site Construction and Installation Impacts. On-site construction of four to six Outrigger Telescopes would result in an increase in the demand for potable water due to the increased number of workers at the site, and the implementation of dust controls. This additional water would be transported to the summit area by the construction contractor(s). Thus, there would be no impact on the existing water system at the WMKO site.

Operation Impacts. Current water consumption at the WMKO is typically 11 kl (3,000 gal) per week for all purposes. Supplying water for three to four personnel at the summit would not require additional water tanker trips nor would its use impact the island water supply (UH IfA 2001a).

Mitigation Measures. No mitigation measures would be required.

4.1.9.2 Wastewater Collection, Treatment, and Disposal

All potable water is disposed of in the WMKO septic system (see Section 3.9.2). The septic/leach field system that currently serves the WMKO will be able to accommodate the additional 9.5 kl (2,500 gal) per month of wastewater generated by project personnel and no on-site impacts would be anticipated.

Potential off-site impacts from wastewater effluent on the basal fresh water lens is extremely unlikely due to the small effluent volumes and the great depth of the basal fresh water lens. This basal fresh water lens is thousands of feet below the surface in the summit area of Mauna Kea. See Section 3.5 for more details.

Mitigation Measures. No mitigation measures would be required.

4.1.9.3 Solid Waste and Hazardous Materials Handling, Storage, and Disposal

Solid Waste. On-Site Construction and Installation Impacts. On-site construction activity would generate waste debris consisting of wood, scrap insulation packaging material, waste concrete, and various other construction materials. Typically this construction debris would be disposed of in large "roll-off" containers that can accommodate waste and debris generated over several days of construction. No other waste material resulting from the construction process would be disposed of in these containers. The construction storage and collection receptacles/bins would be removed from the summit by the construction contractor to an approved landfill site.

Occasional high winds at the summit potentially could extract construction debris from the containers and disperse the material onto Wēkiu bug habitat or into the surrounding slopes of Pu'u Hau 'Oki. Unsecured building materials and equipment could also be susceptible to wind dispersal in the surrounding area.

Operation Impacts. Operation of the Outrigger Telescopes would not generate substantially greater solid wastes than that currently generated by operation of the Keck I and Keck II Telescopes.

Mitigation Measures. The Outrigger Telescope on-site construction and installation contract(s) would contain provisions regarding the management of solid wastes, including measures to secure those wastes against dispersal by high winds (see Appendix D). Examples of such provisions include but are not limited to:

1. Construction containers will be tightly covered to prevent construction wastes from being blown or dispersed by wind. Covering the containers with heavy tarps would protect against construction material being blown into Wēkiu bug habitat or falling onto the surrounding slopes of Pu'u Hau 'Oki. Containers would be equipped with cables to secure the tops and lids to ensure that no debris escapes during high winds.

2. Construction materials stored at the site will be covered with tarps or anchored in place, and not be susceptible to movement by wind.

3. Outdoor trash receptacles will be secured to the ground, have attached lids and plastic liners, and be collected frequently to reduce food availability for alien predators.

4. If construction materials and trash are blown into Wēkiu bug habitat or fall onto the surrounding slopes of Pu'u Hau 'Oki, they will be collected to the extent practicable, with minimum disturbance to the habitat and cultural properties.

Hazardous Materials. On-Site Construction and Installation Impacts. Some hazardous materials may be used during the on-site construction and installation of the Outrigger Telescopes. For example, paints, thinners, solvents and fuel may be transported to the WMKO for specific construction activities.

Operation Impacts. Operation of the Outrigger Telescopes would require periodic maintenance, cleaning and recoating (or aluminizing) of the telescope mirrors and lubrication of ball bearings throughout the facility and the dome weather seals. The maintenance, cleaning, and recoating activities for the Outrigger Telescopes would follow the same procedures and practices as for the Keck I and Keck II Telescopes (see Section 3.9.3). Increased quantities of lubricant, chemical solutions, and water used to remove old aluminum coating would be required for the Outrigger Telescope mirrors. The maintenance activities and the increased quantities of compounds for mirror recoating are discussed below. No mercury would be used for the Outrigger Telescope mirrors, instruments, or other facilities.

Lubrication of Ball Bearings (and Dome Weather Seal). The mechanical elements of the Outrigger Telescopes have ball bearings. The bearings will require periodic lubrication accomplished by injecting lubricant into the bearing. As the new lubricant is injected, "old" lubricant will seep out of the bearing. The "old" lubricant will be removed by wiping with rags.

Mirror Cleaning and Recoating. The mirror cleaning and recoating procedures used to remove the old aluminum coating on the Keck I and Keck II Telescopes are described in Section 3.9.3. The Outrigger Telescope primary mirrors would require cleaning and recoating in the same manner as the Keck mirror segments. Thus, there would be an addition of up to six Outrigger Telescope mirrors to the existing 72 Keck Telescope mirror segments that would require cleaning and recoating on a periodic basis. WMKO may decide to wash the Outrigger Telescope mirrors once per year using a soap and water solution (no hazardous chemicals) and only recoat them every two to three years at the same interval for recoating of the Keck mirror segments. The Outrigger Telescopes would also contain smaller optics ranging in size from very small, 25 millimeters (mm) (1 inch) up to 0.5 m (1.6 ft). The smaller optics also would need to be cleaned periodically and recoated, but since they would be in more protected environments, recoating would only be required on approximately four-year intervals. The smaller optics could have protected silver coatings or gold coatings.

The procedure that would be used to remove the old aluminum coating and apply a new aluminum coating on Outrigger Telescope mirrors would be the same as described in Section 3.9.3 for the Keck Telescope mirror segments. The active ingredients in the aluminum removal solutions would be the same substances discussed in Section 3.9.3. As stated in Chapter 3, Section 3.9.3, the rinse water from the aluminum removal process would be collected, removed, and transported off the site.

Mitigation Measures. Only the amount of hazardous materials that will be used for a particular activity will be transported to the WMKO, thus minimizing the amount of hazardous materials on-site and decreasing the risk of a spill. Painting equipment would be cleaned off-site to reduce the risk of a spill.

4.1.9.4 Electrical Power and Communications

The electrical power requirements of each Outrigger Telescope are estimated to be 30 kilowatts (kW). Four Outrigger Telescopes would require 120 kW and six would require approximately 180 kW. The existing peak load at the Hale Pōhaku substation for all facilities on the summit (including Keck I and Keck II) is approximately 2,000 kW. Peak electrical demand at the WMKO site is currently 440 kW and the operation of the Outrigger Telescopes will increase this by about 41 percent to 620 kW. Peak electrical power usage at WMKO, with the two Keck Telescopes and the six Outrigger Telescopes in operation, would be about 62 percent of its existing 1,000 kW capacity (UH IfA 2001a). The Mauna Kea summit has spare electric power capacity to accommodate the additional construction and operation of all six Outrigger Telescopes. The addition of four to six Outrigger Telescopes would not have an adverse effect on the electrical supply to the WMKO or the Astronomy Precinct.

The communications system for Mauna Kea and Keck I and Keck II has adequate capacity to accommodate the addition of the Outrigger Telescopes. Additional fiber optic cable systems would be installed to interlink the Keck Telescopes and the Outrigger Telescopes into a functionally integrated system.

Mitigation Measures. No mitigation measures would be required.

4.1.9.5 Emergency Services and Fire Protection

Section 3.9.5 discusses the emergency services and fire protection procedures and equipment in use at the Keck I and Keck II Telescopes at the summit.

On-Site Construction and Installation Impacts. The need for emergency services is related to the number of personnel at the summit and the types of work or activities they perform. As described in Section 2.1.3.8, during the period of Outrigger Telescope on-site excavation, a maximum of 15 construction workers would be needed for approximately 9 months. Twelve workers would be required for about 7 months to test and assemble the telescopes. The nature of construction work inherently presents potential risks for accidents and injury. The construction contractor would have the primary responsibility for insuring worker safety. In the event of an injury or accident, the existing emergency preparedness plan and evacuation equipment and procedures that apply to the WMKO and all observatories at the summit would be adequate to provide on-site treatment or evacuation off the summit. No additional equipment, personnel, or modification of emergency procedures are anticipated to be required during on-site construction.

Operation Impacts. As described in Section 2.1.4.1, Outrigger Telescopes operations would require the addition of four new personnel at the WMKO. Existing emergency services and procedures would be adequate to accommodate this small increase in personnel.

The Outrigger Telescopes would include fire alarm systems and suppression equipment similar to those in use at Keck I and Keck II. No special fire suppression or response equipment or procedures would be required for operation of the Outrigger Telescopes. The additional personnel would follow established procedures and would be included in existing WMKO fire drills and annual fire safety training.

Mitigation Measures. No mitigation measures would be required.

4.1.10 Cultural Resources

Impact Assessment Process. This section identifies the impact assessment process for archaeological and traditional cultural resources. This cultural impact assessment includes information relating to the practices and beliefs of Native Hawaiians. Information has been obtained through scoping, Town Hall meetings, Section 106 consultation meetings, and supplemented with existing ethnographic interviews and oral histories (see Section 3.10.4). No historic architectural resources are present within the area of the Proposed Action (PHRI 1999); therefore architectural resources are not evaluated here.

Historic Properties. In a letter to the University of Hawai'i (UH) dated May 3, 1999, SHPD for the first time, formally stated, "...we have come to believe that the cluster of cinder cones which merge and collectively form the summit of Mauna Kea is an historic property and that this single landscape feature probably bore the name Kūkahau'ula. This single landscape feature is now called Pu'u Hau 'Oki, Pu'u Kea, and Pu'u Wēkiu. Several lines of evidence lead us to the conclusion that the cluster of cones is an historic property. ...Given our conclusion that Pu'u Hau 'Oki is part of an historic property, we believe the proposed construction of four to six outrigger telescopes on the site of the WMKO will have an "adverse effect" both on this historic property and on the summit region that we believe is eligible for inclusion in the National Register as an historic district. ...We believe, however, that these "adverse effects" can be mitigated if appropriate measures are adopted..." (See Appendix B) (SHPD 1999).

SHPD believes that the summit region is eligible for inclusion on the National Register of Historic Places (NRHP) as a historic district because "it encompasses a sufficient concentration of historic properties (*i.e.*, shrines, burials and culturally significant landscape features) that are historically, culturally, and visually linked within the context of their setting and environment" (SHPD 1999). Pu'u Hau 'Oki is a culturally significant landscape feature within the district. The boundaries of the district are recommended to coincide with the "extent of the glacial moraines and the crest of the relatively pronounced change in slope that creates the impression of a summit plateau surrounding the cinder cones at or near the summit (*i.e.*, generally above the 3,536 to 3,658-m (11,600 to 12,000-ft) contour)" (SHPD 1999).

In response to the May 3, 1999 letter, NASA contacted and solicited comments from Native Hawaiian organizations and other interested parties. NASA used input from the SHPD and the State of Hawai'i Office of Hawaiian Affairs (OHA) to help identify Native Hawaiian organizations that might be interested in the proposed project. NASA has participated in several meetings hosted by Native Hawaiian organizations. NASA received comments at those forums not only from the host organizations, but also from representatives of other Native Hawaiian organizations and individuals.

Based on the information in the letter from the SHPD, and comments received from Native Hawaiian organizations and individuals, NASA concurred with the SHPD that the cluster of cinder cones of which Pu'u Hau 'Oki is a component be considered a historic property and the summit region of Mauna Kea be considered a historic district eligible for listing on the NRHP. Furthermore, based on such information and comments, NASA concluded that the proposed Outrigger Telescopes project would have an adverse effect on this historic property and this historic district. It should be noted that, even prior to formally initiating the Section 106 process under the National Historic Preservation Act (NHPA), NASA had informally started the process with Native Hawaiian organizations.

Section 106 Consultation Process. Pursuant to the regulations under the NHPA, NASA proceeded with the Section 106 process. NASA initially formally invited four Native Hawaiian organizations to act as Consulting Parties. NASA invited Hui Mālama I Nā Kūpuna o Hawai'i Nei to participate because this organization is specifically referenced in the NHPA. The Hawai'i Island Burial Council, OHA (also specifically referenced in the NHPA), and the Royal Order of Kamehameha I, were invited because of their demonstrated interest and concern about the proposed project. NASA also invited the Advisory Council on Historic Preservation (ACHP) who agreed to participate in the Section 106 process. Two more Native Hawaiian organizations later requested and were given Consulting Party status: Ahahui Ku Mauna and Mauna Kea Anaina Hou.

NASA has also consulted with and invited the OMKM, the Mauna Kea Management Board, and Kahu Ku Mauna to participate in the development of the mitigation measures under the Section 106 process.

As a part of the Section 106 consultation process, NASA prepared on-site and off-site cultural mitigation proposals for consideration by the SHPD, ACHP, and the other Consulting Parties. On-site mitigation measures that were proposed include stabilization of the cinder cone slopes, prevention of accidental dispersal of debris during and after on-site construction, disposition of excavated material, and reduction of noise during on-site construction and operation of the Outrigger Telescopes. Also included were monitoring and other measures that would prevent or minimize deterioration of the visual integrity (*i.e.*, shape and contour) of the cinder cone and its crater. One such measure is for the commitment to provide the Consulting Parties with the opportunity to review and comment on the grading and site development drawings and the construction Best Management Practices plan for the proposed project.

A formal Section 106 meeting was held on February 1, 2001 in Hilo. In addition, NASA held a second Section 106 meeting in Hilo on January 16 and 17, 2002.

Final mitigation measures have been specified in a Memorandum of Agreement (MOA) (see Appendix C of this EA). CARA would ensure that any of the MOA's provisions that relate to on-site construction and installation of the Outrigger Telescopes would be included as provisions in any contracts for on-site construction and installation.

Archaeological Resources. While the potential for the proposed project to affect archaeological properties or burials is reduced because much of the construction would occur on previously disturbed and leveled land, NASA has proposed mitigation measures that assume that such properties could possibly be found anywhere on the site. No area is assumed to be devoid of archaeological properties, simply on the basis of its history. This is particularly important for the slope edges, which may be effectively undisturbed at a rather shallow depth below the surface. Archaeological resources identified within the Mauna Kea Science Reserve fall into several categories: shrines, Adze quarrying and manufacturing, and burials as described in Section 3.10. However, no archaeological sites have been identified on Pu'u Hau 'Oki. In the event that an archaeological property is discovered during excavation for the Outrigger Telescopes, the mitigation measures as described in the MOA will prevent, or reduce adverse effects.

Traditional Cultural Resources. Traditional cultural resources are eligible for listing on the NRHP because of their association with the cultural practices or beliefs of a living community that are: rooted in the community's history; important in maintaining the continued cultural identity of the community; and meet NRHP eligibility criteria (Parker and King 1995). Some Native Hawaiian groups have identified a larger area of Mauna Kea, from the 1,829-m (6,000-ft) elevation to the summit, as a sacred landscape valued for its spiritual significance, and its view plane (Maly 1998; Maly 1999).

Affected cultural groups, in this case Native Hawaiian groups, have identified potential impacts to traditional cultural resources. Studies addressing Mauna Kea have identified the following concerns regarding the summit area:

- Importance of maintaining the integrity of the spiritual and sacred quality of the summit landscape;
- Lack of respect on the part of the astronomy program for Native Hawaiian cultural practices, features, and beliefs; and
- The effect of increased public use on the summit landscape.

Most Native Hawaiians in Maly's (1999) study expressed the desire that no further development of astronomy facilities occur on Mauna Kea. Potential visual and physical impacts on the *pu'u* were described as important concerns considering that many Native Hawaiians hold Mauna Kea to be sacred. Protection of the landscape and view planes among the *pu'u* and other cultural resources was considered important.

In addition to the formal Section 106 meetings, NASA has held additional meetings in Hilo. Kona and Waimea which were attended by individuals, and organizations and member of the general public who stated their position, asked questions, expressed concerns and learned more about the Outrigger Telescopes Project. Many of the issues raised in the meetings concerned historic/cultural resources. NASA representatives have met, formally and informally, with Hawaiian (including Native Hawaiian) groups that have expressed interest in this project. Tables 5.1 and 5.2 in Chapter 5 of this EA provide a listing of the consultations/informal meetings that have taken place. These consultations with interested groups regarding mitigation measures for traditional cultural resources have resulted in a range of construction and monitoring protocols, as set forth in the MOA.

Contemporary Cultural Practices. Contemporary cultural practices identified for the summit area of Mauna Kea include the release of cremated remains; prayer and ritual observances, including the construction of new altars; and a repository of *piko* (umbilical cords) (Maly 1999). Impacts to contemporary cultural practices are often similar to impacts identified for traditional cultural resources. Concerns include the importance of maintaining access to the summit area for spiritual purposes, and maintaining the integrity of the spiritual and sacred quality of the summit landscape.

The ACHP has indicated that Native Hawaiian groups have expressed concerns to them that the proposed facilities would limit their access to the summit area (ACHP 2000). Implementation of the Outrigger Telescopes Project would not result in any additional restrictions on accessibility of the summit area to Native Hawaiians.

Hale Pōhaku. NASA is aware of a complex of historic properties (*i.e.*, two shrines) located to the south and west of the staging area at Hale Pōhaku, outside the UH-leased area, about 30.5 m (100 ft) and 48.8 m (160 ft) distant from the staging area boundary, respectively. The shrine closest to the proposed use is located on an *'a'a* wall, which is separated from the staging area by a drainage swale. It would be extremely unlikely for staging area activities to adversely affect either of these shrines.

Compliance with the Mauna Kea Reserve Master Plan. The recently adopted Mauna Kea Science Reserve Master Plan reduced the potential area for astronomy development from the full Mauna Kea Science Reserve to the Astronomy Precinct of 212 ha (525 ac) (UH 2000b) which includes the proposed project area. The remaining area is a natural/cultural preservation area where astronomy facilities would not be developed. The shape of the Astronomy Precinct was tailored to avoid historic sites, preserve view corridors, and maintain the integrity of the cultural landscape as much as possible. The southern boundary was moved northward to create a greater distance from Lake Waiau and the northern boundary was pulled back to avoid the line of shrines at the 3,960-m (13,000-ft) elevation. Pu'u Poli'ahu is outside the Astronomy Precinct. The eastern boundary was pulled back to reduce the potential visual impact from the Hilo side of the mountain. The plan also protects all undeveloped summit *pu'u* from further development.

On-Site Mitigation Measures. Mitigation measures for cultural impacts associated with the Outrigger Telescopes Project are those set forth in the MOA. Among those are: cultural and archaeological monitoring of the construction area, education of workers on the site, mandatory adherence to the construction Best Management Practices, and consultation with Native

Hawaiian groups to identify methods of protecting cultural values and traditional practices, and general historic property protection measures (see Appendix C). Detailed mitigation measures address the proposed on-site construction project area, the construction staging area at the summit, at Hale Pōhaku, and the construction stockpiling area. Illustrative examples of the on-site mitigation measures are described below.

Archaeological Monitoring: A qualified archaeologist will be hired by CARA, in consultation with the SHPD and OMKM. The Archaeologist will be present to monitor all excavation activities. The Archaeologist will keep a log and map notes of every visit and will follow SHPD draft Hawaii Administrative Rules for archaeological monitoring studies and reports. As part of project implementation, the archaeologist will have the authority to halt work in the vicinity of an inadvertent discovery of human remains and archaeological properties.

Cultural Monitor: In consultation with NASA and the other Consulting Parties, CARA will develop criteria for and select an individual to be the project's Cultural Monitor. This individual will be knowledgeable about Mauna Kea's cultural landscape and the traditions, practices, beliefs, and customs associated with Mauna Kea. The cultural monitor will provide cultural orientation to individuals who are associated with the on-site construction and installation of the Outrigger Telescopes and who will be on Mauna Kea. The Cultural Monitor will be provided free access for monitoring activities during excavation, other on-site construction, and telescope installation. The Cultural Monitor will keep a log and map notes of every visit.

Education: Prior to on-site construction, the contractor(s), supervisors, and all construction workers involved with the Outrigger Telescopes Project will be required to view a videotape reviewing the historic and sacred qualities of Mauna Kea. They will also be advised of the potential of CARA's demanding their removal from this Undertaking if they fail to comply with the conditions imposed by the project.

Cultural Interpretation: During the construction and installation of the Outrigger Telescopes, OMKM, in consultation with the Hawai'i SHPO, will develop and provide interpretive materials concerning the cultural significance of Mauna Kea. The Consulting Parties will be afforded an opportunity to review and comment on the interpretive materials during their development.

Off-Site Mitigation Measures. Under the terms of the MOA, NASA, in consultation with the Office of Mauna Kea Management, will fund, out of funds for the Outrigger Telescopes Project, an initiative that deals with preservation and protection of historic/cultural resources on Mauna Kea and educational needs of Hawaiians.

4.1.11 Socioeconomics

On-Site Construction Employment and Costs. Underground site work would require a maximum of 15 construction workers for approximately 9 months and a maximum of 12 construction workers for about 17 months to assemble and test the enclosures and telescopes. It is assumed that a proportional number of workers would be required for the various phases of construction if Outrigger Telescopes 5 and 6 are installed. Construction workers would either commute from sea level or use existing facilities at Hale Pōhaku construction camp. On-site construction and dome erection, and installation of four Outrigger Telescopes activities are estimated to cost approximately between $7 million and $8 million. The on-site construction and installation of the remaining two Outrigger Telescopes would probably cost about $2.5 to $3 million.

Operations Employment and Cost. NASA would also fund the Outrigger Telescopes Project operation. It is estimated that a total of eight full-time personnel would be added to the WMKO staff; four would be hired when testing of the Keck Interferometric Array begins and four more when operations begin. It is expected that almost all of the observing would be done from the CARA base facilities in Waimea, thus only one or two additional person(s) would be on the mountain at night. The engineering staff would spend the greatest proportion of their time in Waimea, although on occasion they could go to the summit to work on equipment. In addition, there could be several new technicians that would work on the summit. Overall, the daytime presence at the summit would be increased by three people at most (UH IfA 2001a). In summary, the employment and economics impacts of on-site construction of the Outrigger Telescopes Project would be positive and benefit the employment expenditures and revenues accruing to the County of Hawai'i and the State of Hawai'i.

Commercial Activities. The addition of the Outriggers at the WMKO is not expected to produce any substantial increase in commercial tour traffic or similar commercial activities.

Mitigation Measures. No mitigation measures would be required.

4.1.12 Environmental Justice

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires Federal agencies to identify and address the potential for their programs, policies, and actions to have disproportionately high and adverse human health or environmental effects on minority or low-income populations. The companion Presidential Memorandum signed February 11, 1994, directs Federal agencies to include in their NEPA documents an analysis of the effects of their actions on minority and low-income communities, along with mitigation measures for significant and adverse effects.

The proposed project would be located within the Astronomy Precinct, a scientific complex set aside for astronomical observatories and other research activities. The proposed Outrigger Telescopes would be used solely to facilitate the scientific work conducted on the WMKO site.

The proposed on-site construction, installation, and operation of the Outrigger Telescopes at WMKO would not have disproportionately high or adverse effects on low-income or minority populations. Given the nature of the land use in the area, and the fact that the closest major residential areas to the proposed project are Hilo and Waimea, each between 1 and 1-1/2 hours away, environmental justice is not an issue of concern for the proposed project. However, NASA recognizes that Mauna Kea has special cultural significance to Native Hawaiians. Those concerns, impacts, and mitigation measures are discussed in Section 4.1.10.

Mitigation Measures. No mitigation measures would be required.

4.1.13 Visual/Aesthetics

On-Site Construction and Installation Impacts. Any impacts to the visual landscape during the on-site construction of the Outrigger Telescopes Project would be temporary. On-site construction activities at the WMKO site would be visible from most locations within the Astronomy Precinct; however, below the summit area, the existing topography of the mountain would generally preclude the view of those activities. In general, the most visible aspect of construction would be construction-related traffic on the Access Road. At off-mountain areas such as Hilo, Honoka'a, and Waimea, the construction activities should not be visible. The use of prescribed dust controls during construction should substantially reduce this potentially visible evidence of construction activity. As soon as practicable after on-site construction is completed, all excess construction equipment, containers, and excess construction material would be transported off the mountain and the same practice would be implemented after Outrigger Telescope installation is complete.

Operation Impacts. With completion of on-site construction and installation, visibility of the Outrigger Telescopes from the summit area would be limited (UH 2000b). Below the summit area, the existing topography of the mountain would essentially preclude any visual impacts from the Outrigger Telescopes. The view from areas off-mountain such as Hilo, Honoka'a, and Waimea would be largely unaffected by the Outrigger Telescopes (see Figure 3-4). The low amount of visual intrusion from the six Outrigger Telescopes at those off-mountain locations would result from both the relatively low height of each Outrigger Telescope dome relative to the height of the two existing Keck domes (*i.e.*, each Outrigger Telescope dome would be approximately one-third the height of the existing Keck domes located on Pu'u Hau 'Oki). In addition, while the dome on each of the six Outrigger Telescopes would be white, the dome ring walls would be designed to blend into the natural color of the surrounding landscape in keeping with the mitigation measures set forth in the recently adopted Mauna Kea Science Reserve Master Plan (UH 2000b).

Mitigation Measures. No mitigation measures would be required.

4.2 CUMULATIVE IMPACTS OF THE PROPOSED ACTION

Cumulative impacts as defined in the Council on Environmental Quality NEPA implementing regulations at 40 CFR 1508.7, refer to the incremental environmental impacts of the action when added to other "past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions". Reasonably foreseeable, for the purposes of this project, relates to initiation of on-site construction of a new project within the Astronomy Precinct of Mauna Kea within the next seven years. UH has requested that the total time allowed for completion of the Outrigger Telescopes Project be seven years after the CDUA permit is granted.

Except as noted below, NASA is not presently aware of any other project proposed for the Astronomy Precinct that currently is or will be in the on-site construction phase within the next seven years. Beyond the currently permitted construction of the Smithsonian Astrophysical Observatory (SAO) Submillimeter Array Telescope, the Smithsonian Institution has no active proposal for further development during the relevant period. A conceptual study for a New Planetary Telescope (NPT) to replace the existing NASA Infrared Telescope Facility was completed in early 2000; however, there are no plans to consider the NPT further. NASA, aside from the proposed Outrigger Telescopes Project, has no plans for any construction within the Astronomy Precinct on Mauna Kea within the next seven years. Based upon discussions with the National Science Foundation (NSF), that agency currently has no proposals under consideration for construction of any additional telescopes on Mauna Kea. Thus, at the present time, there are no reasonably foreseeable Federal projects planned for the Astronomy Precinct.

The only non-Federally funded project within the Astronomy Precinct of which NASA is currently aware is the proposal by the Subaru Telescope to add an exterior corridor to their control building to serve as access to a new visitor gallery. This relatively small project, if approved, could be initiated in early 2002, requiring about six months to complete. If the project is initiated as presently proposed, it could coincide with the initial on-site construction activities for the Outrigger Telescopes for about a six-month period. During that time there would not be any substantial increase in environmental impacts at Pu'u Hau 'Oki or elsewhere on Mauna Kea. The proposed addition to the Subaru facility would result primarily in a small increase in traffic on the summit road and in the amount of dust generated by construction activities on Pu'u Hau 'Oki. These effects would be experienced for only the anticipated six-month period needed to complete the exterior corridor at Subaru. The addition of the visitor gallery may lead to a small increase in the number of tourists visiting the summit.

A project has been proposed that could involve activities outside the Mauna Kea Science Reserve at Hale Pōhaku—the Mauna Kea Astronomy Education Center (MKAEC). Although the proposed MKAEC would be based primarily at UH-Hilo, the potential exists for an expansion of the existing Visitor Information Station (VIS) at Hale Pōhaku as part of the proposal. This expansion may be Federally funded in part. In addition, the Office of Mauna Kea Management is in the preliminary stages of planning for an expansion of the VIS. While the specifics of the MKAEC proposal (including whether any component would be located at Hale Pōhaku) and timing for its implementation are uncertain at this time, the potential exists for the MKAEC activities at Hale Pōhaku to coincide in timing with on-site construction and installation of the Outrigger Telescopes Project. The OMKM-planned expansion of the VIS could also begin within the next seven years. If the Outrigger Telescopes Project were to coincide or overlap in time with either or both of these activities, the cumulative impacts would be confined largely to additional traffic on the lower portion of the Mauna Kea Access Road between Saddle Road and Hale Pōhaku, and additional dust generation from the potential addition to the Hale Pōhaku facility and Outrigger Telescopes Project use of the staging area at Hale Pōhaku.

The University of Hawaii Institute for Astronomy has a project known as Pan-STARRS that is currently in the conceptual stage and could reach the construction stage within the next seven years. As envisaged at present, Pan-STARRS would consist of four 1.3-m (50-inch) automated telescopes all housed within a single telescope enclosure. There are several potential sites for Pan-STARRS. One possibility, currently seen as the most likely, is to install the system in the existing UH 2.2-m (7.2 ft) Telescope building, replacing the coude spectrograph, which is no longer in service. This could be done with no change in the footprint of the building. Alternative sites, both on Mauna Kea and on Haleakala (Maui), will be considered. In the case of Mauna Kea, the alternatives are the site currently occupied by the UH 0.6-m (24 inches) Telescope and a site adjacent to that telescope. The Institute expects to receive funding for planning and design studies within the next several months. Detailed evaluation of the potential sites for Pan-STARRS will be a major component of these studies. Should Pan-STARRS proceed to the construction stage, minor increase in daily traffic on the summit road, and some generation of dust emissions, and noise would be expected. Since Pan-STARRS would be automated little, if any, increase in operational personnel on the mountain would be expected. There has been growing interest within the astronomy community in development of the next generation of Earth-based optical telescopes. The Mauna Kea Science Reserve Master Plan referred to a Next Generation Large Telescope (NGLT) in its discussion of this topic. Recently, astronomers at the University of California and the California Institute of Technology (Caltech) have begun to explore the possibility of constructing such a telescope. The development of a

NGLT-like telescope is still in the conceptual stage, and construction of such a telescope would require, among other things, development of new technologies and designation of a site. Therefore, the construction within the next seven years of an NGLT-like telescope by Caltech and the University of California remains speculative for purposes of analyzing cumulative impacts in this NEPA document.

All future projects will continue to require Conservation District approval from the Board of Land and Natural Resources. In addition, the recently adopted Mauna Kea Science Reserve Master Plan (UH 2000b) provides that all future development within the Astronomy Precinct, prior to approval by the UH Board of Regents and President, will undergo review by the OMKM, the Mauna Kea Management Board, and the Kahu Ku Mauna. The results of those reviews would be considered by the UH Board of Regents and President in determining whether or not to grant project approval. All future development projects within the Astronomy Precinct and the Mauna Kea Science Reserve would also be required to prepare individual environmental documentation. Proposed projects with substantial Federal involvement would be required to comply with NEPA, NHPA, and other applicable Federal environmental statutes and regulations.

4.3 POTENTIAL ENVIRONMENTAL CONSEQUENCES OF THE NO-ACTION ALTERNATIVE

Under the No-Action Alternative NASA would not fund on-site construction, installation, or future operation of the Outrigger Telescopes Project proposed for the WMKO site at Mauna Kea. The potential environmental impacts described for the Outrigger Telescopes Project in this EA would not occur. If the Outrigger Telescopes are not constructed and installed at WMKO on Mauna Kea, the facilities at the WMKO site would consist of the two existing 10-m (33-ft) Keck Telescopes which are capable of functioning as the Keck-Keck Interferometer. NASA would be able to attain only two of the science objectives discussed in Section 1.3. The remaining four science objectives would not be met. In addition, the No-Action Alternative would result in economic losses to the State of Hawai‘i of the estimated $10 to $11 million for the on-site construction and installation of six Outrigger Telescopes. Further, the incremental revenues that would be associated with operation of the Outrigger Telescopes Project would also be lost to the State. NASA's funding for the Wēkiu bug on-site mitigation, the graduate student autecology study, and the 18-month Wēkiu bug monitoring activities would not occur. NASA's funding for the on and off-site mitigation activities proposed by NASA in the Section 106 process would also not occur.

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5 AGENCIES, ORGANIZATIONS, AND PERSONS CONSULTED

5.1 AGENCIES AND ORGANIZATIONS CONSULTED FOR THE FEDERAL ENVIRONMENTAL ASSESSMENT

The following agencies, organizations, or individuals were consulted during the Federal NEPA process; and copies of the Draft EA and Final EA were mailed to these agencies and organizations.

FEDERAL AGENCIES

Advisory Council on Historic Preservation
U.S. Department of the Interior,
  National Park Service, National Register of Historic Places
  Office of Environmental Policy and Compliance
  U.S. Fish and Wildlife Service, Pacific Islands Manager
U.S. Environmental Protection Agency, (CMD-2), Region 9

STATE AGENCIES

Department of Business, Economic Development & Tourism
Department of Hawaiian Home Lands (courtesy communication)
Department of Health
  Office of Environmental Quality Control
Department of Land and Natural Resources
  Board of Land and Natural Resources
  Historic Preservation Division
Office of Hawaiian Affairs
University of Hawai'i
  Environmental Center
  Institute for Astronomy, University of Hawai'i at Manoa
  Kahu Ku Mauna
  Mauna Kea Management Board
  Office of Mauna Kea Management

COUNTY OF HAWAI'I

Mayor County of Hawai'i (former), The Honorable Stephen Yamashiro (draft EA only)
Mayor County of Hawai'i (present), The Honorable Harry Kim
Department of Planning, Director

ORGANIZATIONS

Ahahui Ku Mauna
California Association for Research in Astronomy
California Institute of Technology
Hawai'i Island Burial Council
Hui Mālama I Nā Kūpuna O Hawai'i Nei

Kona Hawaiian Civic Club, Holualoa
Mauna Kea Anaina Hou
Royal Order Of Kamehameha I

5.2 AGENCIES, ORGANIZATIONS AND INDIVIDUALS RECEIVING COPIES OF THE FEDERAL ENVIRONMENTAL ASSESSMENT

The following agencies, organizations, and individuals were mailed a copy of this Federal Final EA or both the Federal Draft and Final EA's.

FEDERAL AGENCIES

Advisory Council on Historic Preservation
U.S. Department of the Interior
- National Park Service
- Office of Environmental Policy and Compliance
- U.S. Fish and Wildlife Service, Pacific Islands Ecoregion

U.S. Environmental Protection Agency, (CMD-2) Region 9

STATE AGENCIES

Department of Business, Economic Development & Tourism
Department of Land and Natural Resources
- Deputy Director
- Hawai'i Island Board Member
- Hawai'i District Land Agent
- Historic Preservation Division
- Land Division

Office of Environmental Quality Control
Office of Hawaiian Affairs
Department of Hawaiian Home Lands
Office of Planning
University of Hawai'i
- Environmental Center
- Institute for Astronomy, University of Hawai'i at Manoa
- Kahu Ku Mauna
- Mauna Kea Management Board
- Office of Mauna Kea Management

COUNTY OF HAWAI'I

Mayor, The Honorable Harry Kim

ORGANIZATIONS

Aha Kahuna Nui, Hilo
Ahahui Ku Mauna c/o Edward Stevens, Kailua-Kona
Ahahui Malama I Ka Lokahi, c/o Kealii Pang

Association of Hawaiian Civic Clubs, Hilo
Bishop Science Museum, c/o Allen Allison
California Association for Research in Astronomy
California Institute of Technology
Edith Kanakaole Foundation, Hilo
Hamakua Hawaiian Civic Club, Honoka'a
Hawai'i Island Burial Council, c/o SHPD Burials Program
Hawai'i Island Burial Council, c/o Kala'au Wahilani
Hui Mālama I Nā Kūpuna O Hawai'i Nei, c/o Edward Halealoha Ayau
Hui Mālama I Nā Kūpuna O Hawai'i Nei, c/o Kunani Nihipali
Hui Mālama I Nā Kūpuna O Hawai'i Nei, Kealakekua
Ilio'ulaokalani Coalition, c/o Vicky Holt Takamine
KAHEA, c/o Cha Smith
KAHEA, c/o Erline Greer
Ka Lahui Hawai'i, Honolulu
Kawaihae Homestead Association, Kawaihae
Kohala Hawaiian Civic Club, Hawi
Kona Hawaiian Civic Club, Holualoa
Life of the Land, c/o Kat Brady
Mauna Kea Anaina Hou, c/o Kealoha Pisciotta
Protect Kohanaiki Ohana, Kailua-Kona
Queen Liliuokalani Children's Center, Kailua-Kona
Sierra Club (Local Chapter), c/o Nelson Ho
South Kohala Hawaiian Civic Club, Waikoloa
The Royal Order of Kamehameha I, c/o Sir Paul K. Neves, Ali'i Aimoku
The Royal Order of Kamehameha I, c/o Kūhauhau Mamo Naliko Markel
The Royal Order of Kamehameha I, c/o Kaka'olelo Ali'i Sir Robert McKeen Jr.
University of California
Waimea Hawaiian Civic Club, Kamuela
Waimea Hawaiian Homestead Association, Kamuela

INDIVIDUALS WHO REQUESTED COPIES OF THE DRAFT EA OR MADE COMMENTS

Alex Alcantar
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H.G. Adams
Bob Barry
Maurice Boissiere
Doug Codiga
C. Eoalls
Caitlyn Evans
Peter Evans
Susan Harrison Evans
Lawrence Goff
Peter and Kathleen Golden

Lea Hong
Lorraine Higltkin
Linda Horton
Reynolds Kamakawiwo'ole
Virginia Lane
Zelda Langdale
Kaliko McDonald
Blaze Rexroat
Sueko Sakai
Jim and Pam Steenberg
Dennis Stillings (no address provided)
Jan TenBruggencate
Alan Villesvik
John and Linda Villesvik
Deborah Ward

LIBRARIES

To make this Federal EA available to the public, NASA has sent courtesy copies of the draft and Final EA to all libraries within the State of Hawai'i Public Library System, the Regional Libraries, and to certain university and college libraries located in the State of Hawai'i.

COURTESY COPIES

Courtesy copies of this EA have also been mailed to the Congressional delegation of the State of Hawai'i, the Legislative Reference Bureau, and the Chairman of the Hawai'i County Council.

In addition, a courtesy copy of the EA was sent to the Honolulu Advertiser, Hawaii Tribune Herald and West Hawaii Today.

5.3 FORMAL AND INFORMAL CONSULTATIONS

Tables 5-1 and 5-2 provide a summary of formal and informal meetings that NASA has had with interested parties.

TABLE 5-1. OUTRIGGER TELESCOPES PROJECT FORMAL MEETINGS WITH INTERESTED PARTIES

Date	Organization	Location	Type
10/01/99	Hawai'i Island Burial Council - on agenda	Kailua-Kona, Hawai'i	
03/28/00	Delegation meets with Office of Hawaiian Affairs (OHA) staff	Honolulu, Hawai'i	
03/28/00	Presentation at OHA Trustees meeting	Honolulu, Hawai'i	
03/28/00	Delegation meets with Department of Land and Natural Resources (DLNR) and State Historic Preservation Division (SHPD)	Honolulu, Hawa'i	
03/28/00	Attend formal meeting with Royal Order of Kamehameha I	Hilo, Hawai'i	
03/29/00	Delegation meets with Hawaiian Civic Clubs - Kona Chapter	Kailua-Kona, Hawai'i	
03/30/00	Hawai'i Island Burial Council - on agenda	Hilo, Hawai'i	
01/30/01	Delegation meets with U.S. Fish and Wildlife Service (USFWS)	Honolulu, Hawai'i	
01/31/01	Delegation meets DLNR and SHPD	Honolulu, Hawai'i	
01/31/01	Delegation meets with Hawaii Office of Environmental Quality Control (OEQC)	Honolulu, Hawai'i	
02/01/01	National Aeronautics and Space Administration (NASA), Advisory Council on Historic Preservation (ACHP), Department of Hawaiian Home Lands, Hawai'i Island Burial Council, OHA, SHPD, California Institute of Technology (Caltech)/Jet Propulsion Laboratory (JPL), California Association for Research in Astronomy (CARA)/W.M. Keck Observatory (WMKO), Kumu Pono Associates, Pacific Analytics, Science Applications International Corporation (SAIC) (Royal Order of Kamehameha I appeared at the start of the meeting)	Hawaii Naniloa Hotel, Hilo, Hawai'i	Section 106 Meeting
02/05/01	Delegation meets with Office of Mauna Kea Management (OMKM)	Hilo, Hawai'i	
02/05/01	NASA, Public, Caltech/JPL, CARA/WMKO, Kumu Pono Associates, Pacific Analytics, SAIC	Hilo, Hawai'i	Open House Meetings
02/06/01	Presentation at Mauna Kea Management Board (MKMB)	Hilo, Hawai'i	
02/07/01	NASA, Public, Caltech/JPL, CARA/WMKO, Kumu Pono Associates, Pacific Analytics, SAIC	Kailua-Kona, Hawai'i	Open House Meetings
09/27/01	Delegation meets with SHPD	Honolulu, Hawai'i	
10/01/01	NASA, Public, Caltech/JPL, CARA/WMKO, Kumu Pono Associates, Pacific Analytics, SAIC	Kona Outdoor Circle, Kailua-Kona, Hawai'i	Town Hall Meeting*
10/02/01	NASA, Public, Caltech/JPL, CARA/WMKO, Kumu Pono Associates, Pacific Analytics, SAIC	Waimea Community Center, Waimea, Hawai'i	Town Hall Meeting*

TABLE 5-1. OUTRIGGER TELESCOPES PROJECT FORMAL MEETINGS WITH INTERESTED PARTIES (CONT.)

Date	Organization	Location	Type
10/03/01	NASA, Public, Caltech/JPL, CARA/WMKO, Kumu Pono Associates, Pacific Analytics, SAIC	University of Hawai'i at Hilo, Hilo, Hawai'i	Town Hall Meeting*
10/04/01	NASA, Public, Caltech/JPL, CARA/WMKO, Kumu Pono Associates, Pacific Analytics, SAIC	University of Hawai'i at Hilo, Hilo, Hawai'i	Town Hall Meeting*
01/16/02	NASA and all Consulting Parties	Hilo, Hawai'i	Section 106 Meeting
01/17/02	NASA and all Consulting Parties	Hilo, Hawai'i	Section 106 Meeting

* The following organizations either appeared or sent a representative at any one of the Town Hall Meetings.

Ahahui Ku Mauna
Association of Hawaiian Civic Clubs
Conservation Council for Hawai'i
Department of Land and Natural Resources
Hawai'i Island Burial Council
Kahu Ku Mauna members
Ka Pae Aina Hawai'i
Mauna Kea Anaina Hou
Office of Hawaiian Affairs
Office of Mauna Kea Management member
Royal Order of Kamehameha I
Sierra Club member

TABLE 5-2. OUTRIGGER TELESCOPES PROJECT INFORMAL MEETINGS WITH INTERESTED PARTIES

Date	Organization	Location
05/01/01	Office of Mauna Kea Management (OMKM)	Hilo, Hawai'i
	Department of Land and Natural Resources (DLNR) - Big Island Manager	Hilo, Hawai'i
05/02/01	Royal Order of Kamehameha I	Hilo, Hawai'i
	Sierra Club	Hilo, Hawai'i
05/03/01	Hawaiian Civic Club	Hilo, Hawai'i
	Kahu Ku Mauna	Hilo, Hawai'i
05/04/01	Office of Hawaiian Affairs (OHA)	Honolulu, Hawai'i
	Hui Mālama I Nā Kūpuna O Hawai'i Nei	Honolulu, Hawai'i
	State Historic Preservation Division (SHPD)	Honolulu, Hawai'i
07/14/01	Kahu Ku Mauna	Hilo, Hawai'i
07/19/01	OMKM	Hilo, Hawai'i
07/20/01	Kahu Ku Mauna (partial)	Kona, Hawai'i
07/22/01	OMKM	Hilo, Hawai'i
07/23/01	OMKM	Hilo, Hawai'i
07/24/01	Royal Order of Kamehameha I	Hilo, Hawai'i
08/16/01	SHPD	Hilo, Hawai'i
08/22/01	Royal Order of Kamehameha I - Kona Chapter	Kona, Hawai'i
08/23/01	OMKM	Hilo, Hawai'i
08/29/01	OMKM	Hilo, Hawai'i
09/27/01	SHPD	Honolulu, Hawai'i
11/13/01	OHA	Honolulu, Hawai'i
11/14/01	OMKM	Hilo, Hawai'i

Note: Table 5-2 does not include meetings or telephone calls with numerous Hawaiian individuals.

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APPENDIX A

NEPA CONSULTATIONS WITH POTENTIALLY CONCERNED PARTIES

NASA Letter to Potentially Concerned Agencies and Officials, dated August 18, 2000, including the distribution list. Letter provides notification of NASA's National Environmental Policy Act process in the development of an Environmental Assessment for the Outrigger Telescopes Project.

Responses from:

a. U. S. Fish and Wildlife Service, dated September 8, 2000

b. Advisory Council on Historic Preservation, dated September 13, 2000

c. Honorable Stephen K. Yamashiro, Former Mayor, August 23, 2000

Notification:

a. Open House notice mailed to interested parties and commentors on the Draft Environmental Assessment

b. Town Hall Meeting notice mailed to interested parties and commentors on the Draft Environmental Assessment

National Aeronautics and
Space Administration
Headquarters
Washington, DC 20546-0001

AUG 18 2000

Reply to Attn of SD

To Potentially Concerned Agencies and Officials:

In accordance with National Aeronautics and Space Administration (NASA) policies and procedures (14 CFR 1216.1 and 1216.3) and the requirements of the National Environmental Policy Act (42 U.S.C. 4321 *et seq.*), NASA is preparing an environmental assessment (EA) for the proposed Keck Outrigger Telescopes Project to evaluate the environmental impacts that would be associated with NASA's decision to continue funding the Project.

The Keck Outrigger Telescopes would be implemented at the W. M. Keck Observatory (WMKO) site located within the Astronomy Precinct of the Mauna Kea Science Reserve on the Island of Hawai'i. The Keck Outrigger Telescopes Project is a key element in NASA's Origins Program. NASA's Origins Program is directed at answering two basic questions: 1) how did the galaxies, stars, and planets develop (i.e., "Where do we come from?"); and 2) are there other planets aside from ours, that have the conditions necessary to support life (i.e., "Are we alone?"). The goals and objectives of the Origins Program are being furthered by scientific observations currently being made at the two existing Keck Telescopes. NASA's ability to meet the goals of its Origins Program will be enhanced even further when the two existing Keck Telescopes are combined to operate as an interferometer. Implementation of the Keck Outrigger Telescopes, acting in combination with the two Keck Telescopes, would create a powerful tool for pursuing the fundamental questions being asked by NASA's Origins Program and, in turn, would continue to keep the State of Hawai'i at the leading edge of research in astronomy.

The California Association for Research in Astronomy (CARA), which operates the WMKO, has requested permission from the University of Hawaii to undertake installation and operation of the Keck Outrigger Telescopes. WMKO is the site of the two most powerful telescopes in the world -- Keck I and Keck II. The approximately 5-acre WMKO site is subleased to the California Institute of Technology (Caltech) by the University of Hawaii. The Keck Telescopes and WMKO site are operated and maintained by CARA, a non-profit corporation established by the University of California and Caltech. The WMKO site is located within the designated Astronomy Precinct (approximately 525 acres) of the Mauna Kea Science Reserve. The Science Reserve, at over 11,000 acres, is leased to the University of Hawaii by the State of Hawai'i.

The Keck Outrigger Telescopes, if fully implemented, would consist of up to six 1.8-meter (72-inch) telescopes to be placed strategically around the two existing Keck Telescopes. Funding for four Outrigger Telescopes is currently planned by NASA, and NASA funding for two additional Outrigger Telescopes may be considered at a future date. NASA's decision to continue funding the Outrigger Telescopes is contingent upon NASA ensuring that pertinent Federal environmental requirements are satisfied. Alternatives that will be considered in NASA's EA include the no-action alternative as well as other telescope sites where the Outriggers could potentially be located.

In response to CARA's request to install the Keck Outrigger Telescopes, the University of Hawaii prepared a State Draft EA in accordance with Chapter 343 Hawaii Revised Statutes, and Section 11-200-9 of the Environmental Impact Statement Rules (Chapter 200 of Title 11, Administrative Rules). That State Draft EA was released for public review and comment in March of 1999. The State Draft EA and the subsequent public review process served to highlight a number of environmental concerns associated with installing and operating the Keck Outrigger Telescopes. The key issues that have emerged are associated with the cultural resources and uses of Mauna Kea, and potential adverse impact upon the Wekiu bug, a candidate species for listing under the Federal Endangered Species Act. NASA is cognizant of these and other environmental concerns as related to the Keck Outrigger Telescopes Project and will address such concerns in the Federal EA. NASA has also instituted consultations mandated by Section 106 of the National Historic Preservation Act. Your agency or office will be provided with a copy of the Federal Draft EA when it is issued for review and comment.

NASA would welcome any comments and suggestions regarding environmental issues associated with the proposed Keck Outrigger Telescopes Project. All comments and suggestions must be received in writing (by mail or facsimile) by September 18, 2000, to be considered by NASA in preparing its Federal Draft EA. Comments and suggestions should be mailed or faxed to:

Mr. Kenneth M. Kumor
NASA NEPA Coordinator
Environmental Management Division/Code JE
National Aeronautics and Space Administration
300 E Street, SW
Washington, DC 20546-0001
Facsimile: (202) 358-2861

Questions may be directed to Mr. Kumor at (202) 358-1112.

Sincerely,

Richard J. Howard
Keck Interferometer Program Executive
Office of Space Science

Distribution.

Federal

Dr. Don Klima
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Advisory Council on Historic Preservation
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Washington, DC 20004

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Mr. Raynard Soon
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Department of Hawaiian Home Lands
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Dr. Seiji F. Naya
Director
Department of Business, Economic Development &Tourism
No. 1 Capitol District Building
250 South Hotel Street
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<u>County</u>
Honorable Stephen Yamashiro, Mayor
County of Hawai'i
Office of the Mayor
25 Aupuni Street, Room 215
Hilo, HI 96720

Honorable Mr. James Arakaki
Council Chairman
Hawai'i County Council\
County of Hawai'i
25 Aupuni Street, Room 209
Hilo, HI 96720

Ms. Virginia Goldstein
Director
Department of Planning
County of Hawai'i
25 Aupuni Street, Room 109
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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Ecoregion
300 Ala Moana Boulevard, Room 3-122
Box 50088
Honolulu, Hawaii 96850

SEP - 8 2000

In reply refer to: MSR

Mr. Kenneth M. Kumor
NASA NEPA Coordinator
Environmental Management Division/Code JE
National Aeronautics and Space Administration
300 E Street, SW
Washington, DC 20546-0001

Re: Preparation Notice for a Draft Environmental Assessment for the W. M. Keck Observatory Outrigger Telescopes Project at Mauna Kea, Hamakua District, Hawaii

Dear Dr. Kumor:

The U.S. Fish and Wildlife Service (Service) has reviewed the August 18, 2000 Preparation Notice for a Draft Environmental Assessment (DEA) for the W. M. Keck Observatory (WMKO) Outrigger Telescopes Project at Mauna Kea, Hamakua District, Hawaii. The project sponsor is the California Association for Research in Astronomy (CARA), which operates the WMKO and has requested permission from the University of Hawaii Institute for Astronomy (IfA) to undertake installation and operation of the Keck Outrigger Telescopes. The WMKO site is located within the designated Astronomy Precinct (approximately 525 acres) of the Mauna Kea Science Reserve. The National Aeronautics and Space Administration is preparing a DEA for the proposed project to evaluate the environmental impacts that would be associated with NASA's decision to continue funding the project. The following comments have been prepared pursuant to the National Environmental Policy Act (NEPA) of 1969 [42 U.S.C. 4321 *et seq.*; 83 Stat. 852], as amended, the Endangered Species Act of 1973 [16 U.S.C. 1531 *et seq.*; 87 Stat. 884], as amended (Act), and other authorities mandating Service concerns for environmental values. Based on these authorities, the Service offers the following comments for your consideration.

The Keck Outrigger Telescopes, if fully implemented, would consist of up to six 1.8-meter (72-inch) telescopes to be placed strategically around the two existing Keck Telescopes. Funding for four Outrigger Telescopes is currently planned by NASA, and NASA funding for two additional telescopes may be considered at a future date. NASA's decision to continue funding the Outrigger Telescopes project is contingent upon NASA ensuring that pertinent Federal environmental requirements are satisfied.

A Wekiu Bug Mitigation Plan (WBMP) was specifically prepared by Pacific Analytics L. L. C. to address potential problems that might arise during the construction and operation of the Outrigger telescopes. It also includes a longer-range monitoring component that will be important in assessing factors that may affect the life cycle and population growth of the wekiu bug. The recommendations of the report should be included in the DEA for the WMKO Outrigger Telescope Project and should be attached to the Conservation District Use Application (CDUA) to be prepared for the project.

As the WBMP acknowledges, the summit area of Mauna Kea is home to a unique Hawaiian ecosystem. Several endemic lichens, ferns, and arthropods including a lycosid spider (*Lycosa* sp.), a moth species belonging to the genus *Agrotis*, and the wekiu bug (*Nysius wekiuicola*) are found on Mauna Kea and nowhere else in the world. Furthermore, as the WBMP acknowledges, it is possible that construction and operation of the Outriggers could have a deleterious impact on the wekiu bug population. We are pleased that the NASA, CARA, and IfA are committed to do no harm to the wekiu bug population during the proposed construction and operation of the Outriggers. Currently, the wekiu bug is a candidate for Federal listing under the Endangered Species Act. To the best of our knowledge, no other federally endangered, threatened, or candidate species, significant wetlands, or other Federal trust resources occur in the immediate summit area of the proposed project site.

The Service supports the recommendations in the WBMP to minimize project impacts to endemic arthropods on the Mauna Kea summit and minimize the impacts to this high-altitude environment from alien species introductions, garbage generation and collection, and visitor use. The Service also supports the proposed designation of a Natural and Cultural Preserve Area consisting of over 10,760 acres and its permanent preservation as described in the Mauna Kea Science Reserve Master Plan. We believe each of the recommendations made in the WBMP will greatly minimize the possibility of negative impact to wekiu bug habitat.

The Service supports Recommendations IV-1 through IX-3 and requests they be incorporated into the WMKO Outrigger Telescope Project final EA. The DEA should identify any of the recommendations that will not be included in the project due to engineering and seismic considerations and include an explanation of the rationale for this decision. The DEA should also include a discussion of the cumulative impacts to wekiu bug habitat within Pu'u Hau Oki crater from the Subaru and Keck observatory sites. Furthermore, the DEA should discuss the best options for dealing with snowfall on the road leading to the observatory. Graded snow and the dust it captures are likely to impact surrounding wekiu bug habitat if not handled properly.

Since astronomy development began on the summit in 1963, only two formal on-site arthropod studies have been conducted. Since 1963, an estimated 25% of the potential wekiu bug habitat has been lost due to astronomy development. Recent studies have corroborated incidental observations that wekiu bug populations have declined. The Service supports the recommendation to include ongoing monitoring of the wekiu bug as a component of the WMKO Outrigger Telescope Project. However, we request that the DEA for the project specifically describe a long-term biological monitoring program that will be implemented for the entire Mauna Kea Science Reserve. The monitoring program should be designed to provide project sponsors with inferences about ecological changes and the impacts of their projects and their management strategies on natural resources within the reserve. The Service recommends that the implementation associated with this monitoring program be shared by all agencies and corporations involved with research within the reserve. The Service would be happy to review the components of a specific program for monitoring the wekiu bug and other resources, when it is available.

The Service appreciates the opportunity to comment on the project EA Preparation Notice, and we look forward to reviewing the WMKO Outrigger Telescope Project DEA, when it is available. If you have any questions regarding these comments, please contact Service Entomologist Mike Richardson by telephone at (808) 541-3441 or by facsimile transmission at (808) 541-3470.

Sincerely,

Paul Henson

Paul Henson
Field Supervisor
Ecological Services

cc: Mr. Michael Buck, DOFAW
Mr. John Giffin, DOFAW

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Advisory
Council On
Historic
Preservation

The Old Post Office Building
1100 Pennsylvania Avenue, NW, #809
Washington, DC 20004

SEP 13 2000

Mr. Kenneth M. Kumor
NASA NEPA Coordinator
Environmental Management Division/Code JE
National Aeronautics and Space Administration
300 E Street SW
Washington DC 20546-0001

REF: Environmental Assessment for Keck Outrigger Telescopes Project

Dear Mr. Kumor:

We appreciate your August 18, 2000 notification of NASA's intent to prepare an Environment Assessment (EA) for the proposed Keck Outrigger Telescopes project at the Mauna Kea Science Reserve on the Island of Hawai'i. We also acknowledge NASA's initiation of the consultation process pursuant to Section 106 of the National Historic Preservation Act for this project. We have reviewed your letter and our other project documentation, and have the following comments on the scope of the proposed EA for the Keck Outrigger Telescopes.

First, as you know, both our agencies have been contacted by Native Hawaiian organizations concerned that construction of the Outrigger telescopes, and future expansion of the telescope complex on Mauna Kea in general, will continue to affect historic properties on the mountain. These historic properties include the entire summit of Mauna Kea itself, which Native Hawaiians consider to be of extreme importance to their cultural identity. Among other things, they have stated that the proposed new facilities will further limit their access to this site and will debase this sacred mountain, which the Hawai'i State Historic Preservation Officer has determined eligible for inclusion to the National Register of Historic Places. In a letter to you dated February 9, 2000, the State of Hawai'i Office of Hawaiian Affairs also stated its belief that a full Environmental Impact Statement should be prepared for this project, instead of an EA.

We believe that historic properties need to be considered early and in a number of ways in the draft environmental document for this project. Given the prominence of Mauna Kea to the Native Hawaiians, the draft document should provide a mechanism for direct consultation between Native Hawaiian organizations, the Hawai'i Historic Preservation Officer, and the highest levels of NASA, the California Association for Research in Astronomy, and the University of Hawaii, to ensure full consideration of their views and concerns. In making decisions about construction of the Keck Outrigger Telescopes, the following are the kinds of issues that should be considered in consultation with the Native Hawaiians:

* the nature of the historic sites at Mauna Kea, what they are and why they are significant;

* how these historic properties have been, and are being, used by the Native Hawaiians, and how their continued use will or will not be affected by the construction and operation of the Keck Outrigger Telescopes;

* consideration of alternatives to the proposed locations for the telescopes that have been considered;

* description of ways to enhance Native Hawaiian use of the mountain while allowing for construction and operation of the Outrigger Telescopes as originally proposed, and

* description of ways the telescopes could potentially benefit Native Hawaiians, through educational and cultural outreach programs.

We appreciate the opportunity to provide these comments on the issues that will need to be considered in the environmental documents for the Keck Outrigger Telescopes project, and look forward to working with NASA on this endeavor. If you have any questions, or would like to discuss our comments further, do not hesitate to call Dr. Tom McCulloch at 202-606-8554.

Sincerely,

Don L. Klima
Director
Office of Planning and Review

Stephen K. Yamashiro
Mayor

Harry A. Takahashi
Managing Director

Henry Cho
Deputy Managing Director

COUNTY OF HAWAII

25 Aupuni Street, Room 215 • Hilo, Hawaii 96720-4252 • (808) 961-8211 • Fax (808) 961-6553
KONA: 75-5706 Kuakini Highway, Suite 103 • Kailua-Kona, Hawai'i 96740
(808) 329-5226 • Fax (808) 326-5663

August 23, 2000

Mr. Kenneth M. Kumor
NASA NEPA Coordinator
Environmental Management Division/Code JE
National Aeronautics and Space Administration
300 E Street, SW
Washington, D.C. 20546-0001

Dear Mr. Kumor:

Thank you for the opportunity to comment on the proposed Keck Outrigger Telescopes Project within the Mauna Kea Science Reserve.

The County of Hawaii supports this project and the continued use of Mauna Kea as a special place to study the origins of our universe.

The Keck Outrigger Telescopes project has been incorporated into the Master Plan and Management Plan for the Mauna Kea Science Reserve which was recently approved by the University of Hawaii Board of Regents following extensive study and numerous public hearings.

We thank W.M. Keck Observatory for addressing the cultural and endangered species concerns of the community.

Best wishes for the success of the Keck Outrigger Telescopes Project.

Sincerely,

Stephen K. Yamashiro
MAYOR

NOTICE

NASA's Draft Outrigger Telescopes Environmental Assessment Available to Public

The National Aeronautics and Space Administration (NASA) announces the availability to the public of its Draft Environmental Assessment (EA) for the proposed Outrigger Telescopes Project. The Draft EA addresses the environmental impacts that could potentially occur with on-site construction, installation, and operation of six 1.8 -meter (6-feet) diameter Outrigger Telescopes. The proposed Outrigger Telescopes would be strategically placed around the existing Keck I and Keck II telescopes located at the W. M. Keck Observatory site in the Mauna Kea Science Reserve, Island of Hawaii. NASA has made copies of the Draft EA for the Outrigger Telescopes Project available to the public at a number of libraries and other publicly accessible locations throughout the State of Hawaii.

NASA is planning to hold open houses on the Outrigger Telescopes Project Environmental Assessment in Hilo on February 5, 2001 and Kailua-Kona on February 7, 2001. NASA has also initiated consultation under Section 106 of the National Historic Preservation Act. The Draft EA presents proposed mitigation for environmental impacts, including those on historic properties.

NOTICE OF TOWN HALL MEETINGS
9/14/01

The National Aeronautics and Space Administration (NASA) is sending this courtesy notice to all parties who have shown an interest in the proposed Outrigger Telescopes Project on Mauna Kea. NASA is planning to hold Town Hall meetings on the status of the Outrigger Telescopes Project as follows:

- October 1, 2001, 7:00 p.m. to 9:00 p.m., in Kailua-Kona (Kona Outdoor Circle, 76-6280 Kuakini Hwy, Kailua-Kona, HI 96740);
- October 2, 2001, 7:00 p.m. to 9:00 p.m., in Waimea (Waimea Community Center, 65-1260 Kawaihae Road (adjacent to the Waimea Park)); and
- October 3 & 4, 2001, 7:00 p.m. to 9:00 p.m., in Hilo (Campus Center Dining Room, University of Hawaii at Hilo).

The Outrigger Telescopes are proposed to be strategically placed around the existing Keck I and Keck II Telescopes located at the W. M. Keck Observatory site in the Mauna Kea Science Reserve, Island of Hawaii.

If you have any questions, please call the receptionist at the W.M. Keck Observatory on (808) 885-7887.

APPENDIX B

LETTER DATED MAY 3, 1999 FROM THE STATE HISTORIC PRESERVATION DIVISION CONCERNING THE CULTURAL IMPORTANCE OF MAUNA KEA

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII

DEPARTMENT OF LAND AND NATURAL RESOURCES

HISTORIC PRESERVATION DIVISION
Kakuhihewa Building, Room 555
601 Kamokila Boulevard
Kapolei, Hawaii 96707

TIMOTHY E. JOHNS, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTY
JANET E. KAWELO

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
LAND
STATE PARKS
WATER RESOURCE MANAGEMENT

May 3, 1999

Dr. Robert A. McLaren, Interim Director
Institute for Astronomy
University of Hawaii at Manoa
2680 Woodlawn Drive
Honolulu, Hawaii 96822

LOG NO: 23155
DOC NO: 9903PM07

Dear Dr. McLaren:

SUBJECT: Request for Historic Preservation (Chapter 6E, HRS) and National Historic Preservation Act (Section 106) Review –W.M. Keck Observatory Outrigger Telescope Project in the Mauna Kea Science Reserve, Ka`ohe, Hamakua, Hawaii Island TMK: 4-4-15:09

Thank you for your letter of March 17, 1999 and the opportunity to review and comment on the Draft Environmental Assessment (DEA) prepared for the proposal to add four to six 1.8-meter "outrigger" telescopes around the two existing 10-meter Keck telescopes located on Pu`u Hau Oki.

Before discussing our review of the DEA, two aspects of the review process need clarification. First, the DEA and your letter correctly indicate that the project needs to comply with Section 106 of the National Historic Preservation Act (NHPA) because federal funds are being used for the project. Your letter, however, asks that we coordinate our review with the Advisory Council on Historic Preservation (ACHP). According to the Section 106 regulations, it is technically the responsibility of the federal agency, in this case NASA, to determine the effect of a project on historic properties and to consult with the State Historic Preservation Office on its determination. The agency may designate another party, such as IFA, to execute its responsibility. We suggest that you or NASA review our comments on the DEA and, if you agree, submit the recommended determination to our office for our official comment. We would be glad to provide you with any information you need on the Section 106 process. Second, your letter asks us to review the finding of "no significant impact" proposed by the DEA. We do not review determinations of this sort because, if we understand correctly, this assessment considers a combination of factors, issues, and subject matters that are beyond our expertise and jurisdiction. Our assessment of effect in the following discussion conforms with our standard review process and we ask that it be incorporated in the final Environmental Assessment.

The DEA proposes that IFA will be requesting a "no effect" determination for the construction of the outrigger observatories when applying for the appropriate permits. To support this finding, the DEA cites past studies and a compliance letter to argue that no historic properties are present in the project area. It notes that no cultural remains were found on Pu'u Hau Oki in a 1982 reconnaissance survey of the summit cones[1] and no sub-surface remains were reported during the construction of the Keck I or Keck II observatories. It concludes that Pu'u Hau Oki appears to be of no particular cultural significance because ethnographic information compiled in conjunction with the 1982 survey did not attribute any particular significance to the *pu'u*.[2] Finally, the DEA cites a "no effect" assessment received from the State Historic Preservation Office (SHPO) for the establishment of optical test sites on Pu'u Hau Oki (Ltr. Wilson to McLaren, June 30, 1998).

As a point of clarification, the first archaeological reconnaissance of Pu'u Hau Oki actually took place in 1981 when a portion of the cinder cone was surveyed as one of the five alternative locations for the proposed Kitt Peak National Observatory data collecting facilities (Ltr. McCoy to Jeffries, June 9, 1981). A third reconnaissance survey of another part of Pu'u Hau Oki was undertaken in 1990 when the 5.1 acre Subaru Observatory site was surveyed[3]. No archaeological sites were found in either of these surveys.

As you are aware, we are currently reviewing historical, ethnographic, and archaeological information on Mauna Kea in the process of preparing an historic preservation plan for the Science Reserve which includes the summit region. During this process, we have come to believe that the cluster of cinder cones which merge and collectively form the summit of Mauna Kea is an historic property and that this single landscape feature probably bore the name Kukahau'ula. This single landscape feature is now called Pu'u Hau Oki, Pu'u Kea, and Pu'u Wekiu. Several lines of evidence lead us to the conclusion that the cluster of cones is an historic property. These will be discussed in more detail in documents being prepared for the preservation plan. The first line of evidence indicating the cultural and historical importance of the summit is that, at a minimum, some portion of the summit cluster bore the name Kukahau'ula who appears as a character in recorded Hawaiian traditions and as a figure in legends about Mauna Kea[4]. As a character in traditional histories and genealogies, he is the husband of Lilinoe and is named as an *'aumakua* (family deity) of fishermen. A descendant, Pae, was known as an exceptional fisherman whose bones were coveted for fishhooks by the paramount chief Umi. In one legend, Kukahau'ula is cast in a more fanciful role as the suitor and husband of Poliahu, the deity of snow and, poetically, his name is said to allude to the pink hue that can be seen reflecting from the snow-covered summit. Lilinoe plays a similar role in the mountain's traditions in that she appears both as a traditional character and a mythical

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[1] McCoy, P. "Archaeological Reconnaissance Survey." In *Cultural Resources Reconnaissance of the Mauna Kea Summit Region.* Manuscript, Anthropology Department, Bernice P. Bishop Museum, 1982.

[2] McEldowney, H. "Ethnographic Reconnaissance Survey" In *Cultural Resources Reconnaissance of the Mauna Kea Summit Region.* Manuscript, Anthropology Department, Bernice P. Bishop Museum, 1982.

[3] Robbins, J. and H Hammatt. Archaeological Reconnaissance for the Proposed Japanese National Large Telescope, Maunakea, Hawaii. Manuscript prepared by Cultural Surveys Hawaii for MCM Planning. 1990.

[4] Kamakau, S.M. *Ruling Chiefs of Hawaii.* Honolulu: Kamehameha School Press. 1961:215-17. Poepoe, J.M. "Kamehameha I. Ka Nai Aupuni o Hawaii. K Liona o ka Moana Pakipika." *Ka Nai Aupuni.* 1906:April 30. Poepoe, J.M. Bishop Museum Genealogy Book 13:20. B.P. Bishop Museum Library Taylor, E.A. "Ku-Kahau-ula and Poliahu" *Paradise of the Pacific.* Vol. 44(7):12-15, 1931.

figure[5]. She is, however, even more frequently associated with the summit region of Mauna Kea. In addition to being the wife of Kukahau'ula in some traditions, she is said to have been buried near the summit and is called the "woman of the mountain." One tradition has her being an ancestor of the illustrious Mani family who served as warriors and attendants to the paramount *ali'i* of Hawaii Island. In legends, Lilinoe becomes the embodiment of fine mist, the literal meaning of her name, and as such is the companion or sister of Poliahu.

The names Kukahau'ula and Lilinoe are both attributed to cinder cones in the summit region: Kukahau'ula to the summit and Lilinoe to a cone immediately to the southeast of the summit cluster. These names, along with that of Waiau, appear on the earliest reliable map in 1884 and are repeated in the next survey of the summit region in 1891 and 1892[6]. Kukahau'ula is given as the name of "the highest peak" even earlier in 1873 land boundary testimonies[7]. Of all the place names in the summit region, these three are applied the earliest and most consistently to specific landmarks on the mountain. In compiling the 1892 map of Mauna Kea, W.D. Alexander refers to these as "genuine native names[8]." The place name Poliahu appears in traditions and native testimonies as being applied to a trail, spring, pond, and cave[9], but it is not consistently applied to a single and identifiable landscape feature until 1892 when W.D. Alexander proposes attaching this name to "a nameless peak" in honor of the demigoddes, Poliahu, who figures in the tale of Laieikawai[10].

While the association between the summit and Kukahau'ula is sufficiently clear, it is not as clear which specific topographic features at the summit are encompassed by the name. The conclusion drawn here that Kukahau'ula, and thus its association with a significant individual and character, probably applied to the entire summit cluster relies on four major arguments. First, use of the name Pu'u o Kukahau'ula in the boundary testimonies and in subsequent

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[5] Kamakau, S.M. *Ruling Chiefs of Hawaii.* Honolulu: Kamehameha School Press, 1961:215-17, 285. Poepoe, J.M. "Kamehameha I, Ka Nai Aupuni o Hawaii, Ka Liona o ka Moana Pakipika." *Ka Nai Aupuni.* 1906:April 30. Poepoe, J.M. Bishop Museum Genealogy Book 13, page 20. B.P. Bishop Museum Library. Haleole, S.N. "The Hawaiian Romance of Laieikawai.". In *33rd Annual Report of the Bureau of American Ethnology.* Edited by M.W. Beckwith. (1919):480. Taylor, E.A. "Ku-Kahau-ula and Poliahu" *Paradise of the Pacific.* Vol. 44(7):12-15, 1931 Fornander, A. *Fornander Collection of Hawaiian Antiquities and Folk-lore.* Translated and edited by T.G. Thrum. Memoirs of the Bernice P. Bishop Museum, 1919:269. Westervelt, W.D *Legends of Gods and Ghosts.* Boston: H. Ellis, 1915:56.

[6] Lyons, C.J. "North Side of Mauna Kea, Information Sketch." Register Map 1210, Survey Office, State of Hawaii, 1884 to 1891. Lyons, C.J. "Kaohe and Humuula, Hawaii." Register Map 1891, Survey Office, State of Hawaii, 1891. Alexander, W.D. "Summit Peaks of Mauna Kea." Register Map 1860, Survey Office, State of Hawaii, 1892. Baldwin, E.D. Field Book 323:55, Survey Office, State of Hawaii, 1891.

[7] Boundary Commission Books for Hawaii, Microfilm in Archives of Hawaii, Vol. B:35.

[8] Preston, E.D. "Determination of Latitude, Gravity, and the Magnetic Elements at Stations in the Hawaiian Islands, Including a Result for the Mean Density of the Earth, 1891, 1892. In *Report of the Superintendent of the U.S. Coast and Geodetic Survey for the Fiscal Year Ending June 30, 1893, Part II.* Washington: Government Printing Office, 1895:596.

[9] Kamakau, S.M. *Ruling Chiefs of Hawaii.* Honolulu: Kamehameha School Press, 1961:16. Poepoe, J.M. "Kamehameha I, Ka Nai Aupuni o Hawaii, Ka Liona o ka Moana Pakipika." *Ka Nai Aupuni.* 1906:April 30. Boundary Commission Books for Hawaii, Microfilm in Archives of Hawaii, Vol. B:40, 1873.

[10] Preston, E.D. "Determination of Latitude, Gravity, and the Magnetic Elements at Stations in the Hawaiian Islands, Including a Result for the Mean Density of the Earth, 1891, 1892. In *Report of the Superintendent of the U.S. Coast and Geodetic Survey for the Fiscal Year Ending June 30, 1893, Part II.* Washington: Government Printing Office, 1895:596.

notes of field surveys[11] indicates that the name was applied, at a minimum, to the cinder cone (i.e., pu'u) as a whole and not just to the highest peak or what would generally be considered the summit in English usage. Second, on the early survey maps (i.e., 1884 to 1891 and 1891) the name Kukahau'ula is written to the east of the cluster of cones and is not immediately associated with a particular point. In contrast, the highest point on the mountain on these maps is labeled the "summit" and "summit cone" and the triangulation marker on the northeastern peak of the cluster is labeled "Mauna Kea."

The third argument is that place names attributed to the summit cluster are relatively modern because these cones were not differentiated by name until after the 1920s. The name Pu'u Kea, the northeastern part of cluster, first appears in 1937 when commemorative names, such as Macrae, Douglas and Goodrich, were given to other unnamed cones. The names Pu'u Wekiu for the southernmost cone in the cluster and Pu'u Hau Oki for the westernmost cone were recorded by Forester L.W. Bryan in the 1920s and were officially adopted by the Advisory Committee on Geographic Names in 1974[12]. Another factor suggesting the relatively modern origin of these three names is that all are highly descriptive in nature, particularly in contrast to those older names which tend to be associated with traditional or legendary characters. Pu'u Hau'Oki literally means "frosty peak," Pu'u Kea means "white peak," and Pu'u Wekiu means "summit peak." Finally, from most angles of approach, these three named cones or peaks have the appearance of a single, although uneven and complex, landscape feature. It is only after a more thorough examination of this feature that one, if so inclined, would begin to differentiate particular cinder slopes with their associated crater features. Most early historic accounts of visits to the summit essentially describe the summit as a single feature with some parts being higher than others. This is also reflected in the early survey maps which, through hatch marks, depict the cluster of cones as a single unit. At this time, it can not be known with certainty how Hawaiians during the early historic period and their predecessors would have viewed the cluster or what purposes they may have had to make and name particular distinctions within the cluster. Given the unified appearance of the cluster and the prominence of the name Kukahau'ula, however, it seems reasonable, if not probable, that this name applied to this entire landscape feature, including that which is now called Pu'u Hau Oki.

Another line of evidence indicating the summit cluster was of particular and singular significance can be drawn from the archaeological data. The distribution of known shrine locations essentially radiates, at various distances, outward from the base of the summit cluster. This suggests that the summit cluster could have been the central focus of ritual observances and that part of these observances was to avoid or stop short of this central feature. This is further supported by there being no records, with one possible exception (i.e., a 1935 photograph of a slab and stone mound at the summit peak[13]), of shrines on the summit cluster. The practice of avoiding or staying outside that area of greatest significance is common in many religious observances recorded throughout the world. Thus the summit cluster could have been a focal point of the presumably long journey to the summit region. Avoidance of the summit, or the summit region as a whole, for fear of the spiritual nature of

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[11] Boundary Commission Books for Hawaii. Microfilm in Archives of Hawaii. Vol. B:35. 1873 Baldwin, E.D. Field Book 323:55. Survey Office. State of Hawaii. 1891.

[12] Bryan, L.W. Letter to Libert K. Landgraf. December 31. 1973. Department of Planning and Economic Development. Mark. Shelley. Memorandum to Members of Advisory Council on Geographic Names. March 13. 1974. Department of Planning and Economic Development.

[13] Bryan, E.H. *Mauna Kea Here We Come: The Inside Story of an Scientific Expedition.* Honolulu: Privately Published. 1979:35.

this area may be one explanation for the number of times native Hawaiian guides refused or found excuses not to accompany early historic visitors to the summit. In discussing his tour of Hawaii Island in 1823, missionary William Ellis noted that he was told "numerous fabulous tales relative to its [Mauna Kea] being the abode of the gods, and none ever approach its summit..."[14]

Given our conclusion that Pu'u Hau Oki is part of an historic property, we believe the proposed construction of four to six outrigger telescopes on the site of the W.M. Keck Observatory will have an "adverse effect" both on this historic property and on the summit region which we believe is eligible for inclusion in the National Register as an historic district. In the historic preservation plan we will also be proposing that the summit region of Mauna Kea is eligible for inclusion in the National Register of Historic Places as an historic district because it encompasses a sufficient concentration of historic properties (i.e., shrines, burials and culturally significant landscape features) that are historically, culturally, and visually linked within the context of their setting and environment. Tentatively the boundaries of this district will coincide with the extent of the glacial moraines and the crest of the relatively pronounced change in slope that creates the impression of a summit plateau surrounding the cinder cones at or near the summit (i.e., generally the area above the 11,600 to 12,000 foot contour). The cluster of cones forming the summit, including Pu'u Hau Oki, would be a contributing property to this district. We believe, however, that these "adverse effects" can be mitigated if appropriate measures are adopted. To be in compliance with the Section 106 regulations, these mitigation measures need to be stipulated in a signed Memorandum of Agreement (MOA). The MOA should also address those activities occurring at the stockpiling area which could affect, indirectly, the surrounding areas which are also part of the historic district.

The MOA should be relatively easy to prepare as the DEA has already proposed many of the measures we would find appropriate, including those to be executed during the construction phases and those designated as long-range plans. Descriptions of these measures would need to be slightly reworded to explain how these actions would specifically curtail any further degradation of the summit *pu'u* or the historic district. For example, appropriate measures would include those proposed to stabilize the cinder cone slopes, control the accidental dispersal of debris during and after construction, determine the disposition of excavated material which cannot be reused on site, minimize the visibility of the outrigger observatories within the summit region as well as from a distance, and reduce noise during construction and operation of the observatories. In the case of Puu Hau Oki, mitigation should focus on measures that would prevent or minimize those actions that would further deteriorate the structural and visual integrity (i.e., shape and contour) of the cinder cone and its crater.

The history of the project site given on page VI-1 indicates that 34 feet of earth was removed from the top of the site during the construction of the Keck I telescope. We would concur that this alteration effectively precludes the presence of burials. What isn't clear is the exact history of the 71,700 square feet, apparently the site of Keck II, which was left "in its natural state." The description says that this area was leveled during the construction of Keck II. The process of leveling this area or covering it with excavated material from the Keck I site would not necessarily preclude the possibility of burials because they could lie at moderate depths below the natural surface. The specific history of the northern part of the project area should be clarified and, if ground surfaces still exist that were only superficially altered, then we feel

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[14] Ellis, W. *Journal of William Ellis.* 1827 London ed. and 1917 Hawaii ed. Reprint. Honolulu: Advertiser Publishing, 1963:292.

some provision for dealing with potential burials. These should be included in the MOA for the proposed excavation of the light pipes, junction boxes and tunnels. In the historic preservation plan we are currently preparing, we will be asking that any excavation taking place on the summit cones be subject to testing and/or monitoring. This measure would address the persistent claim that burials were previously disturbed during construction of an observatory and the fact that known and suspected burials are present on other cinder cones in the summit region. Exceptions would be those areas that have been previously altered to such an extent that this degree of alteration would preclude the possibility of remaining burials.

To be in compliance with the 1992 amendments of the NHPA, the federal agency or its designee needs to consult with native Hawaiian organizations on undertakings that could have a potential effect on historic properties which are of religious and cultural significance to them. We suggest that you consider contacting those native Hawaiian groups and individuals who have been identified as having a particular interest in Mauna Kea during preparation of the new Mauna Kea Master Plan.

On another matter, concerns have been raised that this assessment and the pending permit applications may be approved and construction begin before the new Mauna Kea Master Plan has been completed and adopted. We agree it would be preferable to complete the application process after the new Master Plan has been adopted. While we feel there is sufficient information to assess the effects of this project on historic properties, it would be preferable to know that the final decisions were made within the context of the new, long-term development and management plan for the summit region.

Our detailed comments on the DEA can be found in Attachment 1. If you should have any questions about our review comments please contact either Patrick McCoy (692-8029) or Holly McEldowney (692-8028).

Aloha,

DON HIBBARD, Administrator
State Historic Preservation Division

PM:amk

APPENDIX C

MEMORANDUM OF AGREEMENT

MEMORANDUM OF AGREEMENT
Among
The National Aeronautics And Space Administration,
The Advisory Council On Historic Preservation,
The Hawai'i State Historic Preservation Officer,
The University of Hawai'i,
The California Association for Research in Astronomy, and
The California Institute of Technology,
Regarding The Outrigger Telescopes Project,
Mauna Kea, Hawai'i

WHEREAS, the National Aeronautics and Space Administration (NASA) has determined that the placement of the four, and potentially six. Outrigger Telescopes (hereinafter referred to as the "Undertaking") adjacent to the existing Keck Telescopes at the W.M. Keck Observatory (WMKO) on the summit of Mauna Kea. will meet the purpose and need of NASA's ground-based interferometry objectives; and

WHEREAS, by signing this Memorandum of Agreement (MOA), the Signatory or Concurring Party does not necessarily signify that the party approves of the Undertaking, but rather that the provisions of the MOA are an appropriate means to mitigate effects on cultural resources in the event that the Undertaking obtains all required approvals and is implemented; and

WHEREAS, NASA has been considering other alternatives, including the No Action alternative; and

WHEREAS, NASA acknowledges that the Native Hawaiian people place spiritual and religious significance on Mauna Kea; and

WHEREAS, NASA has determined that the Undertaking will have an adverse effect on Pu'u Hau 'Oki, one cinder cone within the cluster of cinder cones which merge and collectively form the summit of Mauna Kea. This single landscape feature (*i.e.*, cluster of cinder cones) probably bore the name Kūkahau'ula and is now called Pu'u Hau 'Oki, Pu'u Kea, and Pu'u Wēkiu. NASA, in consultation with the State Historic Preservation Officer (Hawai'i SHPO), has determined that this cluster of cones satisfies the criteria to be eligible for listing as an historic property in the National Register of Historic Places (hereinafter referred to as the "National Register"); and

WHEREAS, NASA has determined that the Undertaking will have an adverse effect on the summit region of Mauna Kea, an area that NASA and the Hawai'i SHPO agree satisfies the criteria for listing as an historic district in the National Register; and

WHEREAS, NASA recognizes that human burials exist in the summit region of Mauna Kea; and

WHEREAS, NASA has made a commitment that a Wēkiu Bug Mitigation Plan will be prepared and implemented as a part of the Undertaking and has determined that some components of the mitigation plan, including certain activities associated with habitat restoration and monitoring, could have an effect on the historic property and historic district; and

WHEREAS, NASA is aware of a complex of historic properties located to the south and west of the staging area at Hale Pōhaku, and the concern of the Hawai'i SHPO to avoid any potential effects on two historic properties (*i.e.*, shrines) located directly south of the staging area; and

WHEREAS, NASA has consulted with the Hawai'i SHPO and the Advisory Council on Historic Preservation (hereinafter referred to as the "Council") on ways to avoid, reduce, or mitigate these adverse effects, pursuant to 36 CFR Part 800, regulations implementing Section 106 of the National Historic Preservation Act (NHPA) (16 U.S.C. 470f), and has invited the Hawai'i SHPO and the Council to participate in the development of this MOA and sign as Signatories; and

WHEREAS, NASA has consulted with and invited those parties who will construct, install, operate, and manage the Outrigger Telescopes—including the California Association for Research in Astronomy (CARA), which will supervise on-site construction, installation, and operation of the Outrigger Telescopes; the University of Hawai'i (UH), which has the responsibility for the overall monitoring and management of the Mauna Kea Science Reserve; and the California Institute of Technology (Caltech), which holds the sublease for the WMKO site—to participate in the development of the terms of this MOA and sign as Signatories; and

WHEREAS, NASA is aware of the historic/cultural significance of Mauna Kea and has conducted and participated in outreach and consultation efforts in Hawai'i to inform local communities, organizations, and the general public of its plans for the proposed construction and operation of the Outrigger Telescopes and their effects on historic properties, and has invited and considered input on potential measures that could avoid, minimize, or mitigate the effects to the historic properties on Mauna Kea; and

WHEREAS, NASA has consulted with and invited the Office of Mauna Kea Management, Mauna Kea Management Board, and Kahu Ku Mauna (hereinafter collectively referred to as OMKM) to participate in the development of this MOA; and

WHEREAS, NASA has consulted with and invited the State Office of Hawaiian Affairs (OHA), and the following Native Hawaiian organizations, the Hawai'i Island Burial Council (hereinafter referred to as the "Burial Council"), the Royal Order of Kamehameha I, Ahahui Ku Mauna, Mauna Kea Anaina Hou, and Hui Mālama I Nā Kūpuna o Hawai'i Nei to participate in the development of the terms of this MOA and sign this MOA as Concurring Parties; and

WHEREAS, NASA's consultations with the parties invited to be Signatories and Concurring Parties and OMKM (hereinafter collectively referred to as "Consulting

Parties") indicate that off-site mitigation should focus on preservation and protection of historic/cultural resources related to Mauna Kea and the educational needs of Native Hawaiians. As a component of the Outrigger Telescopes Project in Hawai'i, NASA is committed to implementing effective measures to preserve and protect historic/cultural resources, expanding the knowledge of Hawaiian culture and address educational needs in the Hawaiian community; and

WHEREAS, Signatory or Concurring Party status is achieved only through signing this MOA.

NOW, THEREFORE, NASA, the Council, the Hawai'i SHPO, UH, CARA, and Caltech agree that, upon NASA's decision to proceed with the Undertaking, such an Undertaking shall be implemented in accordance with the following on-site and off-site stipulations in order to take into account its effects on historic properties; and NASA shall ensure that its funding of the Undertaking is conditioned upon compliance with such stipulations.

I. CULTURAL AND ARCHAEOLOGICAL MONITORING

A. General

1. The Construction Manager, hired by CARA, the contractor(s), supervisors, and all construction workers will be provided training to become aware of the historic/cultural significance of the project site and surrounding areas of the summit as set forth in this MOA.

2. A Cultural Monitor will be provided free access for monitoring activities during excavation, other on-site construction, and telescope installation (See I.C below for qualifications and duties of the Cultural Monitor).

3. A qualified Archaeologist will be present to monitor all excavation activities (See I.D below for qualifications and duties of the Archaeologist).

4. The CARA Construction Manager will oversee the on-site professional personnel and all on-site construction and equipment installation. The CARA Construction Manager will schedule mutually agreed upon meetings with the Archaeologist, Cultural Monitor, and OMKM, to ensure that work is being carried out according to applicable terms of this MOA. The CARA Construction Manager, at the request of the Archaeologist or the Cultural Monitor or on his/her own initiative, has the authority to stop construction if the stipulations in this MOA are not being complied with.

5. The CARA Construction Manager shall encourage the Cultural Monitor and Archaeologist to work closely with one another.

6. Review of any plan hereinafter referenced shall occur within a 45-day period. When a Consulting Party provides comments to one of these plans, the party submitting the plan shall, to the extent practicable during the 45-day review

period, enter into a dialogue with a commentor. NASA, at its sole discretion, may grant time extensions.

B. Monitoring of Historic Properties Affected by the Undertaking

1. Cultural -- Prior to construction, a cultural monitoring plan will be developed by the Cultural Monitor (see I.C below) in consultation with CARA. CARA shall submit the plan for review by NASA and all Consulting Parties.

2. Inadvertent Discovery of Human Remains and Archaeological Properties

   a. Prior to construction, an Inadvertent Discovery of Human Remains and Archaeological Properties monitoring plan will be developed by the Archaeologist (see I.D below) in consultation with the Cultural Monitor and CARA and will comply with draft State Historic Preservation Division Rules (Titles 13-275, 13-279, and 13-280). CARA shall submit this plan for review by NASA and all Consulting Parties. Thereafter, CARA shall submit the plan to the Hawai'i SHPO for approval.

   b. The above monitoring plan (see I.B.2.a) shall include burial and notification components that comply with Hawai'i Revised Statutes (HRS) Title 6E-43.6 (Inadvertent Discovery of Burial Sites), and Hawai'i Administrative Rules (HAR) Title 13-300-40 (Inadvertent Discovery of Human Remains) for the burial components; and with applicable draft State Historic Preservation Division Rules (*e.g.*, Sections 13-275-12, 13-279-1 *et seq.*, and 13-280-1 *et seq.*) for the archaeological components. The burial treatment component will reflect a preference, to the extent practicable, and if confirmed to be culturally appropriate, for any human remains found to be preserved in place.

3. As a minimum, if there were to be an inadvertent discovery of human remains, the Archaeologist has the authority to halt ground-disturbing activities in the immediate area of such remains until all parties identified in the plan have been notified, and the requirements of the appropriately approved plan have been carried out.

4. As a minimum, if previously unidentified historic/archaeological properties (*e.g.*, deposits, artifacts, and stone alignments) were to be discovered during construction, the Archaeologist has the authority to halt ground disturbing activities in the immediate area of such properties until all parties identified in the plan have been notified, and the requirements of the appropriately approved plan have been carried out.

C. Cultural Monitor

1. Qualifications of the Cultural Monitor. In consultation with NASA and the other Consulting Parties, CARA shall develop criteria for and select an individual

to be the project's Cultural Monitor. Any Consulting Party may submit the names of persons who they believe would be appropriate to serve as a Cultural Monitor.

a. This individual will have knowledge or awareness of Mauna Kea's cultural landscape, and traditions, practices, beliefs, and customs associated with Mauna Kea.

b. This individual will be able to communicate cultural values and protocols to others, both within and outside of the culture.

2. Cultural Monitor Responsibilities

a. The Cultural Monitor will become aware of the general scope and requirements of the on-site construction and installation of the Outrigger Telescopes including, but not limited to, becoming familiar with: project boundaries, identified areas of historic/cultural sensitivity, the "Construction Best Management Practices Plan" (BMP), the construction worker responsibilities, responsibilities of the Archaeologist, and the sequence of operations to ensure that mitigation actions are implemented. The Cultural Monitor shall develop the Cultural Monitoring plan referenced in I.B above.

b. The Cultural Monitor will provide cultural orientation to individuals who are associated with the on-site construction and installation of the Outrigger Telescopes and who will be on Mauna Kea. For safety purposes, all communication for the purpose of cultural orientation between project personnel and the Cultural Monitor will be scheduled and overseen by the CARA Construction Manager.

c. The CARA Construction Manager will provide to the Cultural Monitor a weekly schedule of all construction activities planned for the following week. Based on that schedule, the Cultural Monitor will determine his/her need to visit the site during construction and installation as deemed necessary by him/her. For safety purposes, prior to entering the site, the Cultural Monitor will meet and confer with the CARA Construction Manager.

d. The site and grading development drawings and the BMP for the Outrigger Telescopes project site, the staging areas, and nearby areas of the summit region will be provided to the Cultural Monitor. The Cultural Monitor shall keep a log and map notes of every visit — noting date of visit; identifying work locations; noting findings date; and reporting on potential problems, if any. All findings identified and deemed to be significant by the Cultural Monitor shall be reported to the CARA Construction Manager and OMKM; in turn, CARA shall promptly notify NASA, the Council, the Hawai'i SHPO, UH, Caltech, and any other Consulting Party that has requested to be notified of the Cultural Monitor's findings. The Cultural Monitor will submit a final report to the CARA Construction Manager; CARA, in turn, will provide copies to NASA, the Council, the Hawai'i SHPO, UH, OMKM, Caltech, and any other Consulting Party that has requested the report.

e. The Cultural Monitor shall consult with the CARA Construction Manager to determine under what circumstances the Cultural Monitor should have direct authority to halt construction activities in a given area.

D. Archaeologist

1. Qualifications of the Archaeologist. The Archaeologist will be hired by CARA in consultation with the Hawai'i SHPO and OMKM. The archaeologist serving as principal investigator for the Undertaking shall have the following professional qualifications:

a. A graduate degree in archaeology, or anthropology with specialization in archaeology, or an equivalent field;

b. At least one year of cumulative archaeological experience in Hawai'i or the Pacific;

c. At least four months of supervised archaeological field and analytic experience in Hawai'i;

d. At least one year of archaeological research administration or management at a supervisory level with at least four months of field experience;

e. A demonstrated ability to carry research to completion, as shown by completed theses, publications, and manuscripts; and

f. A demonstrated knowledge of historic preservation laws, rules, and guidelines.

2. Archaeologist Responsibilities

a. The Archaeologist will follow State Historic Preservation Division draft Hawaiian Administrative Rules for archaeological monitoring studies and reports (draft HAR Chapter 279). The Archaeologist will develop the Inadvertent Discovery of Human Remains and Archaeological Properties monitoring plan referenced in I.B above.

b. The Archaeologist shall familiarize him/herself with the WMKO site before construction begins.

c. The Archaeologist will become aware of the general scope and requirements for the on-site construction of the Outrigger Telescopes Project. This would include, but not be limited to, becoming familiar with: project boundaries, identified areas of historic/cultural sensitivity, the BMP, construction worker responsibilities, responsibilities of the Cultural Monitor, and the sequence of operations to ensure that mitigation actions are implemented.

d. The Archaeologist will monitor all excavation activities for on-site construction. The CARA Construction Manager will provide to the Archaeologist a weekly schedule of all construction activities planned for the following week. The Archaeologist will have access to the site and be present during all excavation activities. For safety purposes, prior to entering the site, the Archaeologist will meet and confer with the CARA Construction Manager.

e. The site and grading development drawings and the BMP for the Outrigger Telescopes project site, the staging areas, and nearby areas of the summit region will be provided to the Archaeologist. The Archaeologist shall keep a log and map notes of every visit — noting date of visit; identifying work locations; noting findings date; and reporting potential problems, if any. All findings identified and deemed by the Archaeologist to be significant shall be reported to the CARA Construction Manager, the Hawai'i SHPO, and OMKM; in turn, CARA shall promptly notify the NASA, the Council, UH, Caltech, and the Cultural Monitor of the Archaeologist's findings. The Archaeologist will also notify the Cultural Monitor if human remains are found so that he or she can assist with notifying and consulting those individuals and organizations identified in the Inadvertent Discovery of Human Remains and Archaeological Properties monitoring plan. . The Archaeologist will submit a draft report to the CARA Construction Manager; CARA, in turn, will forward the draft report to the Hawai'i SHPO for approval. The approved final report will be distributed by CARA, who will provide copies to NASA, the Council, UH, OMKM, Caltech, and any other Consulting Party that has requested a copy of the report.

II. ON-SITE PRE-CONSTRUCTION, CONSTRUCTION, AND INSTALLATION

A. Grading and Site Development Review

1. Proposed grading and site development drawings will be provided to all the Consulting Parties for a 45-calendar day review and comment period to ensure that every reasonable effort has been made to reduce the adverse effects on Pu'u Hau 'Oki and on the summit region of Mauna Kea by minimizing disturbance from the on-site construction and installation of the Outrigger Telescopes.

2. The goal of the grading and site development planning will be to minimize alteration of the cinder cone as it presently exists, maintain the general shape and form of the cinder cone as it presently exists, and to stabilize the cinder cone in the on-site construction and installation areas.

B. Construction Worker Training

1. As part of an orientation process to ensure work is carried out in as sensitive and respectful a manner as possible, the CARA Construction Manager, the contractor(s), supervisors, and all construction workers will be required to view a specially scripted training videotape reviewing the historic and sacred qualities of Mauna Kea.

2. This training videotape will be prepared by CARA in consultation with the Hawai'i SHPO and OMKM. This training videotape will include a presentation on the history of Mauna Kea and its significance to Native Hawaiians, and an overview of what to do if human remains or archaeological properties are found. CARA shall provide the Consulting Parties an opportunity early in the videotape development process to provide ideas on subject matter that should be discussed and highlighted CARA shall afford the Consulting Parties an opportunity to review the draft script and preview the videotape before the videotape is produced in final form. Should disagreements arise, CARA will enter into consultation to resolve the disagreements. The time for such script review, videotape preview, and consultations shall cumulatively not exceed 45 days, unless CARA, at its sole discretion, agrees to a longer cumulative period.

3. The videotape or related orientation will also advise the workers of the potential that CARA will demand their removal from this Undertaking if they fail to comply with the conditions imposed by the Construction Best Management Practices Plan (see II.C below).

4. The CARA Construction Manager, contractor (s), supervisors, and construction workers will also be briefed by the Archaeologist and Cultural Monitor on Native Hawaiian objects, artifacts, and remains, and what to do if such materials are found during construction activities.

C. Construction Best Management Practices Plan

1. In order to implement a series of precautions and procedures to be undertaken to avoid or minimize adverse effects and prevent or reduce adverse impacts to the cinder cone and inner crater slope during on-site construction and installation, the CARA Construction Manager and the on-site construction and installation contractor(s) will prepare a "Construction Best Management Practices Plan" (BMP) in consultation and coordination with OMKM and UH. The BMP will be finalized prior to the start of construction. This BMP will reference this MOA and include it as an appendix.

2. Prior to the start of construction, CARA will submit the draft BMP to the other Consulting Parties for review. Copies of all comments received will be provided to NASA. CARA will take those comments into account before its final approval of the BMP and prior to mobilization. CARA will take no more than 15 calendar days to conclude consultation on any issues stemming from the comments.

3. On-site construction and installation activities related to the Outrigger Telescopes — from delivery of materials and equipment to the WMKO site or one of the two construction staging areas, excavation and removal of excess cinder to the summit stockpile area through assembly of the domes and telescopes to clean up of the staging, stockpile and WMKO site — will be managed in accordance with the BMP. The CARA Construction Manager will be responsible for following the BMP.

4. To address the effects on historic properties, the BMP will include, but not necessarily be limited to, the following items:

a. The process to be followed if there were to be an inadvertent discovery of human remains or archaeological properties (see I.B above).

b. Site characterization, including the locations of all construction and laydown/stockpile areas on the site, and temporary on-site fill material stockpiles.

c. The sequence of construction activities will be designed to minimize potential adverse effects on historic properties and to allow efficient scheduling of appropriate monitoring times.

d. The specific methods needed to protect the attributes of the historic properties within the project site, staging areas, and within the immediate vicinity of the project area will include, but are not limited to:

(1) Installing a temporary silt fence along the crater rim to facilitate on-site containment of all material, including cinder, so that no such material will spill over the slope. A silt fence will be used whenever excavation occurs within six feet of the slope.

(2) Transferring all excavated material, to the extent not necessary for backfill or Wēkiu bug habitat restoration, to other locations accessible from the established roads on the summit of Mauna Kea. These locations will be identified after consultation with the Hawai'i SHPO and OMKM prior to the start of construction.

(3) Following all applicable County of Hawai'i and State Department of Health (DOH) regulations concerning dust control which include, but are not limited to, suspending all dust-generating activities, securing equipment and materials during high winds and storms, minimizing dust by spraying with water or other environmentally-acceptable soil stabilizers whenever necessary, and, if needed, covering excavated material with a tarp which is anchored down.

(4) Ensuring adherence to effective drainage and erosion control as provided for in the BMP.

(5) Ensuring that precautions are adopted to prevent potential adverse effects on the historic properties arising from use of the staging areas near the summit of Mauna Kea and at Hale Pōhaku.

(6) Providing the process and identifying the project personnel responsible for reporting the inadvertent discovery of human remains or archaeological properties pursuant to the monitoring plans referenced in I.B.

(7) Providing an organization chart that identifies project personnel with the responsibility for maintaining the integrity of the historic properties and the historic district with respect to the following:

(a) controlling all trash and construction material stored on-site so that it does not blow or fall onto surrounding areas of the summit;

(b) recovering trash and construction material which, despite best efforts, blows or falls onto surrounding areas of the summit;

(c) ensuring that all outdoor trash containers will be secured to the ground and have secured lids and plastic liners;

(d) removing all trash, construction debris, and waste material on a regular basis (weekly during construction);

(e) removing all construction equipment and excess materials in a timely manner after construction is completed;

(f) ensuring that a magnetic device is driven over roadways to remove nails and other metallic debris; and

(g) ensuring daily proper disposal of all perishable waste products.

e. To reduce the visual impact on the cinder cone and the historic district, all structures or portions thereof will be of colors designed to blend in with the surrounding terrain; provided, however, that such colors would not adversely affect the operation and scientific capability of the Outrigger Telescopes. CARA will afford the Consulting Parties an opportunity to review and comment on the colors to be used.

f. Characteristics of any discharge of a pollutant into the environment associated with the construction activity (including solid waste, sanitary waste, oily waste, or toxic/hazardous waste, if any) will be identified as soon as it is practicable. Proposed control measures and/or treatment methods for any unplanned or accidental discharge of pollutants associated with construction activity will be developed by the contractor(s) and managed in accordance with the BMP.

g. Noise associated with construction will be minimized through the use of equipment with proper noise muffling devices. Idling of equipment when not in use will be kept to a minimum. The contractor(s) must comply with Hawai'i DOH rules (HAR, Chapter 46, Community Noise Control).

D. Wēkiu Bug Mitigation

Because Wēkiu bug habitat restoration and monitoring may affect the historic/cultural resources of the project site and surrounding areas, and only for this reason, they are mentioned in this MOA. Any activities related to the Wēkiu bug itself will be covered in the separate Wēkiu Bug Mitigation Plan. Prior to implementation of the Undertaking and finalization of the Wēkiu Bug Mitigation Plan, CARA will consult with the Hawai'i SHPO to ensure that the plan contains appropriate provisions that will avoid or minimize, to the extent practicable, any potential adverse effects on the historic property and historic district. These shall include, but not necessarily be limited to, installing permanent signs identifying Wēkiu bug habitat, preventing the dispersal of debris, screening and washing cinder for habitat restoration, placement of the restoration material, and erosion control.

E. Cultural Interpretation

During the construction and installation of the Outrigger Telescopes, OMKM, in consultation with the Hawai'i SHPO, will develop and provide interpretive materials concerning the cultural significance of Mauna Kea. The Consulting Parties will be afforded an opportunity to review and comment on the interpretive materials during their development.

F. On-Site Compliance with Conditions

1. CARA shall ensure that the plans and mitigation measures reflected in this MOA for adverse effects on historic properties, including, visual impacts, erosion control, permit requirements and conditions, and monitoring commitments are incorporated into the contract(s) with its contractors and subcontractors; and that such contract(s) include a provision that CARA's Construction Manager has the authority to enforce such requirements or conditions and, if infractions occur, to order work to stop until the contractor/subcontractor is in compliance.

2. CARA shall make provisions for the Consulting Parties to monitor and review the work during on-site construction and installation activities. However, for safety purposes, all construction site visits must be coordinated through the CARA Construction Manager's office. If it appears that the terms of this MOA are not being followed, Consulting Parties are encouraged to notify NASA, CARA, and the Hawai'i SHPO.

3. Before excavation begins, CARA and NASA will provide points of contact to the Consulting Parties, along with a copy of the final executed Memorandum of Agreement.

III. OFF-SITE MITIGATION MEASURES

Preservation and Protection of Historic/Cultural Resources and Educational Mitigation Measures

1. NASA, in consultation with OMKM, will fund, out of funds for the Outrigger Telescopes Project, an initiative that deals with preservation and protection of historic/cultural resources on Mauna Kea and educational needs of Hawaiians as a mitigation component of the Outrigger Telescopes Project. Funding such an initiative, however, is conditioned on the approval of the Outrigger Telescope's being placed at the WMKO site on the summit of Mauna Kea, Hawai'i. This initiative will be sensitive to Native Hawaiian culture, history, and institutions.

2. The necessary first step is the formation of a local citizens' working group. NASA and OMKM, in consultation with the other Consulting Parties, will ensure the formation of this working group. The working group members will serve on a volunteer basis. OMKM will coordinate and manage the activities of this working group and provide administrative services.

3. Once this working group is formed, its task will be to inform NASA as to what types of opportunities or goals will best benefit Hawaiians, including Native Hawaiians. The working group will be asked to prioritize their proposals. The working group will have one year after it is formed to develop its recommendations, but is encouraged to submit the proposals sooner, if possible.

4. Funding will be subject to the availability of appropriated funds in accordance with Federal law (*e.g.*, the Anti-Deficiency Act). Such funds will be allocated to the proposals as prioritized by the working group until available funds are exhausted.

IV. OPERATIONS

CARA will ensure that all persons involved with the operations of the Outrigger Telescopes shall be required, within a thirty day period of commencing their job, to view as part of worker orientation the training videotape which addresses the cultural significance of Mauna Kea to Native Hawaiians. CARA will report to OMKM quarterly on the status of worker compliance with the viewing of the training videotape.

V. ADMINISTRATIVE STIPULATIONS

A. Dispute Resolution

1. Should any Signatory or Concurring Party object at any time to the manner in which the terms of this MOA are implemented, NASA shall consult with the objecting party(ies) to resolve the objection. NASA shall have no more than 45 days to resolve the objection. If resolution is reached, the terms of this MOA shall be carried out in accordance with such resolution. If resolution is not reached through such consultation, NASA shall forward all documentation relevant to the objection to the Council, including its proposed response to the objection, and request the Council's comments in accordance with 36 CFR 800.2(b)(2). Any comments provided by the Council, and all comments from the Signatory or Concurring Party regarding the objection, shall be taken into account by NASA in reaching its final decision regarding the objection. NASA will promptly provide all Signatory and Concurring Parties with a copy of its final decision regarding resolution of the dispute. After reviewing NASA's decision, the Council or the Hawai'i SHPO, if in disagreement with the decision, may proceed under the provisions of V.B.2 below.

2. NASA's responsibility to carry out all actions under this MOA that are not the subject of the dispute will remain unchanged. Actions subject to dispute under paragraph 1 above shall be carried out in accordance with NASA's final decision.

B. Amendment and Termination

1. If any Signatory believes that the MOA should be amended, that Signatory may propose amendments to the other Signatories and Concurring Parties, whereupon all Signatories and Concurring Parties will consult to consider amendments pursuant to 36 CFR 800.6(c)(7) and 800.6(c)(8).

2. If NASA determines that it cannot implement the terms of this MOA, or if the Council or Hawai'i SHPO determines that the MOA is not being properly implemented, any of these three Signatories may propose that the MOA be terminated. The Signatory proposing termination shall so notify all of the other Signatories and Concurring Parties to the MOA, explaining the reasons for termination and affording these other Signatories and Concurring Parties at least 15 working days to consult and seek alternatives to termination. The parties shall then consult.

3. Should such consultation fail, either NASA, the Council, or the Hawai'i SHPO may terminate this MOA by so notifying the other Signatories and Concurring Parties.

4. Should this MOA be terminated, NASA shall either consult in accordance with 36 CFR 800.6 to develop and execute a new MOA or request the comments of the Council pursuant to 36 CFR 800.7.

C. Duration of this MOA

1. Unless terminated pursuant to Stipulations V.B.3/4 above, this MOA will be in effect until NASA, in consultation with the other Signatories and Concurring Parties, determines all of its terms have satisfactorily been fulfilled, or June 30, 2009, whichever is earlier.

2. Subsequent to the completion of the installation of Outrigger Telescopes 1 to 4, this MOA will be held in abeyance for on-site activities, pending determination by NASA as to whether Outrigger Telescopes 5 and 6 will be installed at the WMKO site. If NASA were to install Outrigger Telescopes 5 and 6, this MOA will remain in full force and effect for on-site activities during the period of installation. This MOA shall not apply to Outrigger Telescopes 5 and 6, if installation of those telescopes were to begin later than December 31, 2007. Should NASA decide to begin on-site installation of Outrigger Telescopes 5 and 6 after December 31, 2007, their installation will be considered a new Undertaking, and NASA will reinitiate the Section 106 process with the Hawai'i SHPO and the Council.

3. Upon determination by NASA that all of this MOA's terms have been satisfactorily fulfilled, the MOA will terminate and have no further force or effect. NASA will promptly notify the other Signatories and Concurring Parties with written notice of its determination and of termination of this MOA.

D. Applicability of this MOA

1. This MOA applies only to the Undertaking as defined herein.

2. If, following execution of this MOA, NASA is unable or decides not to construct or install the Outrigger Telescopes, this MOA will automatically become null and void.

SIGNATORIES TO THIS MEMORANDUM OF AGREEMENT

FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION:

By: Edward Weiler Date: 2-22-02

Printed Name: EDWARD J. WEILER

Title: ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE

FOR THE ADVISORY COUNCIL ON HISTORIC PRESERVATION:

By: John M. Fowler Date: 3/5/02

Printed Name: JOHN M. FOWLER

Title: EXEC. DIR.

FOR THE HAWAI'I STATE HISTORIC PRESERVATION OFFICER:

By: __________ Date: 2/28/02

Printed Name: Don Hibbard

Title: Deputy SHPO

FOR THE UNIVERSITY OF HAWAI'I:

By: __________ Date: __________

Printed Name: __________

Title: __________

FOR THE CALIFORNIA ASSOCIATION FOR RESEARCH IN ASTRONOMY:

By: __________ Date: __________

Printed Name: __________

Title: __________

FOR THE CALIFORNIA INSTITUTE OF TECHNOLOGY

By: __________ Date: __________

Printed Name: __________

Title: __________

SIGNATORIES TO THIS MEMORANDUM OF AGREEMENT

FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION:

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

FOR THE ADVISORY COUNCIL ON HISTORIC PRESERVATION:

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

FOR THE HAWAI'I STATE HISTORIC PRESERVATION OFFICER:

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

FOR THE UNIVERSITY OF HAWAI'I:

By: [signature] for President Evan S. Dobelle Date: 3/5/02

Printed Name: Walter S. Kirimitsu

Title: Senior Vice President for Legal Affairs, University General Counsel and Chief of Staff

FOR THE CALIFORNIA ASSOCIATION FOR RESEARCH IN ASTRONOMY:

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

FOR THE CALIFORNIA INSTITUTE OF TECHNOLOGY

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

SIGNATORIES TO THIS MEMORANDUM OF AGREEMENT

FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION:

By: ______________________ Date: ________________

Printed Name: ______________________

Title: ______________________

FOR THE ADVISORY COUNCIL ON HISTORIC PRESERVATION:

By: ______________________ Date: ________________

Printed Name: ______________________

Title: ______________________

FOR THE HAWAI'I STATE HISTORIC PRESERVATION OFFICER:

By: ______________________ Date: ________________

Printed Name: ______________________

Title: ______________________

FOR THE UNIVERSITY OF HAWAI'I:

By: ______________________ Date: ________________

Printed Name: ______________________

Title: ______________________

FOR THE CALIFORNIA ASSOCIATION FOR RESEARCH IN ASTRONOMY:

By: Frederic H. Chaffee Date: 03/01/02

Printed Name: Frederic H. Chaffee

Title: Director, W. M. Keck Observatory

FOR THE CALIFORNIA INSTITUTE OF TECHNOLOGY

By: ______________________ Date: ________________

Printed Name: ______________________

Title: ______________________

SIGNATORIES TO THIS MEMORANDUM OF AGREEMENT

FOR THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION:

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

FOR THE ADVISORY COUNCIL ON HISTORIC PRESERVATION:

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

FOR THE HAWAI'I STATE HISTORIC PRESERVATION OFFICER:

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

FOR THE UNIVERSITY OF HAWAI'I:

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

FOR THE CALIFORNIA ASSOCIATION FOR RESEARCH IN ASTRONOMY:

By: ______________________ Date: ______________

Printed Name: ______________________

Title: ______________________

FOR THE CALIFORNIA INSTITUTE OF TECHNOLOGY

By: William A. Jenkins Date: 3/4/02

Printed Name: William A. Jenkins

Title: Executive Vice President

PARTY CONCURRING ON THIS AGREEMENT

FOR THE AHAHUI KU MAUNA:

By: ______________________________ Date: ____________________

Printed Name: ___________________________

Title: _____________________________

PARTY CONCURRING ON THIS AGREEMENT

FOR THE HAWAI'I ISLAND BURIAL COUNCIL:

By: ______________________________ Date: ____________________

Printed Name: ___________________________

Title: _____________________________

PARTY CONCURRING ON THIS AGREEMENT

FOR HUI MĀLAMA I NĀ KŪPUNA O HAWAIʻI NEI:

By: ______________________________ Date: ____________________

Printed Name: ___________________________

Title: _____________________________

PARTY CONCURRING ON THIS AGREEMENT

FOR THE MAUNA KEA ANAINA HOU:

By: ______________________________ Date: ____________________

Printed Name: ___________________________

Title: _____________________________

PARTY CONCURRING ON THIS AGREEMENT

FOR THE OFFICE OF HAWAIIAN AFFAIRS:

By: ______________________________ Date: ____________________

Printed Name: ___________________________

Title: _____________________________

PARTY CONCURRING ON THIS AGREEMENT

FOR THE OFFICE OF MAUNA KEA MANAGEMENT:

By: ______________________________ Date: ____________________

Printed Name: __________________________

Title: ____________________________

PARTY CONCURRING ON THIS AGREEMENT

FOR THE ROYAL ORDER OF KAMEHAMEHA I:

By: ______________________________ Date: ____________________

Printed Name: ___________________________

Title: ____________________________

APPENDIX D

WĒKIU BUG MITIGATION PLAN

Wēkiu Bug Mitigation Plan

December 14, 2001

Wēkiu Bug Mitigation Plan

The following plan is based on recommendations provided by natural resource consultants at Pacific Analytics in the Wēkiu Bug Mitigation Report (Pacific Analytics 2000) (revised November 4, 2000) to restore habitat, and to prevent and mitigate impacts to the cinder slopes below the W. M. Keck Observatory (WMKO) complex during on-site construction, installation, and operation, as appropriate, of the proposed Outrigger Telescopes (Pacific Analytics 2000). (Numbers in parentheses after each commitment refer to the corresponding Pacific Analytics recommendation number.) It is the intention and hope that the Wēkiu bug population will actually **increase**, due to protection and restoration of potentially favorable habitat.

1. **Wēkiu bug habitat will be restored in areas damaged by on-site Outrigger Telescope construction, and on the crater floor of Pu'u Hau 'Oki. Restored areas will total at least three times the total area damaged by new construction. (IV-1)**

Areas damaged by new construction will be restored to the extent possible. This will not be possible in areas where new construction covers existing Wēkiu bug habitat with concrete foundations of junction boxes, air pipes, light tunnels, and retaining walls. Restoration of habitat of an area at least three times the area newly damaged will aid in enhancing the Wēkiu bug population in the crater. Material obtained from project excavations not used for backfill will be trucked to the temporary stockpile area where it will be screened and washed and all suitable material returned to Pu'u Hau 'Oki to be used for Wēkiu bug habitat restoration. All excavation material not directly used as fill or for Wēkiu bug habitat restoration will be placed on the mountain at locations to be determined after consultation with the State Historic Preservation Division (SHPD) and the Office of Mauna Kea Management (OMKM).

NASA and CARA have proposed Wēkiu bug habitat restoration within a portion of the crater bottom that was previously damaged by observatory construction on Pu'u Hau 'Oki. The proposed crater bottom restoration area is almost large enough to accomplish the proposed 3:1 restoration goal. Restoration of this area would be followed by restoration of the sloped crater wall habitat that would be disturbed by on-site construction of JB-5 at Outrigger Telescope 2. A third potential habitat restoration area has been identified at Outrigger Telescope 1. This third potential restoration area could be used in future restoration efforts or if the crater bottom restoration effort does not yield sufficient area to attain the 3:1 goal.

Restoration habitat will be composed of screened cinder larger than 1.3 centimeters (cm) (1/2 inch), washed with water to remove ash. Cinder will be spread 30 cm to 46 cm (12 to 18 inches) deep in the restoration areas, and will form a complete interface with cinder in adjacent Wēkiu bug habitat. It may be necessary that cinder be spread more than 46 cm (18 inches) deep in some places, in order to assure the necessary contact with existing habitat.

Screened and washed cinder may be emplaced on the crater floor by partial tilting of the dump bed while the truck is slowly moving. No further working of the screened cinder is required; uneven deposition will make better habitat than an evenly spread or compacted surface. No preparation of the crater floor prior to deposition is required.

The non-permanent barrier blocking vehicle access to the crater floor will be removed to allow transport of the screened cinder into the crater floor. The barrier will be replaced after installation of the restored habitat.

Attractive, non-intrusive, educational signs will be installed near the crater access point along the adjacent service road, (see commitment 3). The signs will have information about Wēkiu bugs and their habitat. (Signs will help prevent unintentional disturbance of habitat by visitors to the summit.). Design of the signs will be consistent with the guidelines presented in the Mauna Kea Science Reserve Master Plan. Prior to installation, sign design and specifications will be submitted to both the Department of Land and Natural Resources (DLNR) and to OMKM for approval.

2. **Under no circumstances during construction, installation, and operation will cinder or other materials be side-cast into Wēkiu bug habitat. Temporary barriers will be built along the slope breaks above the inner slopes of Pu'u Hau 'Oki crater. (IV-2)**

Prior to any construction activities, temporary 3-foot high silt fences will be installed along the rim of the Pu'u Hau Oki crater, where excavation or trenching is planned to take place within six feet of the slope to contain cinder on the site. The temporary silt fences will be maintained by the contractor on a daily basis to repair any damage to the fence.

3. **Educational signs will be placed along the slope break above Wēkiu bug habitat, and at the service road adjacent to the crater floor. (IV-3)**

Many places along the WMKO leveled site provide special scenic vistas. There are foreground views into the Pu'u Hau 'Oki crater, midground views of the summit area, and background views of the entire Island and beyond. These vistas are unique and among the reasons people visit the summit.

Attractive, non-intrusive, educational signs will be installed to inform people about Wēkiu bugs and their habitat. Signs will help prevent unintentional disturbance of habitat by workers and visitors. Design of the signs will be consistent with the guidelines presented in the Mauna Kea Science Reserve Master Plan. Prior to installation, sign design and specifications will be submitted to both the Department of Land and Natural Resources (DLNR) and to OMKM for approval.

4. Water will be applied to excavation sites and cinder stockpiles. (V-1)

Proposed excavation and construction activities will disturb less than one-half acre of the WMKO leveled site during the construction period. Water will be applied to excavation sites and cinder stockpiles during all earthmoving activities.

Construction contractors typically spray water as needed to minimize airborne particulate matter. Potable water is currently transported to the WMKO from Hilo in tankers capable of carrying up to 19 kiloliters (5,000 gallons) per trip. Potable water for dust suppression will also be transported to the site and applied as needed during trenching, bulldozing, or other soil disturbance activities.

The applied water is not expected to cause any negative impact to the Wēkiu bug, and may actually be beneficial. It is possible that the application of water to excavation sites could increase the amount of moisture available for Wēkiu bugs.

5. Dust-generating activities will be suspended during high winds. (V-2)

Storms and accompanying high winds can arise quickly at the summit. These winds are capable of raising dust from recently exposed cinder and ash. Dust-generating activities will be suspended during periods of high winds, and water will be applied to recently exposed cinder and ash.

6. Soil-binding stabilizers will be used sparingly, and will never be applied to Wēkiu bug habitat. (V-3)

Vehicle traffic to WMKO is expected to increase during and after construction of the Outrigger Telescopes. Environmentally-safe soil stabilizers may be applied to road and parking areas to reduce dust during and after on-site construction. Soil stabilizers may be needed to reduce dust during the excavation of Outrigger Telescope foundations and light tunnels. Environmentally-safe soil stabilizers will only be used where the application of potable water is inadequate for dust control. In no case will soil stabilizers be applied directly to Wēkiu bug habitat slopes, nor will they be applied to excavated cinder that is to be used in mitigation habitat. Application of soil stabilizers will be performed under light wind conditions to prevent drift into Wēkiu bug habitat.

Soil stabilizers are often applied to roads to improve stability and suppress dust. Generally, the stabilizers bind soil particles together to form a hard, protected surface. There are many commercially available dust control additives, each with characteristics specific for soil types, climate conditions, and road uses. They also differ in soil penetration potential, suppression duration, and costs. All of these factors will be considered before a soil stabilizer treatment is applied.

Several dust-suppressing soil stabilizers are considered "environmentally friendly" and appear to be free of residuals that can harm native arthropod populations. Most have been tested for toxicity on micro-invertebrates, fish, and wildlife. Professional review before application of soil stabilizer products will reduce the chances of inadvertent impacts to Wēkiu bug habitat. An entomologist familiar with Wēkiu bug autecology will review the potential impacts of products being considered for use, and make recommendations. In no case will soil stabilizers be used indiscriminately, nor will they ever be applied beyond the slope break of the observatory site.

Soil stabilizers are not always appropriate for dust control. An alternative to soil stabilizers is the application of potable water to roads and construction site surfaces. Dust control watering could potentially increase water availability to Wēkiu bugs, enhancing survival and population growth.

7. **The WMKO staff will continue to follow Federal guidelines specifying the use and disposal of substances used in the washing and recoating of observatory mirrors. (VI-1)**

The WMKO 10-meter mirrors are made up of 36 segments, each approximately 1.8 meters (6 feet) in diameter. The proposed Outrigger Telescopes will use mirrors 1.8 meters (6 feet) in diameter. Under standard operating procedures, up to four mirror segments can be recoated in each month. Outrigger Telescope mirrors will be recoated on a similar schedule. The proposed additional four to six Outrigger Telescope mirrors will thus increase the total mirror surface area to be processed by 6 to 8 percent. Mirror recoating effluents at WMKO will be collected, and removed and transported off-site by a licensed waste handler.

8. **Contractors will be required to minimize the amount of on-site paints, thinners, and solvents. Painting and construction equipment will not be cleaned on-site. Contractors will be required to keep a log of hazardous materials brought on-site and report spills immediately to a designated WMKO representative. (VI-2)**

Many components of the proposed Outrigger Telescopes will arrive at the site ready for installation. Some components may require painting. Paints, thinners, and solvents are toxic to Wēkiu bugs. The amounts of such substances transported to the summit will be those required to support the current activity. The amount required for the entire project will not be stockpiled on the summit.

Cleaning paintbrushes, rollers, and paint-spraying equipment requires the use of solvents and thinners. Having these substances on-site increases the risk of spills. Painting equipment will be cleaned off-site to reduce the risk of spills that could impact Wēkiu bug populations.

Contractors will be required to keep a weekly log of hazardous materials they bring to the site. The log will consist of a list of the substances that are being used, and the number and size of the containers that arrive and leave the site. The log will be available for inspection by CARA representatives.

In the unlikely event of an accidental spill of hazardous materials, it will be reported immediately, and appropriate actions will be taken to limit the impact to Wēkiu bugs. Spills will be contained to limit the impact area, and if the spill results in soil contamination, the soil will be removed in a safe and effective manner. Logs and manifests can provide useful information regarding the hazardous materials on site, in case of an accidental spill.

9. Construction trash containers will be tightly covered to prevent construction wastes from being dispersed by wind. (VII-1)

Covering containers will decrease the amount of construction debris that could be blown onto Wēkiu bug habitat. "Roll off" containers will be equipped with secure tops and lids to ensure no debris escapes during high winds. Containers will be collected on a regular basis before they are completely full or overflowing. This could entail collection several times a week, particularly during periods of heavy use.

10. Construction materials stored at the site will be covered with tarps, or anchored in place, and not be susceptible to movement by wind. (VII-2)

Construction materials and supplies will be prevented from being blown into Wēkiu bug habitat by covering them with heavy canvas tarps. Steel cables, attached to anchors that are driven into the ground, can hold materials down.

Construction materials at the site will be tied down or otherwise secured during high winds and at close of work each day. Securing materials will reduce the chances of debris being blown off the site into Wēkiu bug habitat. Preventing debris from blowing onto the habitat slopes will reduce costs and potential habitat disturbance necessary to retrieve the items.

11. If construction materials and trash are blown into Wēkiu bug habitat, they will be collected to the extent practicable, with a minimum of disturbance to the habitat. (VII-4)

Despite efforts to prevent wind-blown construction materials and trash, some debris could end up in Wēkiu bug habitat. Retrieving this debris from sensitive areas will be done carefully and with minimum disturbance. Small pieces of debris will be allowed to blow out of Wēkiu bug habitat to spots where they can be collected safely. Larger debris will be removed with minimum disturbance to slope stability and structure. Methods for removal may vary depending on the material and its location. Contractors will be educated about appropriate debris retrieval methods.

12. **Earthmoving equipment will be free of large deposits of soil, dirt, and vegetation debris that could harbor alien arthropods. (VIII-1)**

(a) **Contractors will be required to pressure-wash earthmoving equipment to remove alien arthropods.**

Alien arthropods can arrive at the summit by two general pathways. First, alien species already on the Island can spread to new localities. Second, alien species can arrive with shipping crates and containers. In order to block the first pathway, heavy equipment, trucks, and trailers will be pressure-washed before being moved to the construction site at Pu'u Hau 'Oki.

Earthmoving equipment and large vehicles and trailers often sit at storage sites for several days or weeks between jobs. Most of these storage sites are located in industrial areas and usually support colonies of ants and other alien arthropods. These species often use stored equipment as refuges from rain, heat, and cold. Ants will colonize mud and dirt stuck to earthmoving equipment and could then be transported to uninfested areas. Spiders occupy stored equipment, looking for food or escaping predation by hiding in protected niches. Once transported to the summit, these species could migrate to Wēkiu bug habitat.

Pressure-washing of equipment before transportation to the construction site at Pu'u Hau 'Oki will remove dirt and mud and wash away ants, spiders and other alien arthropods, thereby reducing the chances of transporting these species to the summit area.

(b) **Contractors will be required to inspect large trucks, tractors, and other heavy equipment before proceeding up the observatory access road.**

Tractor-trailer rigs, earthmoving machinery, and other heavy equipment will be inspected for arthropods before proceeding up the observatory access road. This inspection will be recorded in the contractor's logbook.

13. **All construction materials, crates, shipping containers, packaging material, and observatory equipment will be free of alien arthropods when delivered to the summit. (VIII-2)**

(a) **Contractors will be required to inspect shipping crates, containers, and packing materials before shipment to Hawai'i.**

Alien arthropods can be transported to Hawai'i via crates and packaging. Contractors will be requested to use only high quality, virgin packaging materials when shipping supplies and equipment. Pallet wood will be free of bark and other habitat that can facilitate the transport of alien species. WMKO managers will communicate to shippers, and suppliers the environmental concerns regarding alien arthropods, and inform them about appropriate inspection measures to ensure that supplies and equipment shipped to Hawai'i are free of alien arthropods at the points of departure and arrival.

Shipping containers will be inspected and any visible arthropods removed. Construction of crates immediately prior to use will prevent alien arthropods from establishing nests or webs. Cleaning containers just prior to being loaded for shipping will also eliminate alien arthropod infestations.

Many arthropods may escape detection during shipping inspections. After arrival in Hawai'i, crates or boxes to be transported to the summit will be re-inspected for spider webs, egg masses, and other signs of alien arthropods. Re-inspection prior to transport to the summit will reduce the potential for undetected alien arthropods reaching the summit.

(b) **Contractors will be required to inspect construction materials before transport to the summit area.**

Alien arthropods already resident in Hawai'i are capable of hitchhiking on construction material such as bricks and blocks, plywood, dimensional lumber, pipes, and other supplies. Precautions will be taken to ensure that alien arthropods are not introduced to the Mauna Kea summit area.

Construction materials will be inspected before transport to the construction site. If any alien arthropods are discovered, the infestation will be removed prior to transport. Infestations of ants can be removed using pressure-washing. Infestations of spiders can be removed using brooms, vacuum cleaners, or other similar methods. Pesticide use on materials to be transported to the summit will be avoided.

14. Outdoor trash receptacles will be secured to the ground, have attached lids and plastic liners, and be collected frequently to reduce food availability for alien predators. (VII-3 & VIII-3)

Workers and visitors to the WMKO inevitably often bring some trash with them. Lunch bags, film canisters, wrappers, etc. can be easily blown into Wēkiu bug habitat. Receptacles will be provided to eliminate the dispersal of this kind of trash. The receptacles will be heavy and have attached lids so that they do not become flying objects in the high winds at the summit.

Readily available food supplies can facilitate the establishment of alien arthropods at the summit. Sanitary control of food and garbage will prevent access to food resources that could be used by invading ants and yellowjackets.

Refuse containers will be heavy and secured to the ground. Refuse will be collected on a regular basis before containers are completely full or overflowing. This could entail collection several times a week, particularly in eating areas and during periods of heavy use of the area.

Containers will be regularly washed using steam and/or soap to reduce odors that attract ants and yellowjackets. Plastic bag liners will be used in all garbage containers receiving food to control leaking fluids.

15. New alien arthropod introductions detected during monitoring will be eradicated. (VIII-4)

(a) Ant eradication

Sticky traps designed to capture ants will be deployed immediately after any ants are detected. Persistence of ant detections is indicative of larger infestations, and will prompt a search for and eradication of colonies. Bait and chemical control will be employed only when absolutely necessary and only by a certified pest control professional. In no case will pesticides be applied on or near restored habitat or crater slopes.

(b) Yellowjacket eradication

Traps will be deployed when yellowjackets are detected. Trapping yellowjackets is a useful method of control that does not require pesticides. Lures or baits will improve the effectiveness of traps. Localized yellowjacket populations can be reduced to non-threatening levels if trapping is employed immediately after detection. Traps will be maintained until yellowjackets are no longer detected.

(c) Alien spider eradication

Alien spider webs will be removed when detected. Native lycosid wolf spiders do not make webs. Native sheet-web spiders make tiny webs under the cinder surface. Only alien spiders make large spider webs at the WMKO site. Sweeping such webs away with a broom disrupts alien spider food capture success and destroys egg masses.

16. Construction contracts will ensure that compliance violations are corrected.

The commitments in this Mitigation Plan will become, as applicable, rules and guidance for contractors and operators during on-site construction, installation, and operation of the proposed Outrigger Telescopes, light tunnels, and retaining walls. This will be accomplished through appropriate contract provisions and CARA oversight of contractor activities. A well-designed monitoring plan will detect violation of the rules and guidance. Such a plan has been developed and will be implemented when construction begins. Violations or other errors will be corrected as soon as possible in a manner that protects and enhances Wēkiu bug population and habitat.

APPENDIX E

WĒKIU BUG MONITORING PLAN

WĒKIU BUG MONITORING PLAN

The Wēkiu Bug Monitoring Plan was prepared by Pacific Analytics under contract to Jet Propulsion Laboratory and is bound separately. The Plan was developed based on recommendations found in the Wēkiu Bug Mitigation Report also authored by Pacific Analytics. The Plan was developed to aid in the protection and enhancement of the Wēkiu bug population, and is consistent with the goal of good stewardship of the natural environment on the summit of Mauna Kea.

The Wēkiu Bug Monitoring Plan can be found at url:

http://www.statpros.com/Wekiu_Bug.html

APPENDIX F

DRAFT CONSTRUCTION BEST MANAGEMENT PRACTICES PLAN

DRAFT

W. M. KECK OBSERVATORY

CALIFORNIA ASSOCIATION FOR RESEARCH IN ASTRONOMY

Keck Interferometer Outrigger Telescopes

CONSTRUCTION BEST MANAGEMENT PRACTICES

PLAN (BMP)

Draft Revision A

January 23, 2002

Keck Interferometer Plan

Title:	**Construction Best Management Plan (BMP)**
Author:	James Bell (CARA)
Version:	A – Draft pending site works contract
Date:	1/23/2002
Approvals:	Jim Beletic
Cc:	Peter Wizinowich (CARA), Jim Kelley (JPL)

Upon obtaining project approval for the new Keck Outrigger Telescopes, this Best Management Practices Plan (BMP) will be used to guide all activities associated with construction of the outrigger telescopes. The plan will serve as a working document that may be expanded and revised prior to project start. It will become part of the agreements/contracts with site work contractors. The purpose of this document is to facilitate project management by developing an organizational structure that will guide construction management, designate who has the authority to make decisions, and provide a checklist to ensure compliance with all mitigating measures and conditions on the project. It is a primary management tool for the CARA Construction Manager and Contractor's Project Manager. This Best Management Practices Plan becomes null and void if for some reason the project fails to move forward.

I. OVERVIEW

A. PURPOSE

The purpose of the Construction Best Management Practices Plan (BMP) is to specify the methods and controls which will be implemented to prevent or minimize negative impacts to the surrounding environment, and to the natural and cultural resources on and adjacent to the W. M. Keck Observatory (WMKO) site during the construction of the Outrigger Telescopes project. Included in these controls is a proposed organizational structure which clearly sets forth the lines of authority and responsibility that will ensure proper supervision and oversight throughout the construction process.

The BMP will be overseen by the CARA Construction Manager and implemented by the Contractor's Project Manager. A Construction Management Organization Chart, identifying the proposed hierarchy and working relationships among the various interested parties, is attached (Figure 1). The BMP and accompanying organization chart will be finalized by CARA in coordination with the selected Contractor. It will also be attached to the construction contracts. The CARA Construction Manager will have the primary responsibility for all construction activities.

B. SCOPE OF THE CONSTRUCTION BMP

All construction activities related to the Outrigger Telescopes Project—from delivery of materials and equipment (to either the WMKO site or one of the two construction staging areas, Figure 2), through final clean up of the staging areas, stockpile area (Figure 3) and WMKO site—will be controlled by the BMP. These activities include, but are not limited to:

- Unloading containers at the staging area and delivering the contents to the site.
- Installing sheet piling, as required by the Hawaii Electric Light Company (HELCO), to protect power cables from inadvertent disturbance by construction equipment. Removal of piles upon completion of construction will also adhere to this plan.
- Excavating and trenching for junction boxes, light pipes and air pipes, enclosure and telescope footings, underground coudé rooms and tunnels.
- Removing excess excavated material, not used for backfill, to the approved summit stockpile area (Figure 3) to be screened, washed and used for Wēkiu habitat restoration on and adjacent to WMKO site.
- Grading and shoring for Outrigger Telescope enclosures and junction boxes, including placement of fill and construction of retaining walls.
- Pouring concrete (ready-mixed in Hilo or Waimea) for a tunnel, ring wall, retaining walls and telescope foundations.
- Installing up to five prefabricated junction boxes and up to six prefabricated coudé rooms (or pouring concrete if prefabricated structures are unavailable).
- Installing light pipes (together with electrical conduits) and air pipes.
- Assembling prefabricated enclosures, consisting of ring walls and rotating domes, on site; setting the ring walls on concrete footings and installing the domes on their tops.
- Installing a telescope, dual star module and other hardware within each enclosure.

- Complying with the Wēkiu Bug Mitigation Plan, including the restoration of Wekiu bug habitat.
- Maintaining the summit construction staging and stockpile areas (Figure 3), on-site stockpile areas and the construction staging area at Hale Pohaku (Figure 2) in clean, safe condition.
- Care and maintenance of equipment and vehicles.
- Cleanup of all construction areas.
- Complying with the Memorandum of Agreement on cultural resources.

II. ENVIRONMENTAL AND CULTURAL CONCERNS

A. WĒKIU BUG

Although the actual construction site has been altered by past development activities, nearby Wēkiu bug habitat could be affected by construction of the proposed project (Figure 4). The major negative effects that could occur during Outrigger Telescope construction are: trash, dust, side-cast cinder, introduction of non-native species, and spills of hazardous materials. The control and mitigation of these concerns will follow the Wēkiu Bug Mitigation Plan. Foot traffic in Wēkiu Bug habitat can be harmful to the habitat. The Construction Manager will ensure that the only foot traffic in the habitat will be with the concurrence of the project entomologist.

B. CULTURAL CONCERNS

Historic District. The State Historic Preservation Division (SHPD) believes that the summit region of Mauna Kea is eligible for listing in the National Register of Historic Places as an Historic District. The cluster of cones forming the summit, including Pu'u Hau Oki, would be a contributing historic property to this district and itself meets the criteria for listing in the National Register of Historic Places. Measures that would prevent or minimize activities that would further impact the structural and visual integrity (i.e., shape and contour) of the Pu'u Hau Oki cinder cone and its crater are a primary focus of the BMP.

Potential Burial Sites. Most of the land to be used for the Outrigger Telescopes has been previously altered to such an extent that there is a low probability of discovering burials on the site. An exception to this applies to areas near the outer edges of the Pu'u Hau Oki plateau, where it had not been previously disturbed other than being subjected to side-casting of cinder from the original grading of the plateau. Because the existence of burials cannot be conclusively verified, the project archeologist will monitor all excavation.

View Planes. All above ground parts of junction boxes and retaining walls will be colored to match the cinder.

III. PRE-CONSTRUCTION ACTIONS

A. COORDINATION

Prior to construction mobilization, meetings will be held to finalize all aspects of the construction process. The following information will be exchanged between CARA (including the Archeological, Cultural and Wēkiu Bug Monitors) and the Contractor at least two weeks before these meetings take place.

1.0 Information to be provided by CARA

a) A location map identifying all construction, staging and stockpile areas.

b) A description of the type, composition and quantity of material expected to be excavated during the project and its disposition.

c) A description of the type, composition and quantity of fill material to be used, including locations of temporary on-site stockpiles.

d) A chart showing preferred construction sequence (a schedule of construction activities) that will: (a) minimize potential adverse cultural and environmental effects, and (b) allow efficient scheduling of appropriate monitoring times.

e) A Construction Management Organization Chart, such as shown in Figure 1, that will clearly delineate lines of authority and responsibility; phone numbers of key personnel will also be included.

f) Provide a detailed description of specific mitigating measures to protect and preserve the natural and historic/cultural attributes of the project area.

g) Based on the Organization Chart, designation of areas of responsibility, names and phone numbers of responsible individuals, names and phone numbers of special advisors, and steps that will be taken to accomplish the following:
   - control of all trash and construction material stored on site;
   - removal of all trash on a regular basis;
   - monitoring of construction activity to ensure that no cinder or other materials are side-cast into the Pu'u Hau Oki crater or the outer slopes of the cone;
   - ensuring compliance with all provisions of the Section 106 memorandum of agreement (MOA) to be entered into by NASA, the Advisory Council on Historic Preservation, State Historic Preservation Officer, and others;
   - monitoring the on-site use of paints, thinners, and solvents and other hazardous materials and reporting spills to designated individuals;
   - ensuring that earth-moving equipment is free of large deposits of soil, dirt and vegetation debris that may harbor non-native species; and
   - ensuring that new non native species introductions detected during monitoring as described in Wēkiu Bug Monitoring Plan are eradicated;
   - ensuring compliance with all provisions of the Wēkiu Bug Mitigation Plan.

h) A list of telephone numbers of the responsible persons and alternates to be contacted (day or night) when violations are suspected. (After inspecting a particular incident, these individuals report their findings to the CARA Construction Manager; they do not interact with the workers or try to fix it themselves except for the archaeologist has the immediate authority to stop construction work in the area of an identified or potential find. The resource or burial could easily be destroyed by the time the Construction Manager is found, the issue discussed, and directive given. The archaeologist may also be responsible for discussing any findings with the SHPO and the cultural monitor under the Section 106 MOA.

i) A set of criteria to be used when determining whether or not to stop construction.

j) An emergency response plan for unplanned events to be based on the CARA Safety Manual.

2.0 Information to be provided by the Contractor

a) A list identifying the characteristics of raw materials to be brought to the site or lay down area, including:
   - the type of materials to be used, by construction phase;
   - the frequency of delivery of these materials to the site;
   - the quantities to be stored and length of storage;
   - the location of proposed on-site storage and stockpile areas; and
   - a description of how the Contractor would clean and care for these areas and materials.

b) A written summary of the characteristics and source of any discharge and potential pollutants associated with each construction activity together with proposed control measures or treatment methods, including but not limited to the following discharges:
   - solid waste,
   - oily waste,
   - hazardous waste, and
   - equipment cleaning and washing of cement truck mixers.

c) A written summary describing the type and characteristics of vehicles and equipment to be used, including:
   - the duration of use by construction phase by vehicle and equipment type;
   - emission characteristics by vehicle and equipment type;
   - noise characteristics by vehicle and equipment type;
   - type of fuel used by vehicle and equipment type; and
   - on-site use and/or storage area(s) for each type of equipment.

d) An implementation plan for suspending all dust-generating activities and securing equipment and materials during high winds and storms.

e) A plan to control wind and water erosion during the construction period.

f) An implementation plan for cleaning vehicles and equipment to rid them of non-native species of plants and animals prior to transportation to the construction site.

B. ARCHAEOLOGICAL CONSULTATION

CARA and the Contractor will meet at least 2 weeks before construction starts with a qualified archaeologist as defined in the MOA (known as the project archeologist) to determine the scope and schedule of archaeological monitoring activities during the construction period. The archaeologist will first identify potentially sensitive construction areas on the WMKO site. The archaeologist, in coordination with the CARA Construction Manager and the Contractor, will develop standards and criteria for monitoring excavation activities and determining when remedial actions are required and work must be stopped. The archaeologist will then be present on site to monitor all excavation. The archaeologist will follow SHPD standards for archaeological monitoring studies and reports (HAR Chapter 279). The archaeologist has the immediate authority to stop construction work in the area of an identified or potential find. The archaeologist may also be responsible for discussing any findings with the SHPO and the cultural monitor under the Section 106 MOA. The archeologist is encouraged to work with the cultural monitor in developing monitoring plans and actual monitoring. The archeologist has the discretion to make random visits to the project site, but for safety reasons must check in with the Construction Manger before entering the site.

C. CULTURAL MONITORING

The CARA Construction Manager and the Contractor will meet with the project cultural monitor to determine the scope and schedule of cultural monitoring activities during the construction period at least 2 weeks before construction starts. The cultural monitor, in coordination with the CARA Construction Manager and the Contractor, will develop standards and criteria for monitoring construction activity and determining when remedial actions are required. Details of the monitoring and required qualifications of the monitor are defined in the cultural resources MOA. The project cultural monitor is encouraged to work with the project archeological monitor in developing monitoring plans and actual monitoring. The project cultural monitor has the discretion to make random visits to the project site, but for safety reasons must check in with the Construction Manger before entering the site.

D. FINALIZE PLANS AND PROCEDURES

The CARA Construction Manager and the Contractor Project Manager will meet, discuss and revise all information and produce a final Organization Chart, a set of criteria for ensuring compliance with all mitigating measures, and criteria and procedures for stopping construction if necessary.

E. PREPARE MONITORING AND REPORTING SCHEDULES

The CARA Construction Manager, in consultation with various specialists and the Contractor, will prepare schedules for monitoring on-going activities for compliance with the BMP. Procedures for reporting violations and the status of corrective measures to bring the project into compliance will also be determined. The name and phone number of each monitor will be identified.

F. FIELD MANUAL OF PROCEDURES AND PRACTICES

The CARA Construction Manager, in cooperation with CARA, the Contractor, OMKM and special advisors, will prepare a manual which will incorporate the finalized BMP; specific emergency response plans for injuries, medical emergencies, and fire; other standard practices (CARA's safety manual); and protocols for Wēkiu bug and cultural mitigation. Both CARA and the General Contractor will approve this manual.

The CARA Construction Manager will schedule mutually agreed upon meetings with the Archaeologist, Cultural Monitor, and OMKM, to ensure that work is being carried out according to applicable terms of the MOA.

G. EDUCATION

Prior to starting work on the project site, all project personnel and all contractor(s) employees will be briefed on and shown a videotape concerning the cultural significance of the project area. OMKM will be consulted on the production of the video and advised on the briefings. A natural resource specialist will brief them on the importance of protecting the Wēkiu habitat. Mitigating measures for both cultural and natural resources will be explained in detail. They will also be advised of procedures that must be taken in the event of an infraction of the conditions imposed on the project. Suggestions as to the most effective ways of informing their workers about the importance of adhering to all of the stipulations set forth in the agreement will also be discussed. The archaeological monitor and the cultural monitor will also give presentations to project personnel and contractor employees as specified in the MOA.

IV. CONTROLS

A. CONSTRUCTION SAFETY ZONES

1.0 Pu'u Hau Oki Crater Rim and Outer Slopes

Temporary 3-foot-high silt fences will be installed along the rim of the Pu'u Hau Oki crater and outer slopes, where excavation or trenching is planned to take place where any significant potential that material may be overcast down slope. At a minimum the fences will be located down slope of any area to be excavated within 6 feet of the slope. The temporary silt fences will be maintained by the contractor on a daily basis to repair any damage.

2.0 Other Construction Areas

a) Construction safety fencing and temporary signage to deter unauthorized visitors and Observatory personnel from inadvertently entering into construction zones will delineate each area under construction. To the extent possible, the color of the fencing will blend in with the surrounding cinder terrain.

b) As the construction in each area is completed, the fencing and signage will be removed as soon as practicable.

c) The fencing and signage will remain at any area where archaeological artifacts are found until the State Historic Preservation Division approves removal, if any, of the fencing and temporary signage.

B. HEALTH AND SAFETY

1.0 Noise

a) The Contractor will minimize high noise levels from construction equipment by outfitting all equipment with proper noise muffling devices.

b) The Contractor will comply with State Department of Health (DOH) rules (HAR, Chapter 46, Community Noise Control).

2.0 Air Quality

The Contractor will comply with Hawaii DOH rules (HAR Chapter 11, Section 60.1, Air Pollution Control) and the County of Hawaii grading permit as well as this BMP.

a) Dust Control
   - fugitive dust will be minimized by spraying with potable water or other environmentally acceptable suppressant as necessary. The Wekiu Bug Monitor will define what is environmentally safe; and
   - all dust-generating activities will be suspended during high winds. The critical velocity of these winds will be determined later but is assumed to be about 40 to 50 miles per hour (64 to 80 kilometers per hour).

- Cinder stored in the summit stockpile area at the project site will be covered with heavy tarps as needed to minimize dust.

b) Emissions
- all engine emissions will be mitigated by the use of properly functioning emission control devices as required by law;
- all construction equipment will be properly maintained;
- equipment idling will be kept to a minimum when equipment is not in use.

3.0 Worker Safety

All personnel working on the project site including monitors must attend Pre-Start Safety Induction training that will cover at a minimum:

- CARA and Contractor Safety Policy
- Contractor MSDS Management and Control
- Discussion of harards associated with working at high alititude
- Review of lockout proceedure on dome and telescope.
- Reporting accidents
- Emergancy medical treatment for workers in the event of an accident
- Dealing safely with hazardous materials
- Highlight the critical proceedures that are most likely to affect workers or the project.

The Contractor will comply with all OSHA standards and regulations.

C. *WASTE CONTROLS*

The Contractor will comply with all Hawaii DOH rules.

Every member of the construction crew, managers, observatory personnel, and other people associated with the proposed Outrigger Telescopes Project will undergo an orientation about the impacts of the Outrigger Telescope construction and installation, and how they may prevent and minimize disturbance caused by trash.

1.0 Solid Waste (Construction and Domestic)

a) Construction materials and supplies will be prevented from being blown into Wēkiu bug habitat and historic properties by covering them with heavy canvas tarps, using steel cables attached to anchors.

b) Construction trash containers will be tightly covered to prevent construction wastes from being dispersed by wind.

c) Outdoor trash receptacles will be secured to the ground and have secured lids and plastic liners.

d) "Roll off" containers will be equipped with heavy canvas tarps held securely with cables. Containers will be collected on a regular basis before they are completely full or overflowing.

e) All trash will be removed to an authorized disposal site in either Hilo or Waikoloa. This will be done on at least a weekly basis throughout the construction period.

f) As necessary, a magnetic device will be driven over roadways to remove metallic debris.

2.0 Toxic/Hazardous Waste

a) Contractors will minimize the on-site use of paints, thinners, and solvents.
b) Painting and construction equipment will not be cleaned on-site.
c) Contractors will keep a log of toxic/hazardous materials, if any, brought on-site and their disposition.
d) Spills will be immediately reported to the CARA Construction Manager who will activate the appropriate emergency response procedures.
e) Any toxic/hazardous waste generated by the construction project will be properly disposed of as recommended by CARA's Hazardous Disposal consultant.

D. ACCIDENTIAL CHEMICAL RELEASES

1.0 Precautions

a) Fuel tanks of equipment and construction vehicles will not be filled to the top.
b) Equipment will be properly secured during non-working hours, away from previously identified (during pre-construction activities) sensitive areas.
c) Fuel spill clean-up kits will be readily accessible at the work area at all times.

2.0 Spill Response Plan

a) Procedures for spill response are included in CARA's Safety Manual. Additional requirements will be added if necessary.
b) The Contractor will comply with all Federal and State DOH rules and regulations.

E. SPECIAL CONCERNS

1.0 Cultural Resources

a) Any human remains discovered during the construction process will immediately be reported to the CARA Construction Manager. As set forth in HAR 13-300-40, "Inadvertent discovery of human remains," the Archeologist will immediately order all work stopped in the area of the discovery and report the findings to the following:
   - the State Historic Preservation Division, unless the discovery occurs on Saturday, Sunday or holiday, at which time the report shall be made to the Division of Conservation and Resources Enforcement;
   - the University of Hawaii Office of Mauna Kea Management;
   - the Hawaii County medical examiner or coroner; and
   - the Hawaii County Police Department.

   Work in the discovery area can resume only upon approval of SHPD.
b) Because use of the construction staging and/or stockpile areas within the summit area of the Science Reserve may affect the landscape of a proposed historic property (the summit area of Mauna Kea), the following precautions must be observed:

- construction materials stored at the site must be anchored in place and not be susceptible to movement by wind;
- trash must not be scattered over the site; and
- trash containers must be secured to the ground and tightly covered to prevent construction wastes from being dispersed by wind.

c) The construction staging and stockpile areas on the summit (and in some instances at Hale Pohaku) must be inspected for compliance with the BMP every evening (after the work day is completed), and during high winds and storms. The construction staging and stockpile areas must also be inspected upon completion of all construction and habitat restoration activities to ensure that the areas have been restored.

d) All stipulations in the cultural resource MOA related to construction activities, as well as conditions attached to the Conservation District Use Permit, will be incorporated into this BMP and the construction contract.

2.0 Wēkiu Bug

a) Non-native species
- monitoring will be undertaken to identify any no-native species infestations at the Outrigger Telescopes construction site and staging areas;
- large deposits of soil, dirt and vegetation debris that may harbor non-native species will be removed from all earth-moving equipment by pressure washing or other means at the Contractor's base yard before ascending Mauna Kea;
- large trucks, tractors, and other heavy equipment will be inspected for non-native species at the Contractor's base yard or marine terminal and at the intersection of the Saddle Road and the Summit Road; the inspection near the intersection of the Saddle and Summit Roads will be conducted by a qualified biologist. If non-native species are found at the intersection of the Saddle and Summit Roads, the qualified biologist can either remove the non-native species or send the vehicle back to the base yard for required cleaning;
- the Contractor will ensure that all construction materials, crates, shipping containers, packaging material, and observatory equipment are free of non-native species when delivered to the summit; and
- new non-native species introductions detected during monitoring of the Outrigger Telescopes construction site and staging areas including, but not limited to, ants, yellow jackets and alien spiders, shall be eradicated.

b) Wēkiu Bug Habitat Protection
- soil-binding amendments will be used sparingly
- if construction materials and trash are blown into Wēkiu bug habitat (Figure 4), it will be collected by staff trained by the project entomologist taking care to minimize habitat disturbance.

c) Wēkiu Bug Habitat Restoration. Excess excavated material, not used for backfill or site grading, will be removed to the approved stockpile area, screened and washed. The cinder will be sieved for ½" and larger size and washed with an estimated 1 gal/ft^3. The sieving and washing process should be done simultaneously to minimize a dust plume. All material of suitable size will be used to restore Wēkiu bug habitat on or adjacent to Pu'u Hau Oki. Any remaining material will be placed in the summit area after consultation with the SHPD and Office of Mauna Kea Management.

- The project entomologist will be on site during the habitat restoration and will have the necessary authority to ensure that the work is done properly;
- new cinder will be placed only on previously-disturbed surfaces;
- to the extent possible, the new cinder will match the existing cinder;
- washing of the cinder will be done in such a way that there is no erosion or other marking of the landscape by runoff;
- screening and washing of cinder will occur in an up-slope section of the staging area that is farthest removed from unaltered ground surfaces down slope.

3.0 Construction Staging Areas

a) The Hale Pohaku and summit construction staging areas will be inspected each evening to ensure that all materials are secured and that all trash is placed in appropriate approved containers.

b) When in use, the staging areas will be checked daily for oil spills from vehicles. These spills will be cleaned up immediately and the offending vehicle(s) will be removed from the mountain for maintenance.

c) The staging areas will be checked regularly for the presence of non-native species; any infestations will be immediately eradicated.

4.0 Potential Interference with Observatories

a) Use of exterior lighting is not permitted between sunset and sunrise.

b) Use of any radio transmitter that may interfere with observatory operations is not permitted.

5.0 Photographic Record

a) The contractor shall keep a photographic record of all construction activities on the site starting with pictures before any activities, during and after. This record shall be available for viewing in the site project office. At the end of the job the contractor will deliver 2 copies of the photos, one for CARA and another for OMKM.

V. ENFORCEMENT

It is the responsibility of the CARA Construction Manager to enforce the provisions of the BMP. All monitors will report their findings to him or her.

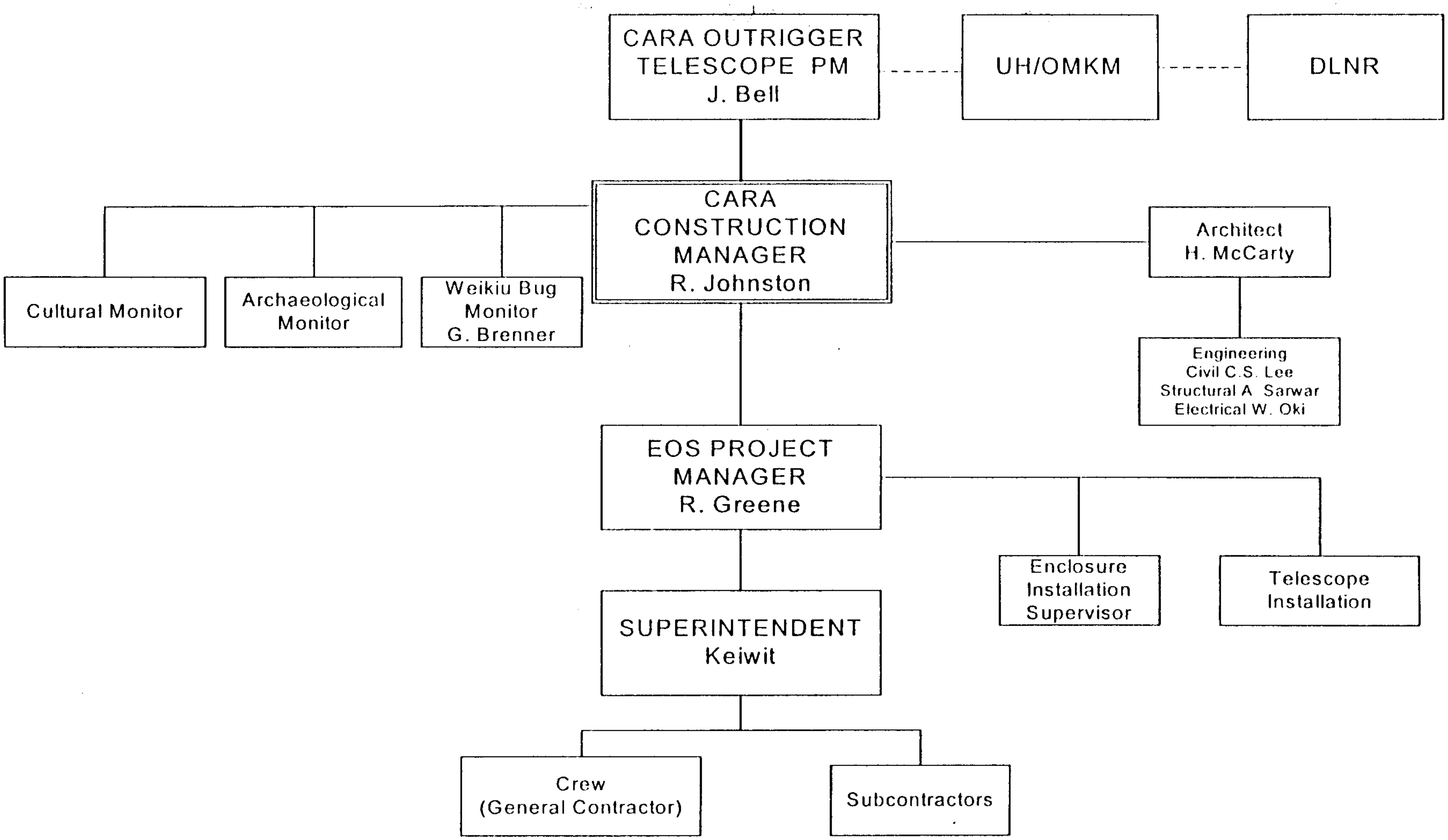


Figure 1
CONSTRUCTION MANAGEMENT ORGANIZATION CHART

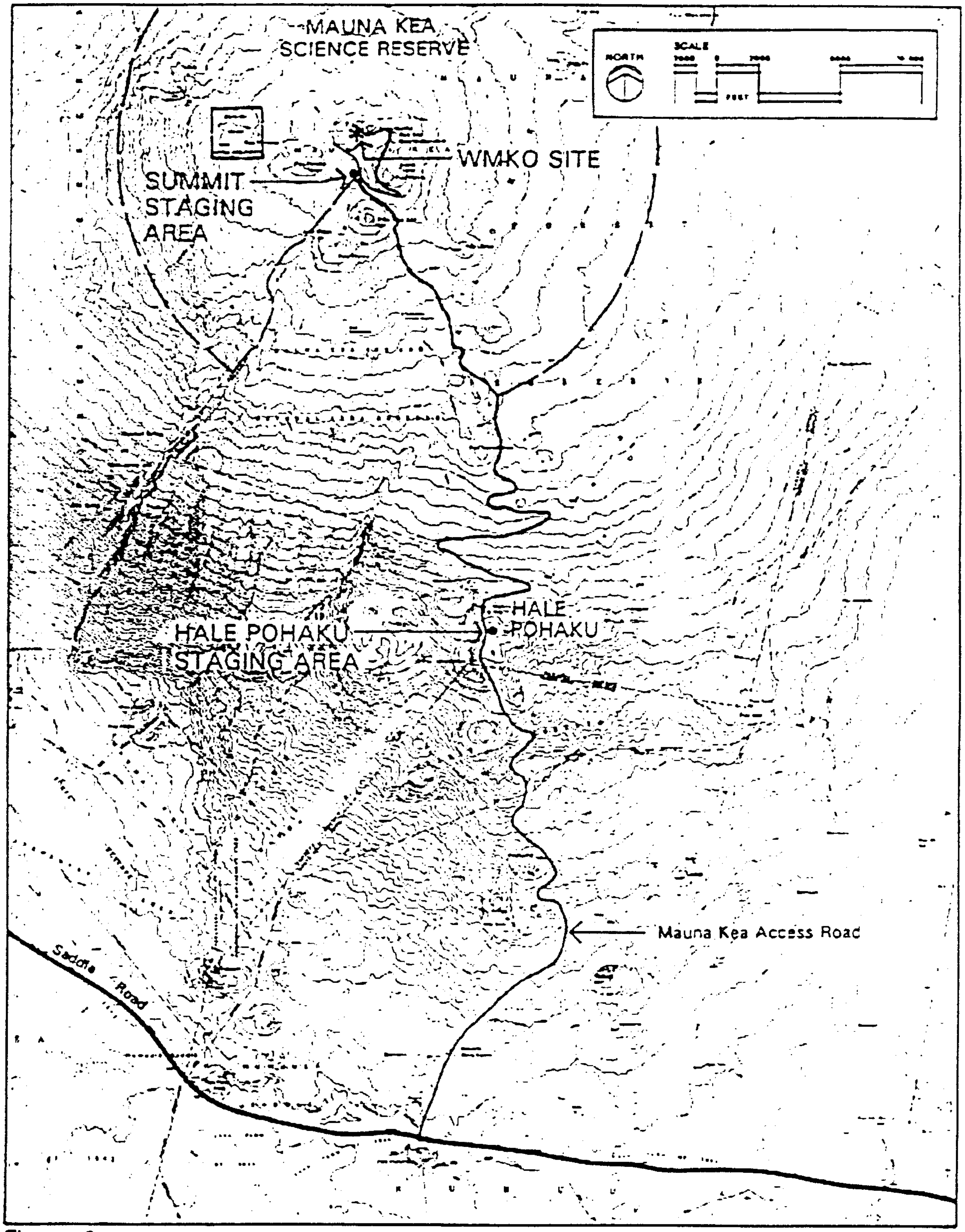
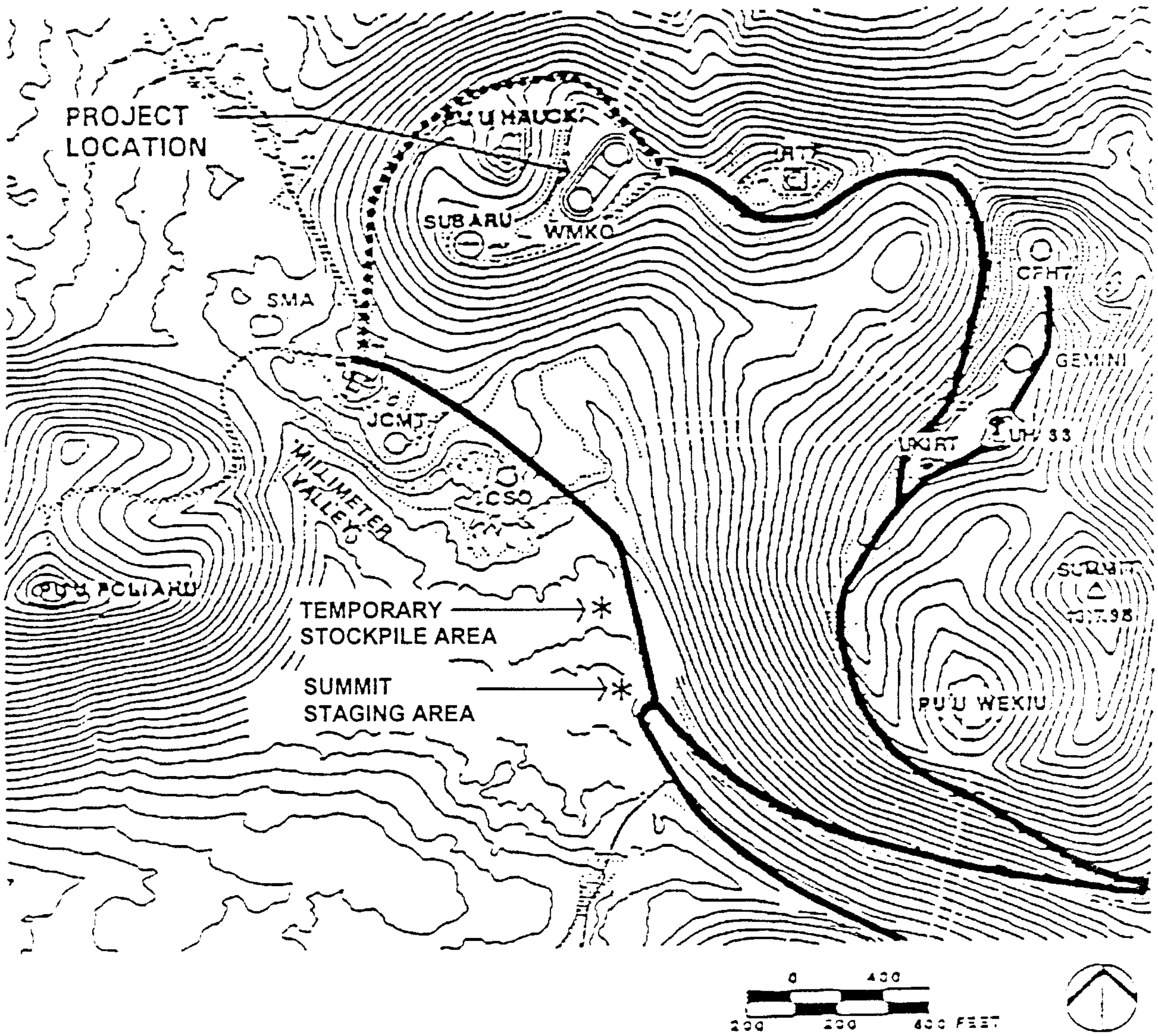


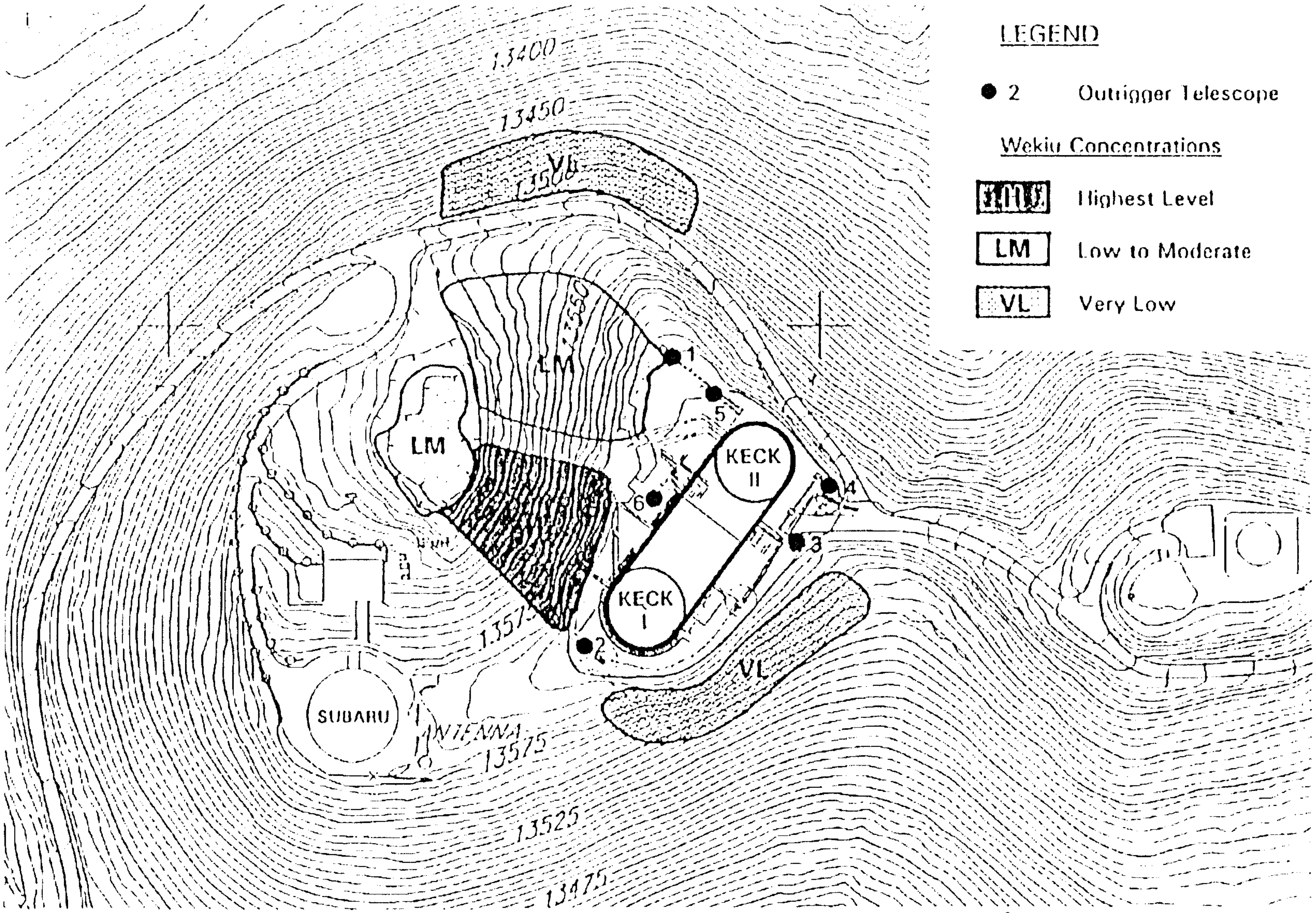
Figure 2
CONSTRUCTION STAGING AREAS



LEGEND

▬▬	PAVED ROADS
•••••	GRAVEL ROADS

Figure 3
LOCATION OF THE PROJECT WITHIN THE SUMMIT AREA



Source: Howarth et al. (1999)

Figure 4

PU'U HAU OKI: AREAS OF WEKIU BUG CONCENTRATION (1997-1998)

APPENDIX G

MITIGATION AND MONITORING MEASURES FOR THE OUTRIGGER TELESCOPES PROJECT

Appendix G

Mitigation and Monitoring Measures for the Outrigger Telescopes Project

The mitigation and monitoring activities for the Outrigger Telescopes Project are provided below. The details of these activities can be found in Chapter 4 and Appendices C, D, E, and F of this Environmental Assessment (EA). Mitigation and monitoring measures associated with historical/cultural resources can be found in the Section 106 Memorandum of Agreement (MOA) in Appendix C. The Consulting Parties invited under the Section 106 MOA include the Advisory Council on Historic Preservation (ACHP), the Hawai'i State Historic Preservation Officer (SHPO), the University of Hawai'i (UH), the California Association for Research in Astronomy (CARA), the California Institute of Technology (Caltech), Ahahui Ku Mauna, Hawai'i Island Burial Council, Hui Mālama I Nā Kūpuna O Hawai'i Nei, Mauna Kea Anaina Hou, the Office of Hawaiian Affairs (OHA), Office of Mauna Kea Management, and the Royal Order of Kamehameha I. Mitigation and monitoring measures associated with the Wēkiu bug and its habitat can be found in Appendices D and E. CARA would ensure that any of the MOA's provisions that relate to on-site construction and installation of the Outrigger Telescopes would be included as provisions in any contracts for on-site construction and installation.

All of these mitigation measures would be implemented by CARA and ensured by NASA during on-site construction, installation, and operation of the Outrigger Telescopes.

HISTORIC/CULTURAL RESOURCE MITIGATION AND MONITORING MEASURES

- The Construction Manager, hired by CARA, the contractor(s), supervisors, and all construction workers will be provided training to become aware of the historic/cultural significance of the project site and surrounding areas of the summit as set forth in the MOA.

- In consultation with NASA and the other Consulting Parties, CARA shall develop criteria for and select an individual to be the project's Cultural Monitor. Any Consulting Party may submit the names of persons who they believe would be appropriate to serve as Cultural Monitor. This individual will have the knowledge or awareness of Mauna Kea's cultural landscape, and traditions, practices, beliefs, and customs associated with Mauna Kea.

- The Cultural Monitor will be able to communicate cultural values and protocols to others, both within and outside of the culture.

- The Cultural Monitor will become aware of the general scope and requirements of the on-site construction and installation of the Outrigger Telescopes Project including, but not limited to, becoming familiar with: project boundaries, identified areas of historic/cultural sensitivity, the "construction Best Management Practices Plan" (BMP), the construction worker responsibilities, responsibilities of the Archaeologist, and the sequence of operations to ensure that mitigation actions are implemented.

- A Cultural Monitor will be provided free access for monitoring activities during excavation. other on-site construction, and telescope installation.

- Prior to construction, a cultural monitoring plan will be developed by the Cultural Monitor in consultation with CARA. CARA shall submit the plan for review by NASA and all other Consulting Parties.

- The CARA Construction Manager shall encourage the Cultural Monitor and Archaeologist to work closely with one another.

- The CARA Construction Manager will provide to the Cultural Monitor a weekly schedule of all construction activities planned for the following week. Based on that schedule, the Cultural Monitor will determine his/her need to visit the site during construction and installation as deemed necessary by him/her. For safety purposes, prior to entering the site, the Cultural Monitor will meet and confer with the CARA Construction Manager.

- The site and grading development drawings and the BMP for the Outrigger Telescopes project site, the staging areas, and nearby areas of the summit region will be provided to the Cultural Monitor. The Cultural Monitor shall keep a log and map notes of every visit—noting date of visit; identifying work locations; noting findings date; and reporting on potential problems, if any. All findings identified and deemed to be significant by the Cultural Monitor shall be reported to the CARA Construction Manager and OMKM; in turn, CARA shall promptly notify NASA, the Council, the Hawai'i SHPO, UH, and Caltech and any other Consulting Party that has requested to be notified of the Cultural Monitor's findings. The Cultural Monitor will submit a final report to the CARA Construction Manager; CARA, in turn, will provide copies to NASA, the Council, the Hawai'i SHPO, UH. OMKM, and Caltech and any other Consulting Party that has requested the report..

- The Cultural Monitor shall consult with the Construction Manager to determine what circumstances the Cultural Monitor should have direct authority to halt construction activities in a given area.

- The Cultural Monitor will provide cultural orientation to individuals who are associated with the on-site construction and installation of the Outrigger Telescopes and who will be on Mauna Kea. For safety purposes, all communication for the purpose of cultural orientation between project personnel and the Cultural Monitor will be scheduled and overseen by the CARA Construction Manager.

- The Archaeologist will be hired by CARA in consultation with the Hawai'i SHPO and OMKM.

- The Archaeologist will meet the professional qualifications set forth in the MOA.

- The Archaeologist will follow State Historic Preservation Division draft Hawaiian Administrative Rules for archaeological monitoring studies and reports (draft HAR Chapter 279). The Archaeologist will develop the Inadvertent Discovery of Human Remains and Archaeological Properties monitoring plan.

- The Archaeologist shall familiarize him/herself with the WMKO site before construction begins.

- The Archaeologist will become aware of the general scope and requirements for the on-site construction of the Outrigger Telescopes Project. This would include, but not be limited to becoming familiar with: project boundaries, identified areas of historic/cultural sensitivity, the BMP, construction worker responsibilities, responsibilities of the Cultural Monitor, and the sequence of operations to ensure that mitigation actions are implemented.

- The Archaeologist will monitor all excavation activities for on-site construction. The CARA Construction Manager will provide to the Archaeologist a weekly schedule of all construction activities planned for the following week. The Archaeologist will have access to the site and be present during all excavation activities. For safety purposes, prior to entering the site, the Archaeologist will meet and confer with the CARA Construction Manager.

- The site and grading development drawings and the BMP for the Outrigger Telescopes project site, the staging areas, and nearby areas of the summit region will be provided to the Archaeologist. The Archaeologist shall keep a log and map notes of every visit — noting date of visit; identifying work locations; noting findings date; and reporting potential problems, if any. All findings identified and deemed by the Archaeologist to be significant shall be reported to the CARA Construction Manager, the Hawai'i SHPO, and OMKM; in turn, CARA shall promptly notify the NASA, the Council, UH, Caltech, and the Cultural Monitor of the Archaeologist's findings. The Archaeologist will also notify the Cultural Monitor if human remains are found so that he or she can assist with notifying and consulting those individuals and organizations identified in the Inadvertent Discovery of Human Remains and Archaeological Properties monitoring plan. The Archaeologist will submit a draft report to the CARA Construction Manager; CARA, in turn, will forward the draft report to the Hawai'i SHPO for approval. The approved final report will be distributed by CARA, who will provide copies to NASA, the Council, UH, OMKM, and Caltech, and any other Consulting Party that has requested a copy of the report.

- Prior to construction, an Inadvertent Discovery of Human Remains and Archaeological Properties monitoring plan will be developed by the Archaeologist in consultation with the Cultural Monitor and CARA and will comply with draft State Historic Preservation Division Rules (Titles 13-275, 13-279, and 13-280). CARA shall submit this plan for review by NASA and all Consulting Parties. Thereafter, CARA shall submit the plan to the Hawai'i SHPO for approval.

- The Inadvertent Discovery of Human Remains and Archaeological Properties monitoring plan shall include burial and notification components that comply with Hawai'i Revised Statutes (HRS) Title 6E-43.6 (Inadvertent Discovery of Burial Sites), and Hawai'i Administrative Rules (HAR) Title 13-300-40 (Inadvertent Discovery of Human Remains) for the burial components; and with applicable draft State Historic Preservation Division Rules (*e.g.*, Sections 13-275-12, 13-279-1 *et seq.*, and 13-280-1 *et seq.*) for the archaeological components. The burial treatment component will reflect a preference to the extent practicable, and if confirmed to be culturally appropriate, for any human remains found to be preserved in place.

- As a minimum, if there were to be an inadvertent discovery of human remains, the Archaeologist will have the authority to halt ground-disturbing activities in the immediate area of such remains until all parties identified in the plan have been notified, and the requirements of the appropriately approved plan have been carried out.

- As a minimum, if previously unidentified historic/archaeological properties (*e.g.*, deposits, artifacts, and stone alignments) were to be discovered during construction, the Archaeologist will have the authority to halt ground disturbing activities in the immediate area of such properties until all parties identified in the plan have been notified, and the requirements of the appropriately approved plan have been carried out.

- Proposed grading and site development drawings will be provided to all the Consulting Parties for a 45-calendar day review and comment period to ensure that every reasonable effort has been made to reduce the adverse effects on Pu'u Hau 'Oki and on the summit region of Mauna Kea by minimizing disturbance from the on-site construction and installation of the Outrigger Telescopes. The goal of the grading and site development planning will be to minimize alteration of the cinder cone as it presently exists, maintain the general shape and form of the cinder cone as it presently exists, and to stabilize the cinder cone in the on-site construction and installation areas.

- When a Consulting Party provides comments to any of the plans, the party submitting the plan shall, to the extent practicable during a 45-day review period, enter into a dialogue with a commentor.

- The CARA Construction Manager will oversee the on-site professional personnel and all on-site construction and equipment installation. The CARA Construction Manager will schedule mutually agreed upon meetings with the Archaeologist, Cultural Monitor, and OMKM, to ensure that work is being carried out according to applicable terms of the MOA. The CARA Construction Manager, at the request of the Archaeologist or the Cultural Monitor or on his/her own initiative, has the authority to stop construction if the stipulations in the MOA are not being complied with.

- As part of an orientation process to ensure work is carried out in as sensitive and respectful a manner as possible, the CARA Construction Manager, the contractor(s), supervisors, and all construction workers involved in the Undertaking will be required to view a specially scripted training videotape reviewing the historic and sacred qualities of Mauna Kea.

- This training videotape will be prepared by CARA in consultation with the Hawai'i SHPO and OMKM. This training videotape will include a presentation on the history of Mauna Kea and its significance to Native Hawaiians, and an overview of what to do if human remains or archaeological properties are found. CARA shall provide the Consulting Parties an opportunity early in the videotape development process to provide ideas on subject matter that should be discussed and highlighted. CARA shall afford the Consulting Parties an opportunity to review the draft script and preview the videotape before the videotape is produced in final form. Should a disagreement arise, CARA will enter into consultation to resolve the disagreements. The time for such script review, videotape preview, and consultations shall cumulatively not exceed 45 days, unless CARA, at its sole discretion, agree to a longer cumulative period.

- The videotape or related orientation will also advise the workers of the potential that CARA will demand their removal from this Undertaking if they fail to comply with the conditions imposed by the construction Best Management Practices Plan.

- The CARA Construction Manager, contractor (s), supervisors, and construction workers will also be briefed by the Archaeologist and Cultural Monitor on Native Hawaiian objects, artifacts, and remains, and what to do if such materials are found during construction activities.

- In order to implement a series of precautions and procedures to be undertaken to avoid or minimize adverse effects and prevent or reduce adverse impacts to the cinder cone and inner crater slope during on-site construction and installation, the CARA Construction Manager and the on-site construction and installation contractor(s) will prepare a Construction "Best Management Practices Plan" (BMP) in consultation and coordination with OMKM and UH. The BMP will be finalized prior to the start of construction. This BMP will reference the MOA and include it as an appendix.

- Prior to the start of construction, CARA will submit the draft BMP to the other Consulting Parties for review. Copies of all comments received will be provided to NASA. CARA will take those comments into account before its final approval of the BMP and prior to mobilization. CARA will take no more than 15 calendar days to conclude consultation on any issues stemming from the comments.

- On-site construction and installation activities related to the Outrigger Telescopes—from delivery of materials and equipment to the WMKO site or one of the two construction staging areas, excavation and removal of excess cinder to the summit stockpile area through assembly of the domes and telescopes to clean up of the staging, stockpile and WMKO site —will be managed in accordance with the BMP. The CARA Construction Manager will be responsible for following the BMP.

- To address the effects on historic properties, the BMP will include, but not necessarily be limited to, the following items:

  — The process to be followed if there were to be an inadvertent discovery of human remains or archaeological properties.

— Site characterization, including the locations of all construction and laydown/stockpile areas on the site, and temporary on-site fill material stockpiles.

— The sequence of construction activities will be designed to minimize potential adverse effects on historic properties and to allow efficient scheduling of appropriate monitoring times.

— The specific methods needed to protect the attributes of the historic properties within the project site, staging areas, and within the immediate vicinity of the project area will include, but are not limited to:

- Installing a temporary silt fence along the crater rim to facilitate on-site containment of all material, including cinder, so that no such material will spill over the slope. A silt fence will be used whenever excavation occurs within six feet of the slope.

- Transferring all excavated material, to the extent not necessary for backfill or Wēkiu bug habitat restoration, to other locations accessible from the established roads on the summit of Mauna Kea. These locations will be identified after consultation with the Hawai'i SHPO and OMKM prior to the start of construction.

- Following all applicable County of Hawai'i and State Department of Health (DOH) regulations concerning dust control which include, but are not limited to, suspending all dust-generating activities, securing equipment and materials during high winds and storms, minimizing dust by spraying with water or other environmentally-acceptable soil stabilizers whenever necessary, and, if needed, covering excavated material with a tarp which is anchored down.

- Ensuring adherence to effective drainage and erosion control as provided for in the BMP.

- Ensuring that precautions are adopted to prevent potential adverse effects on the historic properties arising from use of the staging areas near the summit of Mauna Kea and at Hale Pōhaku.

- Providing the process and identifying the project personnel responsible for reporting the inadvertent discovery of human remains or archaeological properties pursuant to the monitoring plans.

- Providing an organization chart that identifies project personnel with the responsibility for maintaining the integrity of the historic properties and the historic district.

- To reduce the visual impact on the cinder cone and the historic district, all structures or portions thereof will be of colors designed to blend in with the surrounding terrain; provided, however, that such colors would not adversely affect the operation and scientific capability of the Outrigger Telescopes. CARA will afford the Consulting Parties an opportunity to review and comment on the colors to be used.

- Characteristics of any discharge of a pollutant into the environment associated with the construction activity (including solid waste, sanitary waste, oily waste, or toxic/hazardous waste, if any) will be identified as soon as it is practicable. Proposed control measures and/or treatment methods for any unplanned or accidental discharge of pollutants associated with construction activity will be developed by the contractor(s) and managed in accordance with the BMP.

- During the construction and installation of the Outrigger Telescopes, OMKM, in consultation with the Hawai'i SHPO, will develop and provide interpretive materials concerning the cultural significance of Mauna Kea. The Consulting Parties will be afforded an opportunity to review and comment on the interpretive materials during their development.

- Prior to implementation of the Undertaking and finalization of the Wēkiu Bug Mitigation Plan, CARA will consult with the Hawai'i SHPO to ensure that the plan contains appropriate provisions that will avoid or minimize, to the extent practicable, any potential adverse effects on the historic property and historic district. These shall include, but not necessarily be limited to, installing permanent signs identifying Wēkiu bug habitat, preventing the dispersal of debris, screening and washing cinder for habitat restoration, placement of the restoration material, and erosion control.

- CARA shall ensure that the plans and mitigation measures set forth in the MOA for adverse effects on historic properties, including, visual impacts, erosion control, permit requirements and conditions, and monitoring commitments are incorporated into the contract(s) with its contractors and subcontractors; and that such contract(s) include a provision that CARA's Construction Manager has the authority to enforce such requirements or conditions and, if infractions occur, to order work to stop until the contractor/subcontractor is in compliance.

- CARA shall make provisions for the Consulting Parties to monitor and review the work during on-site construction and installation activities. However, for safety purposes, all construction site visits must be coordinated through the CARA Construction Manager's office. If it appears that the terms of this MOA are not being followed, Consulting Parties are encouraged to notify NASA, CARA, and the Hawai'i SHPO.

- Before excavation begins CARA and NASA will provide points of contact to Consulting Parties, along with a copy of the final executed Memorandum of Agreement.

- NASA, in consultation with the Office of Mauna Kea Management, will fund, out of funds for the Outrigger Telescopes Project, an initiative that deals with preservation and protection of historic/cultural resources on Mauna Kea and educational needs of Hawaiians as a mitigation component of the Outrigger Telescopes Project. Funding such an initiative, however, is conditioned on the approval of the Outrigger Telescope's being placed at the WMKO site on the summit of Mauna Kea, Hawai'i. This initiative will be sensitive to Native Hawaiian culture, history, and institutions.

  — The necessary first step will be the formation of local citizens' working group. NASA and the Office of Mauna Kea Management, in consultation with the other Consulting Parties will ensure the formation of this working group. The working group members will serve on a volunteer basis. The Office of Mauna Kea Management will coordinate and manage the activities of this working group and provide administrative services.

— Once this working group is formed, its task will be to inform NASA as to what types of opportunities or goals will best benefit Hawaiians, including Native Hawaiians. The working group will be asked to prioritize their proposals. The working group will have one year after it is formed to develop its recommendations, but it is encouraged to submit proposals sooner, if possible.

— Funding will be subject to the availability of appropriated funds in accordance with Federal law (*e.g.*, the Anti-Deficiency Act). Such funds will be allocated to the proposals as prioritized by the working group until available funds are exhausted.

- CARA will ensure that all persons involved with the operations of the Outrigger Telescopes shall be required, within a thirty day period of commencing their job, to view as part of worker orientation the training videotape which addresses the cultural significance of Mauna Kea to Native Hawaiians. CARA will report to OMKM quarterly on the status of worker compliance with the viewing of the training videotape.

WĒKIU BUG MITIGATION AND MONITORING MEASURES

- Wēkiu bug habitat will be restored in areas damaged by on-site Outrigger Telescope construction, and on the crater floor of Pu'u Hau 'Oki. Restored areas will total at least three times the total area damaged by new construction.

- Under no circumstances during construction, installation, and operation will cinder or other materials be deliberately side-cast into Wēkiu bug habitat. Temporary barriers will be built along the slope breaks above the inner slopes of Pu'u Hau 'Oki crater.

- Educational signs will be placed along the slope break above Wēkiu bug habitat, and at the service road adjacent to the crater floor.

- Potable water will be applied to excavation sites and cinder stockpiles as required to minimize dust during earthmoving activities.

- Dust generation will be minimized during construction to the extent practicable. Only small or contained areas will be affected at any given time.

- Dust-generating activities will be suspended during high winds.

- Soil-binding stabilizers will be used sparingly, and will never be applied to Wēkiu bug habitat. Application of environmentally safe soil stabilizers may be applied to roads and parking areas to reduce dust during and after on-site construction. Environmentally safe soil stabilizers will only be used in situations where the application of potable water is inadequate for dust control. Soil stabilizers will be applied under light wind conditions to prevent cinder dust drift due to wind into Wēkiu bug habitat. Products considered for use will be reviewed by an entomologist familiar with Wēkiu bug ecology prior to being considered for use.

- Contractors will be required to minimize the amount of on-site paints, thinners, and solvents. Painting and construction equipment will not be cleaned on-site. Contractors will be required to keep a log of hazardous materials brought on-site and report spills immediately to a designated WMKO representative.

- The amounts of such substances transported to the summit will be those required to support the current activity.

- Construction trash containers will be tightly covered to prevent construction wastes from being dispersed by wind.

- Construction materials stored at the site will be covered with tarps, or anchored in place, and not be susceptible to movement by wind.

- Earthmoving equipment will be free of large deposits of soil, dirt, and vegetation debris that could harbor alien arthropods.

- Contractors will be required to pressure-wash earthmoving equipment to remove alien arthropods.

- Contractors will be required to inspect large trucks, tractors, and other heavy equipment before proceeding up the observatory access road.

- All construction materials, crates, shipping containers, packaging material, and observatory equipment will be free of alien arthropods when delivered to the summit.

- Contractors will be required to inspect shipping crates, containers, and packing materials before shipment to Hawai'i.

- Contractors will be required to inspect construction materials before transport to the summit area.

- Outdoor trash receptacles will be secured to the ground, have attached lids and plastic liners, and be collected frequently to reduce food availability for alien predators.

- New alien arthropod introductions (ants, yellow jackets, and spiders) detected during monitoring will be eradicated.

- Construction contracts will ensure that compliance violations are corrected.

- Cinder or ash will be moved to temporary stockpile areas and covered with tie-down tarps. Permanent placement of any excavated cinder fill and ash from the project area during on-site construction will be determined in consultation with the State Historic Preservation Division (SHPD) and the Office of Mauna Kea Management (OMKM).

- Educational signs will be placed along the slope break above Wēkiu bug habitat, and at the service road adjacent to the crater floor. Attractive, non-intrusive, educational signs will be installed to inform people about the Wēkiu bugs, their habitat, and the historic/cultural significance of the area.

- Strict adherence to precautions and procedures outlined in the construction Best Management Practices Plan (BMP's) will be required to maintain slope stability.

- As part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology, and to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors.

- If construction materials and trash are blown into Wēkiu bug habitat or fall onto the surrounding slopes of Pu'u Hau 'Oki, they will be collected to the extent practicable, with minimum disturbance to the habitat and cultural properties.

- Two types of Wēkiu bug monitoring will be implemented: (1) compliance monitoring to investigate the extent to which contractors, operators, managers, and visitors comply with Wēkiu bug protection guidelines and rules; and (2) effectiveness monitoring to investigate the changes in Wēkiu bug habitat and population that may happen concurrent with and/or subsequent to construction of the Outrigger Telescopes.

OTHER MITIGATION MEASURES

- In order to minimize negative effects, appropriate traffic control measures will be taken, and all trips of heavy oversized loads, such as those transporting the telescope components, will be scheduled during off-peak hours so as not to interfere with normal traffic flow in Kawaihae, Waimea, or along the Saddle Road.

- Contractors will properly maintain construction vehicles and equipment to minimize combustion emissions. Engine emissions would be controlled by the use of functional emission devices as required by law. Equipment idling will be kept to a minimum when not in use.

APPENDIX H

RESPONSE TO COMMENTS CONCERNING THE HYDROLOGY OF MAUNA KEA

DRAFT ENVIRONMENTAL ASSESSMENT FOR THE OUTRIGGER TELESCOPES PROJECT PUBLISHED BY NASA IN DECEMBER 2000

RESPONSE TO COMMENTS CONCERNING THE HYDROLOGY OF MAUNA KEA

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I. EXECUTIVE SUMMARY

Comments on the Draft Environmental Assessment [NASA, 2000] for the proposed Outrigger Telescopes Project at the W. M. Keck Observatory (WMKO) site on Pu'u Hau Oki focus in part on possible impacts that construction, construction staging activities, and operations may have on surface and ground water systems of Mauna Kea. In this report the hydrologic systems that operate on and beneath the summit and upper slopes of Mauna Kea are described, concentrating on the dynamics of drainage basins that could be directly impacted by the construction and operation of the telescopes.

The summit (4,205 meters [13,796 feet] maximum altitude above mean sea level) and upper slopes (above approximately 3,000 meters [9,843 feet]) of Mauna Kea consist of a dry, cold tundra environment. Surface stream flow is ephemeral and occurs only in response to storms and rapid snowmelt. Because of the low surface water influx rates the saturated water table is located thousands of feet beneath the summit. However, there are perched ground water systems at the summit in which snow melt and rain enter the subsurface, flow along impermeable boundaries, and emerge as springs and seeps on the slopes of the mountain.

The summit and slope drainage basins of relevance to this report are as follows:

- The northern side of Pu'u Hau Oki is the upper portion of a drainage basin that empties into Kuupahaa Gulch on the northern side of the mountain.
- The southern side of Pu'u Hau Oki is the upper portion of a drainage basin that includes the Submillimeter Valley (construction staging site) and drains into Pohakuloa Gulch on the southern side of Mauna Kea.
- Lake Waiau, a pond within Pu'u Waiau, has a small drainage basin that includes the inner slopes of Pu'u Waiau and a portion of a lava flow to the north. This basin is distinct and isolated from the nearby Pohakuloa Gulch basin, although overflow from the Lake does occasionally empty into the gulch.
- Hale Pohaku (construction staging site), located on the slopes of Mauna Kea, is located within a drainage basin that includes a number of channel systems on the southern side of the mountain. The basin is separate from the Pohakuloa Gulch basin.

Issues associated with the dynamics of water and transport of mechanical (i.e., particulate material) and dissolved (i.e., carried in solution) sediment loads within affected drainage systems are as follows:

- There will not be any discernable increase in mechanical sediment load carried by water as a consequence of construction and construction staging activities if tephra (general term for volcanic cinders and/or ash) excavated and removed from the construction site is stockpiled in a manner that minimizes the erosion and transport potentials.

- Washing volcanic tephra in the Submillimeter Valley staging area for the Wēkiu Bug habitat restoration will be done with potable water and would add only a very small addition to the water that is naturally within that portion of the Pohakuloa Gulch drainage system on an annual basis.
- Dissolved Sediment Load: Chemicals that are accidentally spilled at the construction or construction staging sites would remain in the upper few meters of the surface until flushed by ephemeral saturated ground water flows generated by storms and rapid snow melts. The reasons are that: (a) except for Lake Waiau, shallow subsurface materials at the summit are not saturated with water (i.e., the system is within the vadose zone, the zone where water does not fully occupy pores in tephra and cracks in rocks), except during storms and rapid snow melt events, and (b) the transport of dissolved materials within the vadose zone is extremely slow (10 to 1,000 times as slow) as compared to saturated flow. Thus, storms and rapid snow melts, which saturate the upper few meters of the surface, are required for transport of dissolved materials down hill as ground and surface flows. Storms and rapid snow melt events are rare and most of these events occur during the winter season. Thus, surface and subsurface flow would be maximized during this season. Immediate response and clean up would mitigate any problems associated with entry into and transport by the ephemeral ground and surface water systems.
- A modest increase of sewage effluent associated with the WMKO facilities is expected once the Outrigger Telescopes are in operation. The septic system for the WMKO facilities is on the southern side of Pu'u Hau Oki, i.e., within the Pohakuloa Gulch drainage basin. The small effluent discharge, combined with microbially-induced oxidation, will preclude the possibility of down hill contamination.

II. INTRODUCTION

The WMKO Telescopes are located at approximately 4,146 meters [13,603 feet] above mean sea level (MSL) on the cone Pu'u Hau Oki on the summit of Mauna Kea, Hawaii (Figures 1-3). Plans have been proposed for construction of six Outrigger Telescopes surrounding the two Primary Telescopes (Keck 1 and 2). Plans include use of construction staging areas within the Submillimeter Valley located to the south of the WMKO facility, and perhaps at Hale Pohaku, located at approximately 2,835 meters [9,302 feet]. Comments on the Draft Environmental Assessment [NASA, 2000] for the construction and use of the Outrigger Telescopes focused in part on the potential impact on the hydrology of Mauna Kea, including both surface and subsurface systems. To address comments on the hydrology of Mauna Kea the author was engaged by the California Association for Research in Astronomy (CARA) to provide a report that addresses the following questions:

1) "What is the connectivity of the summit area of Mauna Kea, including in particular Pu'u Hau Oki and the WMKO site, to and role in, the hydrology and water quality (ground and surface) of Mauna Kea, i.e. what is the context of surface and underground drainage from Pu'u Hau Oki and the WMKO site?
2) What is the potential for effluents from the Outrigger Telescopes Project (gravel washing, waste water, storm water, and inadvertent spills of hazardous materials) to affect the hydrology and water quality of Mauna Kea resources (ground and surface),

including Lake Waiau and the streams and outcrops down slope of the WMKO site on Pu`u Hau Oki?

3) What is the connectivity and role of ground water and surface drainage at the temporary use areas near Submillimeter Valley and Hale Pohaku to the hydrology and water quality (ground and surface) of down slope areas of Mauna Kea?
4) What is the potential for effluents from temporary use of these areas (tephra washing for Wēkiu bug habitat restoration media, waste water, storm water, and inadvertent spills of hazardous materials) to affect the hydrology and water quality of down slope Mauna Kea resources (ground and surface)?"

To address the questions this report is structured in the following way. First, an overview is presented that focuses on the hydrology of Mauna Kea so that detailed answers can be placed in context of the overall set of hydrologic processes that operate on and beneath the summit and slopes of the mountain. Second, answers are provided for each of the specific questions posed above. The work presented is based on: (a) extensive literature surveys, (b) analyses of climatic data, (c) detailed drainage basin mapping using LANDSAT, ASTER, aerial photography, digital terrain maps, and field mapping, (d) hydrologic field work on Mauna Kea and subsequent laboratory analyses of water, tephra, and rock samples conducted by the author and students over the past several years, and (e) use of modeling to infer rates of transport associated with the hydrologic cycles that operate on and below the summit and upper slopes (higher than approximately 3,000 meters [9,843 feet]) of Mauna Kea.

The ability to evaluate the hydrologic cycles associated with Mauna Kea was made possible by the author's multiyear studies of the summit and upper slopes of the mountain. This work was done as part of the Washington University Pathfinder Program in Environmental Sustainability in which small groups of undergraduates consider environmental issues from scientific, engineering, societal, and cultural viewpoints [Arvidson and Johnson, 1998]. The senior capstone experiences for the years 1999, 2000, and 2001 have focused on issues associated with balance between use of the summit area for telescopic observations and the preservation of the unique and fragile landscapes, ecosystems, and archeological sites that make the mountain such an awe inspiring feature. The work accomplished to date is summarized in Appendix 1 of this report.

III. HYDROLOGIC CYCLE ASSOCIATED WITH MAUNA KEA

Mauna Kea rises up to 4,205 meters [13,796 feet] and is one of five shield volcanoes that comprise the island of Hawaii [Juvik and Juvik, 1998]. It is the northeastern most of the five volcanoes and is connected to Mauna Loa through a saddle that runs east to west. Mauna Kea is also connected to the Kohala Mountains (oldest volcanic construct) to the northwest (Figure 1).

The northeastern or windward flanks of Mauna Kea are subjected to extensive rainfall that is a consequence of warm, moisture laden surface air driven up the slopes of the mountain from northeast to southwest by the trade winds. The trade winds are a consequence of the synoptic scale (i.e., pertaining to regional scales) meteorology associated with the Pacific Ocean anticyclone (high pressure zone) that is centered to the north (summer) and northeast (winter) of Hawaii [Erasmus, 1986]. Precipitation occurs as the air expands and cools as it moves up the slopes of the mountain, a process known as adiabatic expansion and cooling. Since cool air cannot hold as much vapor as warm air, the dew point temperature is reached and precipitation results. For example, the annual precipitation ranges from approximately 600 centimeters [236 inches] at the Makahanaloa Station on the lower slopes [Juvik and Juvik, 1998] to approximately 50 centimeters [20 inches] at the Very Large Baseline Array Station at an altitude of 3,840 meters [12,599 feet] [Metcalf, 2001]. The summit is even drier in that Cruikshank [1986] reports an annual average precipitation of 15 cm [6 inches] based on data from 1969-1977 for optical telescope sites located on the summit cones.

High precipitation values associated with trade wind induced lifting of surface air masses extend to approximately 2,000 meters [6,562 feet]. At that altitude the ascending air meets subsiding, warmer air associated with the Pacific Ocean anticyclone. This meeting of air masses produces an atmospheric inversion layer in which the surface air temperatures increase by a few degrees Celsius over only hundreds of meters of altitude. Above the inversion layer the air tends to become cooler with increasing altitude and to be dry and stable. In fact, the altitude of the inversion layer varies from between 1,500 to 3,000 meters [4,921 to 9,843 feet], depending on weather systems and season. The upper slopes and summit of Mauna Kea are located above the inversion layer, providing a climate for these areas that is best described as a dry, cold tundra-like environment. For reference, Cruikshank [1986] reports an average maximum monthly temperature of 11 degrees Celsius [52 degrees Fahrenheit] in September and a minimum monthly average of –5 degrees Celsius [23 degrees Fahrenheit] for February and March for data collected on the summit from 1969 to 1977.

On most days, clouds, fog, and rain are kept beneath the inversion layer on Mauna Kea (Figures 1 and 2). Particularly during the winter, storms from the southeast and southwest can reach the upper slopes and summit of the mountain. These storms are associated with a number of synoptic systems, including tropical cyclones. As a consequence, most precipitation above the inversion layer occurs during winter storms as snow, freezing rain, and rain. Typically the storm systems provide the majority of annual precipitation over a very small period of time (Figure 4). Finally, fogs are common just below the inversion layer and fog drip from leaves provide a source of soil moisture for the upland Mamane-Ohia shrub systems and Koa-Ohia forests (Figures 1 and 2).

The low precipitation rates, combined with high evaporation rates [Lovenduski, 2000] on the upper slopes and summit of Mauna Kea, drive a hydrologic system without perennial streams or extensive bodies of standing water. The saturated water table (surface below which pores and cracks are full of water) is far below the summit of the mountain. This conclusion is consistent with the drilling activities at the summit, which show only 10 percent pore water at the bottom of the 40 meters [131 feet] maximum drill depth [Harding et al., 1998]. In addition, long baseline electrical resistivity surveys along the Saddle Road between Mauna Kea and Mauna Loa suggest that the water table is as low as 610 meters [2,001 feet] beneath the 1,980 meters [6,496 feet] saddle elevation [Zohdy and Jackson, 1969], suggesting that the water table level is many thousands of feet beneath the summit. The low water table elevation is a consequence of the low summit precipitation rates, combined with the high evaporation rates due to the low relative humidity [Lovenduski, 2000 and Figure 4].

Mauna Kea is estimated to have massive reservoirs of ground water [Mink and Sumida, 1984]. Given the climatology and hydrology associated with the mountain, by far most of the input for these systems must be in the form of precipitation on the northeastern or windward slopes, below the inversion layer. For example, the Eastern Mauna Kea aquifer system is estimated to produce a sustainable yield of 1.47 billion liters/day [388 million gallons/day] whereas the Western Mauna Kea aquifer system is estimated to have a sustainable yield that is much less, only 79.5 to 212 million liters/day [21 to 56 million gallons/day] [Juvik and Juvik, 1998]. This vast difference is a consequence of the geography of rainfall associated with trade winds and high precipitation on the windward slopes of the mountain. Further, the input from the summit and upper slopes is very small in comparison to input from rainfall on the lower slopes.

As noted, the summit of Mauna Kea does exhibit numerous channels and gullies that extend down hill, connecting to larger gulches that have been cut into the slopes of the mountain (Figure 3). Further, numerous small seeps and springs can be found on the upper slopes of Mauna Kea, largely emanating from permeable interfaces close to the contact between the glacial till deposits and volcanic materials [Wentworth and Powers, 1952; Appendix 1]. In addition, Lake Waiau is a small pond located within Pu'u Waiau at the summit [Woodcock, 1980; Appendix 1]. Thus, the summit does have an active hydrologic system, but one dominated by ephemeral stream flow in response to storm-induced precipitation and rapid snow melt, shallow ground water flow and surface emanations as seeps and springs, and one small open body of water. The shallow ground water flow and the presence of Lake Waiau are both consequences of perched ground water systems in which subsurface flow from rainfall and snow melt on the summit is guided down-hill by the presence of impermeable substrates, including lava flows, clay layers, and perhaps permafrost zones [Woodcock and Groves, 1969; Woodcock, 1974; Woodcock and Friedman, 1979]. Except during storms and periods of rapid snowmelt the pore and cracks within the shallow subsurface are not saturated with water, except beneath Lake Waiau.

The specific questions to be addressed in this report are related to the presence of surface and subsurface systems at the summit and Hale Pohaku that would transport water, mechanical sediment load (i.e., the load of particulate material), and dissolved sediment load (i.e., the load of material carried in solution) to the upper slopes of Mauna Kea. To evaluate the connectivity of the WMKO site and construction staging sites in the Submillimeter Valley and Hale Pohaku to down hill transport systems, an extensive analysis was conducted of drainage systems based on literature surveys, analyses of remote sensing and digital terrain maps, and work conducted by the author and his students from 1999-2001 focused on the hydrology of Lake Waiau and the source of water emanating from the springs and seeps on the southern upper slopes of the volcano [Appendix 1]. For this report, LANDSAT Thematic Mapper false color infrared data with a spatial resolution of 30 meters/pixel (98 feet/pixel), along with NASA's TERRA satellite ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) data with 15 meters/pixel (49 feet/pixel) were co-registered to digital terrain models generated from 7.5' quadrangle sheets (Figures 1-3). A stereo aerial photograph taken on 9/30/92 (Frame 107, EROS Data Center ID AB592004485), after the Keck 1 Telescope was built, and while the Keck 2 Telescope was under construction, was also co-registered to these data sets. The particular aerial photograph was chosen because it provides a clear and high-resolution view of the summit region. These data products were then used to define in detail the drainage basins that begin at the summit and extend down the slopes of Mauna Kea. This analysis was accomplished by: (a) using automated software to search for ridge and valley lines that define basin areas, and (b) validation by visual comparisons of the results with the stereo images, key terrain features, and field-based total station measurements (i.e., ground surveys) made by the author and his students at the summit and upper slopes from 1999 to 2001 (Appendix 1). Key connectivity results are presented in Figures 2 and 3 and are as follows:

- Pu'u Hau Oki (WMKO site) is at the summit of Mauna Kea and forms the upper-most portions of drainage systems extending to the north into Kuupahaa Gulch and to the south into Pohakuloa Gulch.
- The Submillimeter Valley (construction staging site) is located down hill of Pu'u Hau Oki in the Pohakuloa Gulch drainage system.
- Lake Waiau is fed by a small drainage basin that includes the inner walls of the cone and a portion of a nearby lava flow. Importantly, this small drainage system is isolated from the Pohakuloa Gulch system that drains the Submillimeter Valley and Pu'u Hau Oki, although overflow from the Lake does occasionally empty into the gulch.
- Hale Pohaku (construction staging site) is located on the southern slopes of Mauna Kea and is within a drainage basin that feeds a number of systems. The basin is separate from the Pohakuloa Gulch basin.

The author and students have conducted several years of research on the hydrology of Lake Waiau and the springs and seeps located on the upper southern slopes of Mauna Kea [Lovevduski, 2000; Ebel, 2001; Johnson, 2001; Appendix 1]. Specifically rain was collected at 1,980, 2,800, 3962, and 3,990 meters [6,496, 9,187, 12,999 and 13,091 feet] in 1999 and 2000 and both the hydrogen and oxygen isotopic compositions were determined, as shown on Figure 5. As air moves up the slopes of the mountain and rainfall occurs, water molecules containing the heavy isotopes of hydrogen and oxygen are more likely to be included in precipitation as compared to water containing light isotopes of these elements. As the air ascends further and precipitation continues, the remaining vapor will become increasingly fractionated or enriched in light hydrogen and oxygen isotopes. The resulting rainfall will thus become increasingly enriched in light isotopes with increasing altitude. This fractionation phenomenon forms an isotopic pattern that is characteristic of rain associated with specific hydrologic systems, i.e., it provides an altitudinal fingerprint of the source of water (Figure 5).

Springs located on the western flank of the Pohakuloa Gulch at altitudes of 2,591 to 3,353 meters [8,501 to 11,001 feet] were sampled in 1999 and isotopes were determined. The isotopic compositions of the springs are indistinguishable from rain collected at the summit (Figure 5), demonstrating that the hydrology of the summit and upper flanks is dominated by flow of current summit rainfall and snow melt. This conclusion is also supported by the measurement in spring waters of radioactive tritium produced by atomic bomb blasts in the 1950's and 1960's [Woodcock, 1980]. Tritium has a half-life of 12.43 years and finding tritium in the spring waters demonstrates that current summit rain is the source of the spring water. Thus, no evidence exists in the isotopic data for subsurface ancient ice as a water source, i.e., there is no evidence for an extensive body of ancient buried ice that is undergoing melting to supply the springs and seeps. Further, no evidence exists for fog drip as a source of spring water since fog typically is produced by a single cycle of evaporation and condensation and has an isotopic signature close to sea level precipitation [Aravena et al., 1989].

Interestingly, Lake Waiau water is isotopically heavy as compared to local rain water, with a composition that varies dramatically with the detailed history of precipitation and evaporation (Figure 5). The reason is that the open water associated with the Lake is subjected to extensive evaporation because of the low relative humidity and extensive solar insolation typical for the summit area. In fact, one dimensional models of the Lake dynamics demonstrate that inputs are associated with short, intense periods of local precipitation and snow melt. Outputs are restricted to continuing evaporation and occasional overflow into the Pohakuloa Gulch during the few times per year when input into the Lake causes the level to overtop a sill and excess water spills into a local gully that feeds into the Gulch (Figure 6).

As a side note, Lake Waiau water was observed by the author to be green in color in August 2000 and again in August 2001. This was due to the presence of algae. The fact that this situation existed in 1935 as reported by Gregory and Wentworth [1937] suggests that the algal growth is a natural part of the Lake ecosystem and not due to anthropogenic influences.

Finally, to estimate the mechanical load of sediment carried down-hill during storms and rapid snow melt it was necessary to conduct a comparative analysis of the basins associated with Mauna Kea and a number of other basins of comparable size that have been gaged to estimate annual sediment transport rates. Specifically, Flaxman [1972] conducted an analysis of 39 basins in the Southwestern United States and found that annual sediment yield in cubic meters/square meter could be predicted from average annual rainfall and temperature, basin slope, and sediment properties, with a linear correlation coefficient of 96%. Using similar data for the Pohakuloa Gulch Basin (average annual precipitation and temperature for the summit [Cruikshank, 1986], grain sizes derived from the drill sample data [Hayashi and Miller, 1991], extent of outcrop inferred from drill samples and field work, and basin slope of 8%), a yield equivalent to removing a layer 1 mm thick/year was obtained using Flaxman's [1972] formulation. This means on average the basin in being denuded at a rate of 1 mm/year, with material transported into the Gulch. Similar results were found for the other basins on the summit and upper slopes.

IV. DETAILED ANSWERS TO QUESTIONS

- Question 1: What is the hydrologic connectivity between Pu'u Hau Oki and down slope systems?

  Pu'u Hau Oki is located at the high altitude portion of two drainage systems, the Pohakuloa Gulch drainage basin from the summit to the southern side of the mountain, and the Kuupahaa Gulch drainage basin on the northern side. The Pohakuloa Gulch system includes the septic system leach field located on the southern side of Pu'u Hau Oki, according to maps provided to the author from the WMKO personnel [James Bell, WMKO, 9/10/01]. This system also includes the Submillimeter Valley construction staging area and the washing zone for tephra being prepared for Wēkiu Bug habitat restoration.

- Question 2: What is the expected magnitude of mechanical and dissolved sediment loads transported between Pu'u Hau Oki and down slope systems?

  Mechanical Load: Sediment at the summit and upper slopes is only transported mechanically by surface water systems during storms and periods of rapid snow melt, i.e., when there is surface water flow. The question becomes how much additional sediment would be created during construction and staging activities that would be transported by surface water flows? That is, what increase in erosion and transport is expected? To answer this question it is necessary to estimate the amount and type of tephra to be uncovered during construction and to evaluate the erosion and transport potentials for these materials.

  As currently proposed, about 918 cubic meters [1,200 cubic yards] of tephra will be excavated on Pu'u Hau Oki to install light and air pipes and junction boxes [Univ. Hawaii, 2001]. Another 1,835 cubic meters [2,400 cubic yards] of material will be excavated for footings, coude' rooms, and Outrigger Telescopes 5 and 6 [University of Hawaii, 2001]. The total amount of tephra to be excavated would thus be 2,753 cubic meters [3,600 cubic yards]. Approximately 50% of the excavated material would be used as backfill. The remaining material (about 1,376 cubic meters (48,587 cubic feet)) would be taken to the Submillimeter Valley for screening and grading in preparation for Wēkiu Bug habitat restoration on Pu'u Hau Oki. Screened cinder of suitable size for Wekiu bug habitat restoration would be washed. The remaining cinder would be stored in areas accessible to established roads on the summit [Draft MOA, 2001].

  In fact, no discernable increase in erosion and transport of mechanical sediment load by surface water flows is expected as a consequence of construction, stockpiling, and washing if the following guidelines are employed. Tephra to be used as backfill should be protected in piles until used. Tephra to be stockpiled in other areas on the summit must be placed in regions away from ephemeral channels and in a manner that minimizes the surface area of exposed materials. The optimum configuration would be to maintain the same surface area/volume ratio for the stockpiled materials as existed before excavation.

Dissolved Sediment Load: Chemicals that are accidentally spilled at the construction or construction staging sites would remain in the upper few meters of the surface until flushed by ephemeral saturated ground water flows generated by storms and rapid snow melts. The reasons are that: (a) except for Lake Waiau, shallow subsurface materials at the summit are not saturated with water (i.e., the system is within the vadose zone, the zone where water does not fully occupy pores in tephra and cracks in rocks), except during storms and rapid snow melt events, and (b) the transport of dissolved materials within the vadose zone is extremely slow (10 to 1,000 times as slow) as compared to saturated flow. Thus, storms and rapid snow melts, which saturate the upper few meters of the surface, are required for transport of dissolved materials down hill as ground and surface flows. Storms and rapid snow melt events are rare and most of these events occur during the winter season. Thus, surface and subsurface flow would be maximized during this season. Immediate response and clean up would mitigate any problems associated with entry into and transport by the ephemeral ground and surface water systems

Sewage Effluent: A modest increase 9,463 liters/month [2,500 gallons/month] of sewage effluent associated with the WMKO facilities is expected once the Outrigger Telescopes are in operation. The septic system for the WMKO facilities is on the southern side of Pu'u Hau Oki, i.e., within the Pohakuloa Gulch drainage basin. The small effluent discharge, combined with microbially-induced oxidation, will preclude the possibility of down hill contamination.

- Question 3: What is the hydrologic connectivity between Submillimeter Valley and down slope drainage systems, and Hale Pohaku and down slope drainage systems?

  The Submillimeter Valley (construction staging area) is part of the drainage basin that feeds the Pohakuloa Gulch.

  Hale Pohaku (construction staging area) is located on the southern slope of Mauna Kea at an elevation of approximately 2,835 meters [9,302 feet]. It is within a drainage system that extends down slope to feed a number of channel systems. This system is not connected to the Pohakuloa Gulch basin and thus is not connected to the WMKO facilities or the Submillimeter Valley.

- Question 4: What is the expected magnitude of mechanical and dissolved sediment loads transported between the Submillimeter Valley and down slope drainage systems, and Hale Pohaku and down slope drainage systems?

  Mechanical Load: Washing volcanic tephra in the Submillimeter Valley staging area for the Wēkiu Bug habitat restoration will be the primary mode by which additional water will be introduced into the natural hydrologic system from the staging areas. Washing will be done with potable water and will add only very small amount of water to the upper portion of the Pohakuloa Gulch drainage system. For example, as part of the screening and grading operation up to 248 cubic meters [8,757 cubic feet] of suitably sized tephra may be washed for habitat reconstruction, in a ratio of one gallon of water per cubic foot (134 liters/cubic meter) of tephra [James Bell, WMKO, personal communication, 12/12/01]. The water volume is approximately equivalent to one or two tanker-truck loads. With a 50 centimeters/year [20 inches/year] [data from Metcalf, 2001] precipitation rate into the Submillimeter Valley above the washing station, approximately 222,525,000 liters [58,746,600 gallons] of water will be added to that portion of the basin naturally. The water added for washing will thus comprise 1/6710 of the annual water budget. If it is assumed that the 15 centimeters/year [6 inches/year] [Cruikshank, 1986] is the appropriate annual precipitation to use, then the ratio would decrease to 1/2,014 of the annual budget, still a very small fraction.

Washing volcanic tephra in the Submillimeter Valley staging area for the Wēkiu Bug habitat restoration will produce reject tephra that is too fine-grained to be of use for the Bug habitat restoration. Assuming an 82% rejection rate after screening [James Bell, WMKO, personal communication, 12/12/01] and 1,376 cubic meters [48,587 cubic feet] of tephra to begin with, approximately 1,128 cubic meters [39,830 cubic feet] of reject tephra will be produced. To minimize the erosion and transport of these materials the reject tephra should be placed in locations away from ephemeral channels and in a manner that minimizes the surface area/volume ratio of the stockpiled material.

Dissolved Sediment Load: Chemicals that are accidentally spilled at the construction or construction staging sites would remain in the upper few meters of the surface until flushed by ephemeral saturated ground water flows generated by storms and rapid snow melts. The reasons are that: (a) except for Lake Waiau, shallow subsurface materials at the summit are not saturated with water (i.e., the system is within the vadose zone, the zone where water does not fully occupy pores in tephra and cracks in rocks), except during storms and rapid snow melt events, and (b) the transport of dissolved materials within the vadose zone is extremely slow (10 to 1,000 times as slow) as compared to saturated flow. Thus, storms and rapid snow melts, which saturate the upper few meters of the surface, are required for transport of dissolved materials down hill as ground and surface flows. Storms and rapid snow melt events are rare and most of these events occur during the winter season. Thus, surface and subsurface flow would be maximized during this season. Immediate response and clean up would mitigate any problems associated with entry into and transport by the ephemeral ground and surface water systems.

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VI. Figure Captions

Figure 1- Landsat thematic mapper false color image of Mauna Kea with elevation contours in units of m above sea level. The change from green to blues, grays and reds above 3,000 meters marks the change from uplands forest and shrub to outcrops of rock and tephra associated with the dry, cold tundra environment at the summit and upper slopes of the mountain. TM bands 2, 4, and 7 (0.56, 0.83, 2.215 micrometers) comprise the color composite.

Figure 2- ASTER false IR color image (bands 1, 2, and 3; 0.56, 0.66, 0.81 micrometers) of summit and upper slopes of Mauna Kea. Red areas at periphery of image show upper limit of vegetative cover. Blue pattern marks location of glacial till. Summit and flank cones are dark to red. Box shows coverage of aerial photograph shown in Figure 3. Red lines superimposed on image demarcate drainage divides whereas blue lines show major drainage channels and gullies.

Figure 3 – False color IR aerial photograph showing summit area of Mauna Kea and overlain with drainage divides (red lines) and major drainage channels (blue lines) for system draining to Pohakuloa and Kuupahaa Gulches. Locations of Lake Waiau, Pu'u Hau Oki , WMKO site (only one of two primary telescopes was constructed at the time; slab for second can be seen), and VLBA meteorology station site are shown.

Figure 4 – Cumulative precipitation at the Mauna Kea VLBA weather station from August 1999 to August 2000 showing the large storm in December, 1999.

Figure 5 – Stable isotopes for rain on the slopes and summit of Mauna Kea, Lake Waiau in August 1999 and 2000 and springs on the upper slopes of the volcano for August 1999. The solid line is the fractionation trend for precipitation as a function of elevation above sea level for Mauna Kea. The dashed line shows the fractionation associated with evaporation of Lake water into the dry air at the summit.

Figure 6 – Lake Waiau one-dimensional finite difference hydrologic model results consistent with the stable isotope trends shown in Figure 5 and Lake levels measured in August 1999 and August 2000. Day refers to Julian Day. Lake overflow starts at 2.5 meters depth. Lake inflow is due to rainfall and snowmelt from drainage basin. Evaporation depends on solar insolation, wind speed, humidity, and Lake area.

VII. Appendix 1: Synopsis of Work Done on Mauna Kea as Part of Pathfinder Program in Environmental Sustainability

The Pathfinder Program in Environmental Sustainability (http://wufs.wustl.edu/pathfinder) at Washington University in St. Louis is a four-year pathway for students with environmental interests and a strong desire to pursue case studies of the environment from the perspectives of science, engineering, culture, and policy [Arvidson and Johnson, 1998]. Freshman field work includes hands-on study of portions of the Missouri River agricultural floodplain devastated by the 1993 floods and now converted to the U. S. Fish and Wildlife Big Muddy Refuge. Students also participate in on site studies of: (a) the Mojave National Preserve during the freshman year spring break, and (b) selected issues in environmental sustainability in Hawaii during a week at the end of the fall semester of the sophomore year. During August of 1999, 2000, and 2001 the students and faculty mentors conducted field work on Mauna Kea, followed by detailed analyses of data and generation of reports during the academic year. The work was coordinated by Program Director, Raymond E. Arvidson, a geomorphologist with over 25 years of experience working on surface dynamics of the Earth, Mars, and Venus.

The Pathfinder August 2000 field work and subsequent laboratory studies revealed new information about the hydrogeology of Lake Waiau and the uniqueness of the summit cones:

*The drainage basin for the Lake was defined based on total station measurements and analysis of digital elevation data. The basin is separate from those associated with the observatories at the summit, implying that runoff from the observatories on the surface or in the subsurface will not be incorporated in the Lake [Ebel, 2001].

*The Raleigh fractionation line for rain was defined by collecting rain from several elevations and measuring D/H and $^{18}O/^{16}O$ stable isotopes [Johnson, 2001]. The linear trend defines the extent to which heavy water precipitates preferentially, leading to light water at high elevations.

*Two water pans were placed near the Lake and filled with Lake water and water collected at sea level from August 7-16, 2001. Isotopic fractionation occurred as the water evaporated, providing an empirical trend to help understand Lake water removal by evaporation. A portable meteorology station was set up near the pans and recorded data needed to model the rate of evaporation with time. The modeled evaporation and the volume evaporated from the pans agree to within a factor of two [Lovenduski, 2000].

*A one dimensional hydrologic model was developed to explain the Lake dynamics and was calibrated using Woodcock [1974] Lake level and precipitation data [Ebel, 2001]. Sensitivity analyses using the model demonstrate that the Lake is dominated by input from local precipitation and loss by evaporation, except when Lake levels become high enough to overspill into the Gulch.

*The Lake water was full of algae in August 2000 so in-situ identification of surfactants was precluded since the approach involves transmission spectrophotometry. Further, analysis of AVIRIS hyperspectral image data shows that the Lake was also in an algal bloom in April 2000 when the AVIRIS data were acquired. Laboratory analyses of cation concentrations for water samples demonstrate that the Lake underwent a factor of two dilution from August 1999 to 2000 [Johnson, 2001]. This volume increase is consistent with measured Lake levels that show a factor of two increase in volume during this time period.

*Water D/H and $^{18}O/^{16}O$ stable isotope patterns, concentrations of chemical materials, and initial hydrologic modeling demonstrate the Lake increased in volume by a factor of two between the summers of 1999 and 2000. This increase was associated with the addition of runoff and snowmelt from water without appreciable concentrations of chemical materials. We are currently working with detailed meteorology data for the relevant time period from the MK VLBA archives to validate our results with our hydrologic model.

*In addition to the Lake studies we also took advantage of our time at the summit during 2000 to do ground truth calibration of geologic mapping of cones from AVIRIS data. We have identified and mapped kaolinite, montmorillonite, saponite, and hematite.

The August 2001 field-work focused on finding and detailed mapping of seeps and springs on the upper slopes of Mauna Kea within the Waikahalulu Gulch. Table 1 is a summary of senior projects currently underway by the undergraduates who participated in the field work.

Table 1: Undergraduate Students, August 2001 Mauna Kea Field Activities, and Topics for Senior Reports

Research Activity
Analysis of isotopic signatures for water collected from within Waikahalulu Gulch; Development of thermal models for seeps, including topographic effects and latent heat associated with evaporation.
Ground penetrating radar measurements and analyses of depths of colluvium and glacial till next to Waikahalulu Gulch, along with tephra deposits from Pu'u Keonehehee.
Analysis of AVIRIS hyperspectral data to infer uniqueness of Pu'u Waiau and Pu'u Poliahu and potential for Wēkiu Bug habitat.
Stereo imaging of seep within Waikahalulu Gulch to generate digital elevation maps.
Vegetation density and soil moisture mapping of the Koa and Mamane Forests, southern flanks of Mauna Kea, from analysis of ASTER data, calibrated with field work.
Estimation of water fluxes from seep located within Waikahalulu Gulch using thermal imaging, digital elevation maps, and thermal models.
Temporal changes in summit associated with telescope construction inferred from aerial and radar images; Sustainability statement for summit focused on what is unique and should be spared construction disturbances.
Detailed mapping of vegetation in and near seep within Waikahalulu Gulch; Initial modeling of biogeochemical cycles associated with Lake Waiau.
Modeling of stone strips and mapping of locations from radar; Consideration of time scales for formation and recovery from anthropogenic disturbances.
Physiological effects of high altitude work.

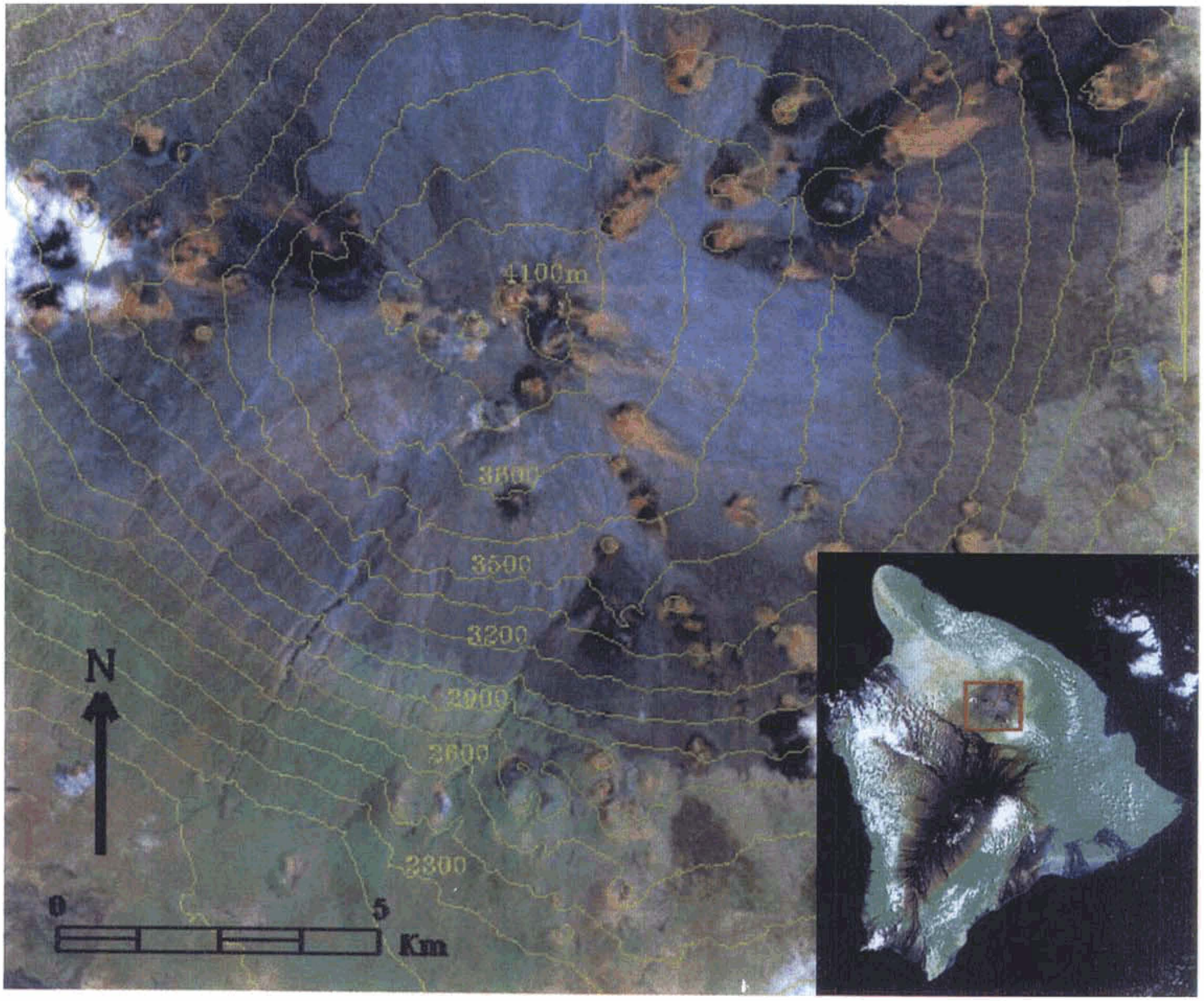


Figure 1.

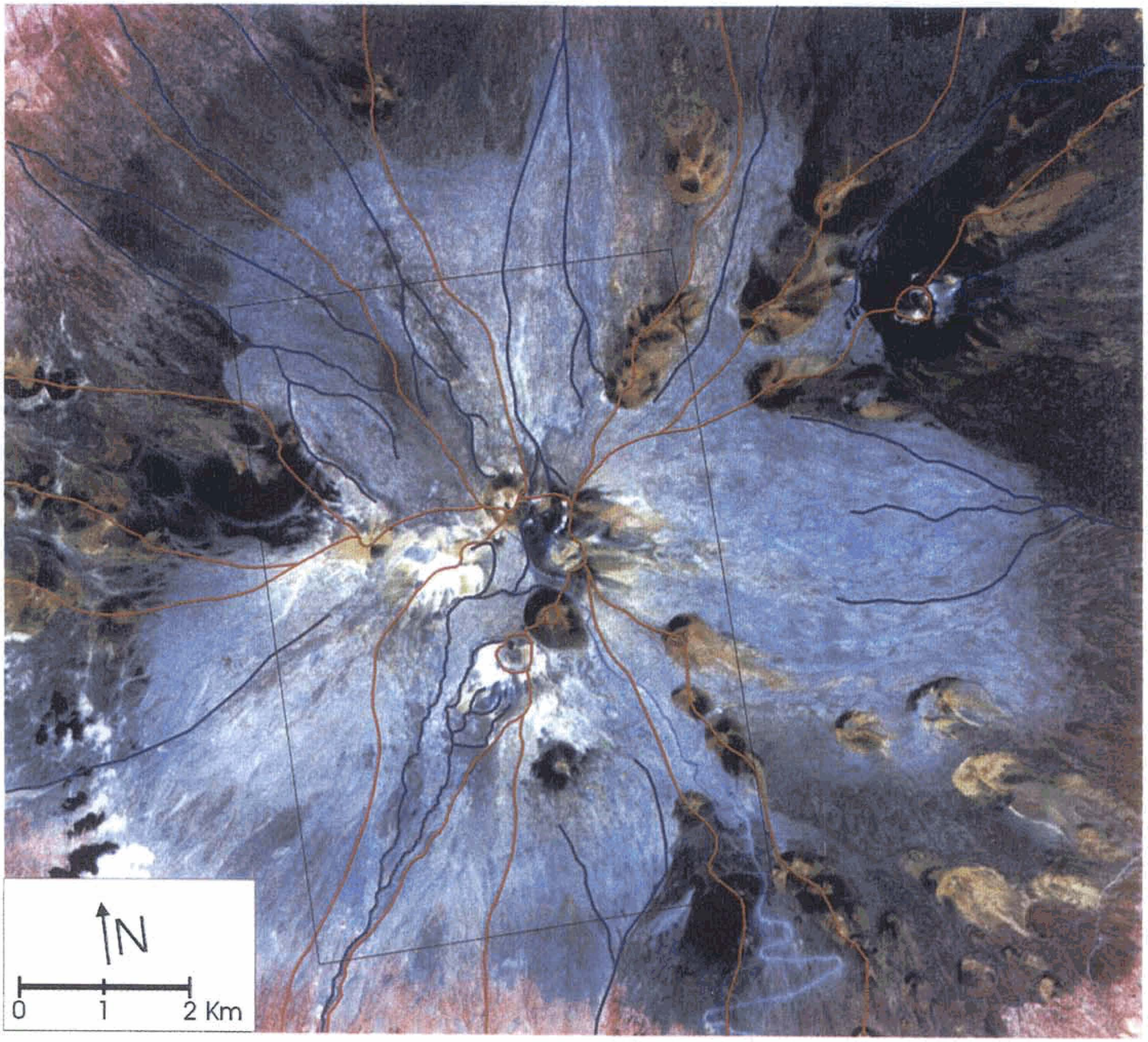
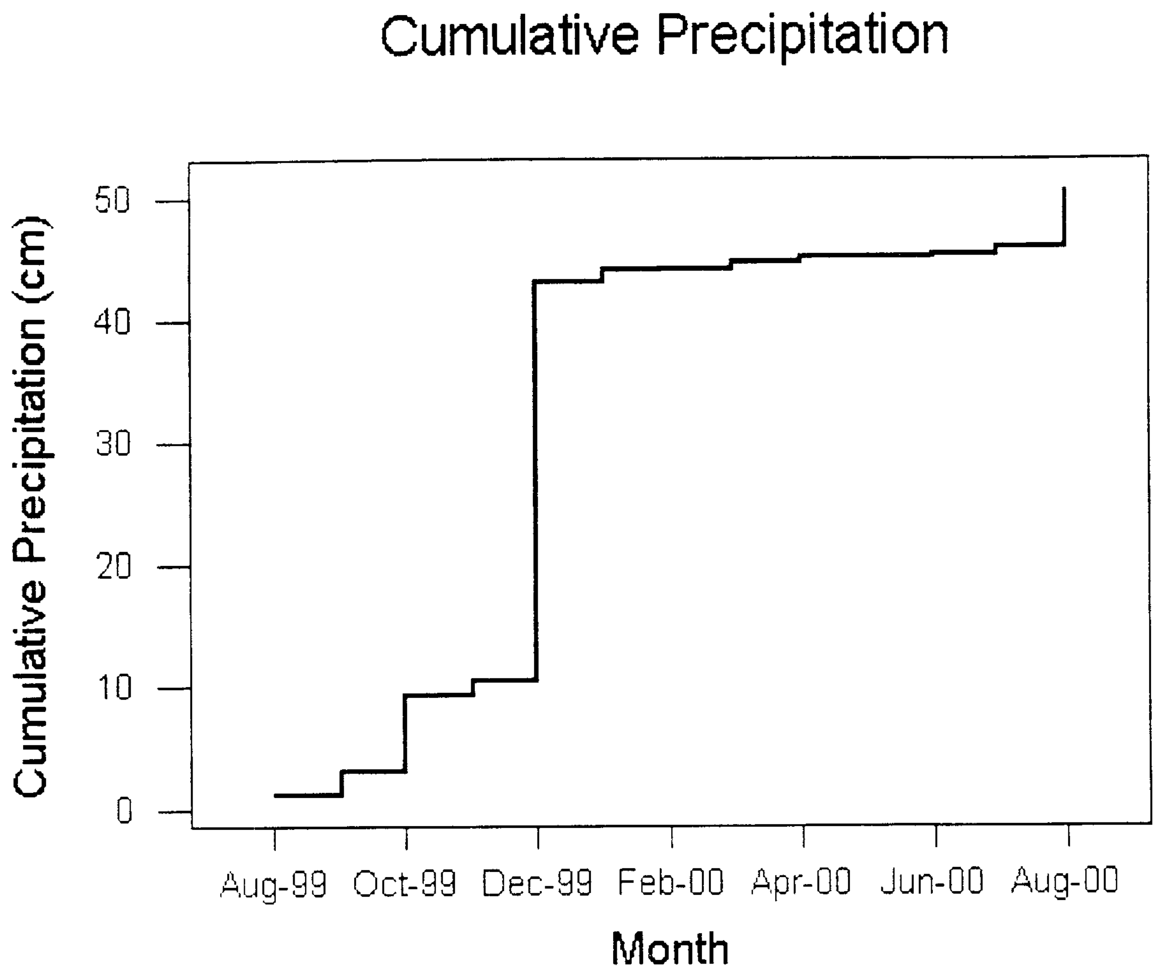


Figure 2.


To Kuupahaa
Gulch
Pu'u
Hau Oki
Submillimeter
Valley
Pohakuloa
Gulch
Lake
Waiau
N
0
0.5
1 Km

Figure 3.



Cumulative Precipitation
Cumulative Precipitation (cm)
0
10
20
30
40
50
Aug-99
Oct-99
Dec-99
Feb-00
Apr-00
Jun-00
Aug-00
Month

Figure 4.

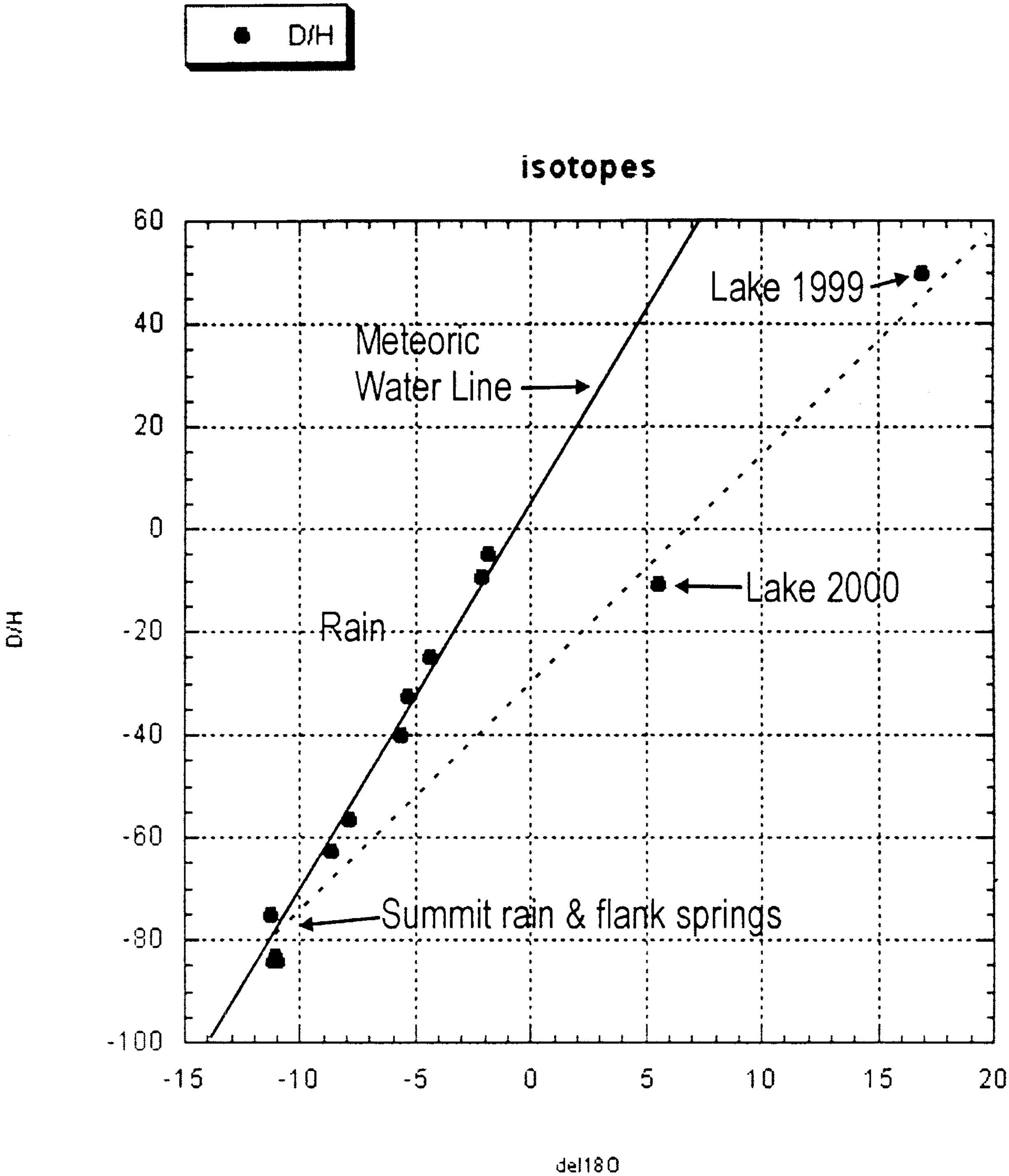
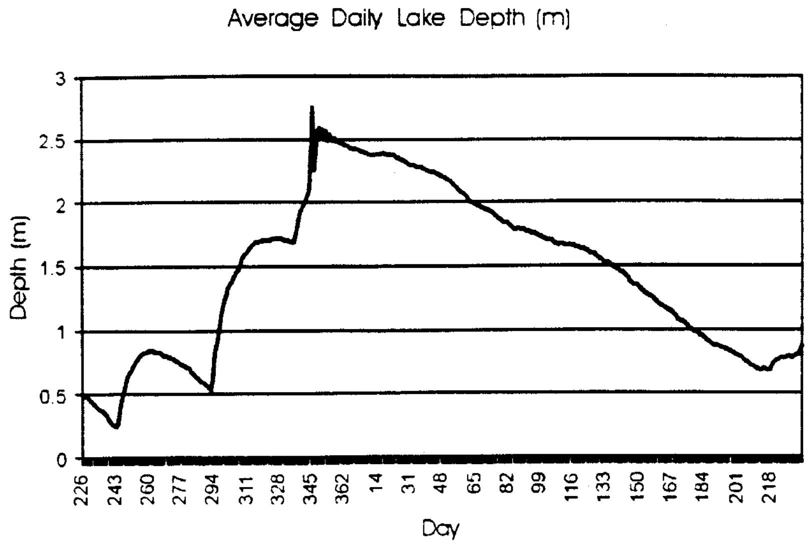
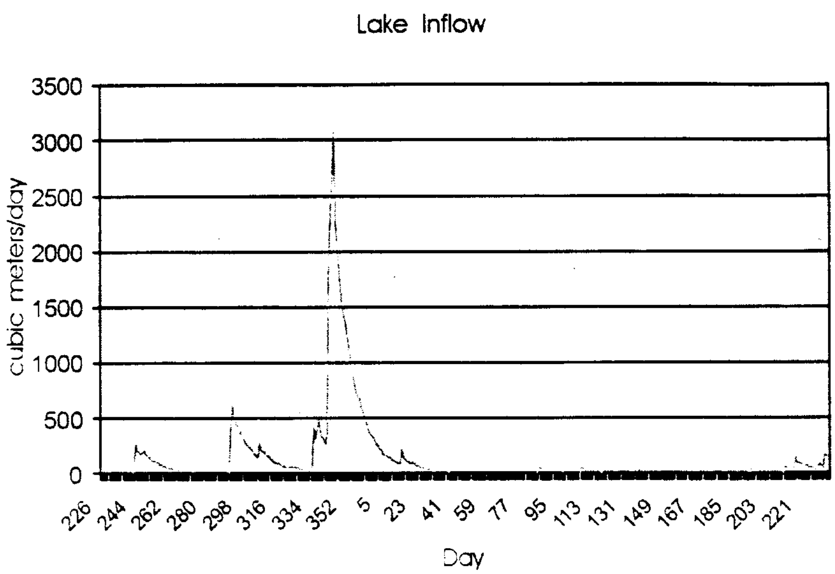

D/H
isotopes
60
40
20
0
-20
-40
-60
-80
-100
-15
-10
-5
0
5
10
15
20
D/H
del18O
Meteoric
Water Line
Lake 1999
Lake 2000
Rain
Summit rain & flank springs

Figure 5.


Average Daily Lake Depth (m)
Depth (m)
3
2.5
2
1.5
1
0.5
0
226
243
260
277
294
311
328
345
362
14
31
48
65
82
99
116
133
150
167
184
201
218
Day


Lake Inflow
cubic meters/day
3500
3000
2500
2000
1500
1000
500
0
226
244
262
280
298
316
334
352
5
23
41
59
77
95
113
131
149
167
185
203
221
Day

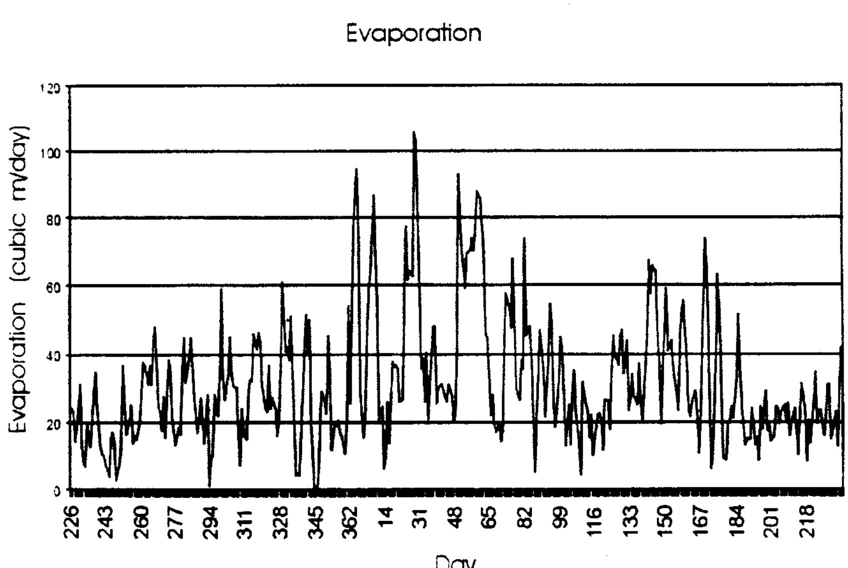

Evaporation
Evaporation (cubic m/day)
120
100
80
60
40
20
0
226
243
260
277
294
311
328
345
362
14
31
48
65
82
99
116
133
150
167
184
201
218
Day

Figure 6.

APPENDIX I

RESPONSE TO COMMENTS ON THE DRAFT ENVIRONMENTAL ASSESSMENT

TABLE I-1. LISTING OF COMMENTORS

Commentor Number	Date of Comment	Organization	Individual Presenting Comments
C-1	undated	U.S. Fish and Wildlife Service	Paul Henson
C-2	02/09/01	County of Hawaii, Department of Planning	Christopher J. Yuen
C-3	02/13/01	Hawaii Community College	Fred D. Stone, PhD
C-4	02/14/01	Individual	Deborah Ward
C-5	02/15/01	Ahahui Ku Mauna	Ed Stevens
C-6	02/19/01	Individual	Bob Barry
C-7	02/19/01	Sierra Club	Nelson Ho
C-8	02/21/01	Professor, University of Alaska	Lance Petersen
C-9	02/22/01	Malama O Puna	René Siracusa
C-10	02/22/01	Individual	Jim and Pam Steenberg
C-11	02/22/01	Individual	John Villesvik
C-12	02/23/01	Office of Mauna Kea Management	Walter Heen
C-13	02/23/01	Individual	Alan Villesvik
C-14	02/07/01	Individual	Reynolds Kamakawiwo'ole
C-15	02/13/01	Volcano Rainforest Retreat	Kathleen and Peter Golden
C-16	02/23/01	Office of Hawaiian Affairs	Colin Kippen, Jr.
C-17	03/16/01	Hawaii Island Burial Council	Nālei Pate-Kahakalau
C-18	03/21/01	Department of Land and Natural Resources/State Historic Preservation Division	Gilbert Coloma-Aragan
C-19	03/30/01	Conservation Council for Hawaii	Karen Blue
C-20	03/24/01	Royal Order of Kamehameha I	Kuauhau Mamo Naliko Markel; Kaka'olelo Ali'i Sir Robert McKeen Jr.; Ali'i Aimouku Ali'i Sir Paul Neves K.G.C.K.
C-21	04/10/01	Hui Malama I Nā Kūpuna o Hawai'i Nei	Edward Halealoha Ayau

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Ecoregion
300 Ala Moana Boulevard, Room 3-122
Box 50088
Honolulu, Hawaii 96850

In reply refer to: MSR

JAN 12 2001

Mr. Richard Howard
Senior Program Executive
Office of Space Science, Code SD
NASA Headquarters
300 E Street, SW
Washington, DC 20546-0001

Re: Draft Environmental Assessment for the W. M. Keck Observatory Outrigger Telescopes Project at Mauna Kea, Hamakua District, Hawaii

Dear Mr. Howard:

The U.S. Fish and Wildlife Service (Service) has reviewed the December 2000 Draft Environmental Assessment (Draft EA) for the W. M. Keck Observatory (WMKO) Outrigger Telescopes Project at Mauna Kea, Hamakua District, Hawaii. The project sponsor is the California Association for Research in Astronomy (CARA), which operates the WMKO and has requested permission from the University of Hawaii Institute for Astronomy (IfA) to undertake installation and operation of the Keck Outrigger Telescopes. The WMKO site is located within the designated Astronomy Precinct (approximately 525 acres) of the Mauna Kea Science Reserve (MKSR). The National Aeronautics and Space Administration (NASA) is preparing a Final EA for the proposed project to evaluate the environmental impacts that would be associated with NASA's decision to continue funding the project. The following comments have been prepared pursuant to the National Environmental Policy Act (NEPA) of 1969 [42 U.S.C. 4321 et seq.; 83 Stat. 852], as amended, the Endangered Species Act of 1973 [16 U.S.C. 1531 et seq.; 87 Stat. 884], as amended (Act), and other authorities mandating Service concerns for environmental values. Based on these authorities, the Service offers the following comments for your consideration.

The Keck Outrigger Telescopes, if fully implemented, would consist of up to six 1.8-meter (72-inch) telescopes to be placed strategically around the two existing Keck Telescopes. NASA currently plans funding for four Outrigger Telescopes, and NASA funding for two additional telescopes may be considered at a future date. NASA's decision to continue funding the Outrigger Telescopes project is contingent upon NASA ensuring that pertinent Federal environmental requirements are satisfied.

A revised Wekiu Bug Mitigation Report (WBMR) was prepared by Pacific Analytics L. L. C. and completed in November 2000 to provide guidance for protecting and enhancing the Wekiu bug population and habitat during construction and operation of the proposed Outrigger Telescopes. The Report addresses five major concerns related to on-site construction, installation, and operation of the Outrigger Telescopes, and provides twenty specific recommendations for Wekiu bug protection. The Draft CARA Wekiu Bug Mitigation Plan

(WBMP) attached to the Draft EA contains sixteen commitments based on those same twenty recommendations. The WBMR also includes an outline for a longer-range monitoring program that will be important in assessing factors that may affect the life cycle and population growth of the rare, native Wekiu bug. The Draft WBMP contains no commitment to this recommendation, however, the Draft EA states that a monitoring plan is being developed.

As the November 2000 WBMR and Draft EA acknowledge, the summit area of Mauna Kea is part of a unique Hawaiian ecosystem. Several endemic lichens, ferns, and arthropods including a lycosid spider (*Lycosa* sp.), a moth species belonging to the genus *Agrotis*, and the Wekiu bug (*Nysius wekiuicola*) are found on Mauna Kea and nowhere else in the world. Furthermore, as the WBMR recognizes, it is possible that construction and operation of the Outriggers could have a deleterious impact on the Wekiu bug population. We are pleased that the NASA, CARA, and IfA are committed to do no harm to the Wekiu bug population during the proposed construction and operation of the Outriggers. Currently, the Wekiu bug is a candidate for Federal listing under the Endangered Species Act. To the best of our knowledge, no other federally endangered, threatened, or candidate species, significant wetlands, or other Federal trust resources occur in the immediate summit area of the proposed project site.

The Service supports the twenty recommendations in the November 2000 WBMR and the sixteen commitments in the Draft WBMP, that when implemented, will minimize project impacts to endemic arthropods on the Mauna Kea summit and reduce the potential for disturbance to this high-altitude environment from alien species introductions, garbage generation and collection, and visitor use. The Service also supports the proposed designation of a Natural and Cultural Preserve Area consisting of over 10,760 acres and its permanent preservation as described in the Mauna Kea Science Reserve Master Plan. We believe each of the recommendations made in the November 2000 WBMR and the commitments in the Draft EA will greatly reduce the possibility of negative impact to Wekiu bug habitat.

The Service supports Recommendations IV-1 through IX-3 of the WBMR and commitments 1 through 16 of the Draft WBMP, and requests they be incorporated into the WMKO Outrigger Telescopes Project Final EA. They should also be attached to the Conservation District Use Application (CDUA) to be prepared for the project. The Final EA should identify any of the WBMR recommendations that will not be included in the project and include an explanation of the rationale for this decision. The Final EA should also include a discussion of the cumulative impacts to Wekiu bug habitat within Pu'u Hau Oki crater from the Subaru and Keck observatory sites.

1A

1B

Since astronomy-related development began on the summit in 1963, only two formal on-site arthropod studies have been conducted. Since 1963, an estimated 25% of the potential Wekiu bug habitat has been lost due to astronomy-related development. Recent studies have corroborated incidental observations that Wekiu bug populations have declined. The Service supports the recommendation to include ongoing monitoring of the Wekiu bug as a component of the WMKO Outrigger Telescope Project. However, we request that the Final EA for the project specifically describe the protocols of a long-term biological monitoring program that will be implemented for the entire Mauna Kea Science Reserve. The monitoring program should be

1C

designed to provide project sponsors with inferences about ecological changes and the impacts of their projects and their management strategies on natural resources within the reserve. Because the proposed Wekiu bug mitigation would serve little scientific value without a detailed long-term monitoring program, we believe the absence of specific monitoring details within the Draft EA to be a serious omission. The Service would be happy to review the components of a program for specifically monitoring the Wekiu bug, as well as other resources, when the details of such a program have been developed.

The Service further recommends that a comprehensive natural resource monitoring program be developed for the entire MKSR. The implementation associated with this monitoring program may be shared by all agencies and corporations involved with research within the reserve. 1D

The Service appreciates the opportunity to comment on the Draft EA, and we look forward to reviewing the WMKO Outrigger Telescopes Project Final EA, when it is available. If you have any questions regarding these comments, please contact Service Entomologist Mike Richardson by telephone at (808) 541-3441 or by facsimile transmission at (808) 541-3470.

Sincerely,

Paul Henson

Paul Henson
Field Supervisor
Ecological Services

cc: Mr. Michael Buck, DOFAW
Mr. John Giffin, DOFAW
Mr. Kenneth Kumor, NASA
Ms. Wendy Wiltze, USEPA - Honolulu

RESPONSES TO COMMENTS

Commentor No. 1: U.S. Fish and Wildlife Service (Paul Henson)

Response to Comment 1A:

The commentor is referring to the Wēkiu Bug Mitigation Report (Pacific Analytics 2000). For those who wish to read the Wēkiu Bug Mitigation Report, see website www.statpros.com/Wekiu_Bug.html The report provides 20 recommendations for consideration by the Outrigger Telescopes Project. As reported in the Draft Environmental Assessment, the Wēkiu Bug Mitigation Plan encompasses 16 of those recommendations. The four recommendations that were not incorporated in the Outrigger Telescopes Project Wēkiu Bug Mitigation Plan are noted below along with the rationale for why they were not incorporated into the Plan.

Recommendation IV-4: The W.M. Keck Observatory (WMKO) staff should continue current practices for dealing with on-site snow events.

The current practice for dealing with snow events is not under the jurisdiction of the Outrigger Telescopes Project. NASA has forwarded this recommendation to the Mauna Kea Support Services and the University of Hawaiʻi.

Recommendation VI-1: The WMKO staff should continue to follow Federal guidelines specifying the use and disposal of substances used in the washing and recoating of observatory mirrors.

The WMKO process for use and disposal of substances used in the washing and recoating of observatory mirrors would continue to follow Federal guidelines. The WMKO staff would be responsible to ensure the proper use and disposal of substances. However, this is not specific to the Outrigger Telescopes project; it is part of the on-going operations of the WMKO site. Where disposal practices are specific to the Outrigger Telescopes, they will be covered under the construction Best Management Practices Plan.

Recommendation IX-1: A Wēkiu Bug Monitoring Plan should be developed, with both compliance and effectiveness monitoring components.

The Wēkiu Bug Monitoring Plan was under development at the time of the Draft Environmental Assessment. The Plan has since been completed and is briefly described in Section 4.1.5 of this Environmental Assessment with a reference provided in Appendix E.

Recommendation IX-2: The Wēkiu Bug Monitoring Plan should be implemented through a Monitoring Program.

This Wēkiu Bug Monitoring Plan would be implemented at the start of construction of the Outrigger Telescopes, and would continue for 18 months after restoration of Wēkiu Bug habitat. In addition, as part of project implementation, NASA will fund a graduate student to study Wēkiu Bug autecology, and to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors.

Long-term monitoring of the Wēkiu Bug for the entire Mauna Kea Science Reserve is recommended in the Mauna Kea Science Reserve Master Plan Final Environmental Impact Statement, and would be the responsibility of the University of Hawaiʻi. The comment has been referred to the University of Hawaiʻi.

RESPONSES TO COMMENTS

Commentor No. 1: U.S. Fish and Wildlife Service (Paul Henson)

Response to Comment 1B:

Section 3.6.1 of this Environmental Assessment addresses the status of the Wēkiu bug as indicated by two sampling programs conducted between 1982 and 1997 (i.e., before and after construction of the W. M. Keck Observatory and the Subaru Observatory). Each study included Pu'u Hau 'Oki within the study area. While a comparison of the two studies, separated in time, indicate an apparent decline in Wēkiu bug populations within the study areas (including Pu'u Hau 'Oki), no definitive cause for the decline can be ascribed. A portion of the crater bottom of Pu'u Hau 'Oki has been included in the Wēkiu bug habitat restoration proposed in the Outrigger Telescopes Wēkiu Bug Mitigation Plan.

Response to Comment 1C:

The Wēkiu Bug Monitoring Plan includes clearly stated objectives and a discussion of systematic monitoring (Appendix E references the Plan). It includes monitoring modules for Habitat Restoration, Slope Stability, Dust Control, Hazardous Materials, Trash Control, Alien Arthropods, Wēkiu Bug Population Change, and Wēkiu Bug Habitat Structure. A total of twenty-four specific questions of interest have been addressed in the Wēkiu Bug Monitoring Plan. A schedule and detailed sampling protocols are also included in the plan. This Wēkiu Bug Monitoring Plan would be implemented at the start of construction of the Outrigger Telescopes, and would continue for 18 months after restoration of the Wēkiu Bug habitat. As stated previously, as part of project implementation, NASA will fund a graduate student to study Wēkiu Bug autecology, and to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors.

Again, long-term monitoring of the entire Mauna Kea Science Reserve is recommended in the Mauna Kea Science Reserve Master Plan Final Environmental Impact Statement, and is the responsibility of the University of Hawai'i. The comment has been referred to the University of Hawai'i.

Response to Comment 1D:

A biological monitoring program for the entire Mauna Kea Science Reserve is not within the jurisdiction of NASA. However, NASA has forwarded this recommendation to University of Hawai'i for consideration.

Harry Kim
Mayor

Christopher J. Yuen
Director

Roy R. Takemoto
Deputy Director

County of Hawaii

PLANNING DEPARTMENT

25 Aupuni Street, Room 109 • Hilo, Hawaii 96720-4252
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February 9, 2001

Mr. Richard Howard
Senior Program Executive
Office of Space Science, Code SD
NASA Headquarters
300 E Street SW
Washington, D.C. 20546-0001

Dear Mr. Howard,

Subject: Draft Environmental Assessment for the Outrigger Telescopes Project

Thank you for the opportunity to comment on the Draft Environmental Assessment for the Outrigger Telescopes Project. The project location lies within an area designated as conservation by the State of Hawaii and the County of Hawaii. As such, regulatory jurisdiction rests with the State Department of Land and Natural Resources.

If you have any questions, please call Norren Kato at 961-8288 or email us at planning@ilhawaii.net.

Sincerely,

CHRISTOPHER J. YUEN
Director of Planning

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RESPONSES TO COMMENTS

Commentor No. 2: County of Hawaii, Department of Planning (Christopher J. Yuen)

Response to Comment 2A:

Thank you for confirming that the project location will be within the Conservation District under the jurisdiction of the State Department of Land and Natural Resources.

Hawai'i Community College
University of Hawai'i

13 Feb 2001

To: Richard J. Howard, Senior Program Executive
Office of Space Science, NASA Headquarters
300 E. Street, SW
Washington, DC 20546-0001

Response to Draft Environmental Assessment for the Outrigger Telescopes Project for the Keck (NASA/CARA) telescope.

The Draft Environmental Assessment for the Keck Outrigger Telescopes Project has failed to adequately address the potential impacts of the proposed outrigger telescope development on the summit ecosystem, and has failed to disclose full 3A information on the status of the population of the Wekiu bug (*Nysius wekiuicola*). Since the Wekiu bug is proposed for listing as an endangered species, it is essential that any alteration of its habitat must be based on thorough knowledge of its population size, life history and critical habitat. It is clear that a full EIS must be completed in order to adequately address the potential impacts of this construction project.

A Wekiu Bug Mitigation Report was prepared by Pacific Analytics, LLC for the Keck Outrigger Telescopes Project, and this was the basis for the Wekiu bug mitigation measures presented as Appendix C of the Draft EA. However, the Mitigation Report was not included with the Draft EA. Omission of the full mitigation report makes it 3B difficult to evaluate the basis for the mitigation measures reported in the Draft EA.

The 1997-98 field assessment of the Wekiu Bug conducted for the Master Plan/EIS of the Mauna Kea Science Reserve revealed extremely low population numbers, only a few dozen individuals being recorded over the entire summit area during the entire period of the survey. The largest number of individuals were collected in the inner slopes of Pu`u Hau Oki crater, the area that will be the most impacted by construction. However, numbers were so low that ANY further change to the area could be fatal to the few remaining individuals. No construction should be begun, or mitigation measures implemented, until it is determined whether the changes will have a positive 3C or negative impact. Such a determination should be made as part of the preparation of a full EIS.

MATH & NATURAL SCIENCES DIVISION
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On page 96 of the Draft EA under **Mitigation Measures**, the last sentence of the first paragraph states: "A comprehensive monitoring plan is being developed to ensure contractor compliance to the Mitigation Plan and measure the effectiveness of restoration efforts." **Failure to disclose this comprehensive monitoring plan as part of the Draft EA makes it imperative that a full EIS be conducted which includes this plan.** Lack of the plan in the Draft EA in effect means that it is NOT part of the mitigation. 3D

Page 87, section 4.1.1, second paragraph of the Draft EA states:

> "The proposed on-site construction, installation, and operation of the Outrigger Telescopes would also be consistent with the ... Mauna Kea Science Reserve Master Plan, as well as with the State of Hawai`i and County of Hawai`i land use policies, plans, and regulations (UH 2000b)."

This statement is a critical component of the proposed construction, **yet none of the relevant sections of the Master Plan have been disclosed in the Draft EA.** Specific policies, plans and regulations have not been identified, and the measures necessary to make the proposed activities consistent with them have not been detailed, as should take place in a full EIS. For example, the Master Plan was established to ensure that individual construction activities in the Science Reserve area be part of the overall management of the area. If each construction project are allowed to go ahead with piecemeal mitigation measures without attention to an overall monitoring effort, a hodge-podge of conflicting implementation measures will result. Specific examples include: 3E

1. Page C-6, section 12: "Earthmoving equipment will be free of **large** deposits of soil, dirt, and vegetation debris that could harbor alien arthropods." (highlight mine)

What constitutes a large deposit of soil? Ants, mites, spiders, soil centipedes and other small arthropods can survive in small soil areas or on the machinery itself. A thorough pressure steam cleaning **of all soil and other foreign material** is the only way to adequately guard against further introduction of alien arthropods and weed seeds. 3F

Part (a) states "Contractors will be required to pressure-wash earthmoving equipment to remove alien arthropods" while (c) states "Contractors will be required to inspect large trucks, tractors, and other heavy equipment before proceeding up the observatory access road." These measures are clearly not enforceable as outlined in the Draft EA. Contractors do not have the expertise to determine whether alien arthropods are present on equipment. Inspection should be done at the base of Saddle Road, on both the Hilo and Kona sides, not "before proceeding up the observatory access road", which is already high on Mauna Kea and too late to institute corrective actions. Indeed, no corrective actions are included in the mitigation plan.

Inspection by the contractor is a recipe for failure: independent inspectors with training in entomology, and without a financial stake in the project, are absolutely essential. Pressure steam cleaning and inspection stations need to be established at both ends of Saddle Road, in Hilo and Kawaihae. Materials shipped into Hawai`i from overseas must also be inspected by an independent agency with qualified inspectors, NOT the contractor. 3G

These mitigation measures are clearly inadequate, and are doomed to failure unless they are made part of a comprehensive policy applied to all summit construction activities. If cleaning and inspection are required only of the NASA/CARA facility, it will still be inadequate to protect Mauna Kea's summit ecosystems. All construction equipment and materials destined for the summit area should be inspected and cleaned. 3H

2. Section C-1: Wekiu bug habitat will be restored in areas damaged by on-site Outrigger Telescope construction ...

Attempting to implement restoration efforts without first conducting a full and thorough field examination of existing Wekiu bug populations prior to the beginning of construction activities has the potential of doing more harm than good. Yet the Draft EA assumes that such restoration can proceed without the necessary prior studies. This is a major omission of the Draft EA, which should be included in a full EIS. The EIS also must include details of how the monitoring and recovery efforts are to be integrated into the Mauna Kea Science Reserve Master Plan. Mitigation measures must be integrated into a larger plan for ongoing monitoring and management of the summit ecosystems of Mauna Kea, not just restricted to one species over a small portion of its range. 3I

Failure to adequately integrate the mitigation measures in the Draft EA into the Mauna Kea Science Reserve Master Plan.

By failing to specify how the mitigation and monitoring activities will integrate into the Mauna Kea Science Reserve Master Plan, the proposed Keck Outrigger Telescopes Project is following the practice of piece-meal development of the summit which typified the period covered by the previous Management Plan. The new Master Plan was supposedly designed to prevent the lack of implementation of the provisions in the previous plan. However, the Draft EA fails to explain how the proposed mitigation and monitoring measures will be "consistent with" Master Plan "policies, plans and regulations". If such policies, plans and regulations have not yet been instituted, then new projects such as the Keck Outriggers should not be permitted to proceed with their own set of mitigation measures. For example, by allowing contractors to self-inspect their machinery, the Draft EA sets up its own standards which may or may not be acceptable. A Federal EIS should deal comprehensively with the procedures in the Master Plan. This should include a clear outline of the decision-making process between the Mauna Kea Management Advisory Committee, the UH Hilo Chancellor, the Department of Land and Natural Resources, and the Hawai`i State Land Board. 3J

Standards for monitoring and mitigation should follow consistent guidelines set up by the Mauna Kea Management Advisory Board.

Fred D. Stone, Ph.D.
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Testimony for the "Town Meeting" and
Response to Draft Environmental Assessment for the Outrigger Telescopes Project for the Keck (NASA/CARA) telescope.

Fred D. Stone, Ph.D.
Hawai`i Community College
200 W. Kawili St.
Hilo, Hawai`i, 96760

I am re-submitting the comments that I submitted in February, 2001 in response to the Draft EA for the Keck Outrigger Telescopes Project. Although the environmental assessment rules call for a timely response by the agency in charge (NASA), I have had NO response other than a letter of acknowledgement that NASA had received my comments. I believe that the points I raised are serious and substantive. NASA's failure to respond is a breach of the environmental assessment process. Now, we are told there will be "Town meetings" to gather information so NASA can move ahead with their request to the Department of Land and Natural Resources for a CDUA for the project. There has been no word from NASA about the status of the Draft Environmental Assessment. If NASA has received permission to proceed with the outrigger project without following Federal regulations, why have we not been informed? 3K

There has been one major positive finding since I submitted my comments; Dr. Dan Polhemus, a researcher from the Smithsonian Institution discovered a healthy population of the Wekiu Bug living in Pu`u Hau Kea in the Ice Age Natural Area Reserve. Since the conditions in the inner crater of Pu'u Hau Kea are similar to those that existed in Pu'u Hau Oki prior to its disturbance during construction of the Keck and Subaru telescopes, <u>this is additional evidence strongly suggesting that construction activities are the cause of the drastic decline of the wekiu bug in the summit area</u>. Until this issue is resolved by a thorough survey of the current status of the wekiu and other species living in the summit ecosystem, no further action to proceed with construction of the outrigger telescopes should be taken. 3L

<u>COMMENTS SUBMITTED FEBRUARY, 2001</u>:

The Draft Environmental Assessment for the Keck Outrigger Telescopes Project has failed to adequately address the potential impacts of the proposed outrigger telescope development on the ecosystem, and has failed to disclose full information on the status of the population of the Wekiu bug (*Nysius wekiuicola)*. Since the Wekiu bug is proposed for an endangered listing, it is essential that any alteration of its habitat must be based on thorough knowledge of its population size, life history and critical habitat. It is clear that a full EIS must be completed in order to adequately address the potential impacts of this construction project.

A Wekiu Bug Mitigation Report was prepared by Pacific Analytics, LLC for the Keck Outrigger Telescopes Project (revised Nov. 4, 2000), and this was the basis for the Wekiu bug mitigation measures presented as Appendix C of the Draft EA. However, the Mitigation Report was not included with the Draft EA. Omission of the full mitigation report makes it difficult to evaluate the basis for the mitigation measures reported in the Draft EA.

The 1997-98 field assessment of the Wekiu Bug conducted for the Master Plan/EIS of the Mauna Kea Science Reserve revealed extremely low population numbers, only a few dozen individuals being recorded over the entire summit area during . The largest number of individuals were collected in the inner slopes of Pu`u Hau Oki crater, the area that will be the most impacted by construction. However, numbers were so low that ANY further change to the area could be fatal to the few remaining individuals. No construction should be begun, or mitigation measures implemented, until it is determined whether the changes will have a positive or negative impact. Such a determination should be made as part of the preparation of a full EIS.

On page 96 of the Draft EA under **Mitigation Measures,** the last sentence of the first paragraph states: "A comprehensive monitoring plan is being developed to ensure contractor compliance to the Mitigation Plan and measure the effectiveness of restoration efforts." **Failure to disclose this comprehensive monitoring plan as part of the Draft EA makes it imperative that a full EIS be conducted which includes this plan.** Lack of the plan in the Draft EA in effect means that it is NOT part of the mitigation.

Page 87, section 4.1.1, second paragraph of the Draft EA states:

> "The proposed on-site construction, installation, and operation of the Outrigger Telescopes would also be consistent with the ... Mauna Kea Science Reserve Master Plan, as well as with the State of Hawai`i and County of Hawai`i land use policies, plans, and regulations (UH 2000b)."

This statement is a critical component of the proposed construction, yet **none of the relevant sections of the Master Plan have been disclosed in the Draft EA.** Specific policies, plans and regulations have not been identified, and the measures necessary to make the proposed activities consistent with them have not been detailed, as should take place in a full EIS. For example, the Master Plan was established to ensure that individual construction activities in the Science Reserve area be part of the overall management of the area. If each construction project are allowed to go ahead with piecemeal mitigation measures without attention to an overall monitoring effort, a hodge-podge of conflicting implementation measures will result. Specific examples include:

1. Page C-6, section 12: "Earthmoving equipment will be free of **large deposits of soil**, dirt, and vegetation debris that could harbor alien arthropods." (highlight mine)
What constitutes a large deposit of soil? ants, mites, spiders, soil centipedes and other small arthropods can survive in small soil areas or on the machinery itself. A thorough pressure steam cleaning **of all soil and other foreign material** is the only way to adequately guard against further introduction of alien arthropods and weed seeds.

Part (a) states "Contractors will be required to pressure-wash earthmoving equipment to remove alien arthropods" while (c) states "Contractors will be required to inspect large trucks, tractors, and other heavy equipment before proceeding up the observatory access road." These measures are clearly not enforceable as outlined in the Draft EA. Contractors do not have the expertise to determine whether alien arthropods are present on equipment, and inspection should be done at the base of Saddle Road, on both the Hilo and Kona sides, not "before proceeding up the observatory access road", which is already high on Mauna Kea and too late to institute corrective actions. Indeed, no corrective actions are included.

Inspection by the contractor is a recipe for failure: independent inspectors with training in entomology, and without a financial stake in the project, are absolutely essential. Pressure steam cleaning and inspection stations need to be established at both ends of Saddle Road, in Hilo and Kawaihae. Materials shipped into Hawai`i from overseas must also be inspected by an independent agency with qualified inspectors, NOT the contractor.

These mitigation measures are clearly inadequate, and are doomed to failure unless they are made part of a comprehensive policy applied to all summit construction activities. If cleaning and inspection are required only of the NASA/CARA facility, it will still be inadequate to protect Mauna Kea's summit ecosystems. All construction equipment and materials destined for the summit area should be inspected and cleaned.

2. Section C-1: Wekiu bug habitat will be restored in areas damaged by on-site Outrigger Telescope construction ...

Attempting to implement restoration efforts without first conducting a full and thorough field examination of existing Wekiu bug populations prior to the beginning of construction activities has the potential of doing more harm than good. Yet the Draft EA assumes that such restoration can proceed without the necessary prior studies. This is a major omission of the Draft EA, which should be included in a full EIS. The EIS also must include details of how the monitoring and recovery efforts are to be integrated into the Mauna Kea Science Reserve Master Plan. Mitigation measures must be integrated into a larger plan for ongoing monitoring and management of the summit ecosystems of Mauna Kea, not just restricted to one species over a small portion of its range.

RESPONSES TO COMMENTS
Commentor No. 3: Hawaii Community College (Fred D. Stone, Ph.D.)

Response to Comment 3A:

This Environmental Assessment contains a thorough discussion of the biological resources of the summit area cinder cones and of the biological resources of the elevations below the summit area cinder cones. The discussion is based on the best scientific information available and references existing studies regarding the summit area ecosystem, including two major vegetation analyses (Smith and others 1982; Char & Associates 1999), two arthropod assessments (Howarth and Stone 1982; Howarth and others 1999), and 12 other associated literature references. To summarize that discussion: no floral species have been found in the vicinity of the Outrigger Telescopes Project site, and the only indigenous resident animal species found on summit area cinder cones are eleven species of Hawaiian arthropods. The status of the Wēkiu bug is addressed in this Final Environmental Assessment, and the design and planning of the Outrigger Telescopes has been proactive and protective of Wēkiu bugs and their habitat.

Potential impacts of the proposed Outrigger Telescopes Project on Wēkiu bug habitat and populations were analyzed and are discussed in the Draft Environmental Assessment (see Chapter 4, Environmental Consequences), and were more thoroughly explored in the Wēkiu Bug Mitigation Report. The Wēkiu Bug Mitigation Plan represents implementation of the recommendations contained in the Wēkiu Bug Mitigation Report, which were based on data, and recommendations in the 1982 and 1997/98 arthropod assessments (Howarth and Stone 1982; Howarth and others 1999). Combined with input from entomologists familiar with Wēkiu bug biology and the best information available in published scientific literature, this Final Environmental Assessment adequately addresses any potential impact to the Wēkiu bug as evidenced by the Mitigation and Monitoring plans.

Response to Comment 3B:

The Wēkiu Bug Mitigation Report was referenced in the Draft Environmental Assessment and is referenced in this Final Environmental Assessment. For those who wish to read the Wēkiu Bug Mitigation Report, see website www.statpros.com/Wekiu_Bug.html.

Response to Comment 3C:

This Final Environmental Assessment evaluates the potential impact of on-site construction, installation, and operation of the Outrigger Telescopes Project on the Wēkiu bug (see Section 4.1.6). See also Response to Comment 3A.

The Outrigger Telescopes Project will not lead to the extinction of the Wēkiu bug. Less than 0.009-ha (0.022-ac) of Wēkiu bug habitat would be disturbed during construction of the Outrigger Telescopes. This would represent about 0.008 percent of the 120-ha (300-ac) estimated size of occupied Wēkiu bug habitat in the summit region of Mauna Kea (Howarth and others 1999). It is the goal of the Wēkiu Bug Mitigation and Monitoring plans to expand Wēkiu bug habitat and enhance the Wēkiu bug population in Pu'u Hau 'Oki. The Wēkiu Bug Mitigation and Monitoring plans are adequate and are addressed in this EA.

RESPONSES TO COMMENTS
Commentor No. 3: Hawaii Community College (Fred D. Stone, Ph.D.)

Response to Comment 3D:

A reference to the Wēkiu Bug Monitoring Plan is provided in this Final Environmental Assessment in Appendix E. A brief description of the Plan can be found in Section 4.1.6 of this Environmental Assessment.

Response to Comment 3E:

The proposed Outrigger Telescopes Project is consistent with the recently adopted Mauna Kea Science Reserve Master Plan. Further, NASA and the California Association for Research in Astronomy have coordinated with the University of Hawai'i Institute for Astronomy and the Office of Mauna Kea Management in the proposed project in the manner set out in the Mauna Kea Science Reserve Master Plan. The Office of Mauna Kea Management has reviewed and commented on NASA's Draft Environmental Assessment (see Commentor 12 in this Appendix); the Office of Mauna Kea Management has and will continue to be consulted in the planning and design of the Outrigger Telescopes Project.

It is not within NASA's jurisdiction to propose mitigation and monitoring activities for areas of the Mauna Kea Science Reserve other than the Outrigger Telescopes Project site. However, NASA has forwarded this recommendation to the University of Hawai'i for consideration.

Response to Comment 3F:

This cited provision is intended to ensure that construction equipment directly associated with the Outrigger Telescopes Project destined for the W.M. Keck Observatory site has been thoroughly cleaned prior to proceeding to the site.

Contractors would be required to pressure wash their construction machinery prior to transport to Mauna Kea. The machinery would be inspected near the intersection of Saddle Road and the Mauna Kea Access Road by a qualified specialist hired by the California Association for Research in Astronomy. If the vehicle is clean, it will move forward; however, if there is an infestation or some kind of problem, the vehicle will not be permitted to proceed. These contractor requirements would be ensured through the adherence to the construction Best Management Practices Plan (BMP), which will be made a provision of the contract (see Appendix F for a draft BMP).

Response to Comment 3G:

All materials shipped into Hawai'i for the project will be inspected in accordance with the existing State of Hawai'i custom safeguards. At the point of entry, the project construction contractor is not the inspector for such shipments.

Response to Comment 3H:

Thank you. Your comment is respectfully noted and referred to the University of Hawai'i.

RESPONSES TO COMMENTS

Commentor No. 3: Hawaii Community College (Fred D. Stone, Ph.D.)

Response to Comment 3I:

The recommendations in the Wēkiu Bug Mitigation Report are based on data gathered during the 1982, and 1997/98 arthropod assessments (Howarth and Stone 1982; Howarth and others 1999), combined with input from entomologists familiar with Wēkiu bug biology and the best information available in published scientific literature. This report was used to develop the Wēkiu Bug Mitigation and Monitoring plans (see Appendices D and E). NASA has consulted with the U.S. Fish and Wildlife Service concerning the Wēkiu Bug Mitigation Report.

The Outrigger Telescopes Project will not lead to the extinction of the Wēkiu bug. Less than 0.009-ha (0.022-ac) of Wēkiu bug habitat would be disturbed during construction of the Outrigger Telescopes. This would represent about 0.008 percent of the 120-ha (300-ac) estimated size of occupied Wēkiu bug habitat in the summit region of Mauna Kea (Howarth and others 1999). It is the goal of the Wēkiu Bug Mitigation and Monitoring plans to expand Wēkiu bug habitat and enhance the Wēkiu bug population in Pu'u Hau 'Oki.

The habitat restoration protocol is based on the best scientific information available about the habitat needs of the Wēkiu bug. The protocol is based on the following information.

1. Wēkiu bugs appear to prefer habitat made of loose cinder 1.3 centimeters (cm) (½ inch) in size or larger. In past studies (Howarth and Stone 1982; Howarth and others 1999), the highest concentration of Wēkiu bugs were collected in habitat consisting of 25 to 38 cm (10 to 15 inches) of 1.3 cm (½ inch) size or larger cinder, with an impenetrable ash layer below the cinder. This information leads us to conclude that restored habitat consisting of 30 to 46 cm (12 to 18 inches) of loose 1.3 cm (½ inch) size or larger cinder will be acceptable to Wēkiu bugs.

2. Wēkiu bug habitat occurs on undisturbed portions of crater floors in summit cinder cones (Howarth and Stone 1982; Howarth and others, 1999). In 1982, 6,230 Wēkiu bugs were collected on the crater floor of Pu'u Wēkiu and 430 Wēkiu bugs were collected on the crater floor of Pu'u Hau 'Oki. During the 1997/98 arthropod assessment, Wēkiu bugs were found on the crater floor of Pu'u Wēkiu and Pu'u Hau 'Oki, and on the inner slopes of Pu'u Hau 'Oki adjacent to the crater floor. Since suitable habitat does not exist on the crater floor of Pu'u Hau 'Oki, Wēkiu bugs from the adjacent inner slopes apparently migrate to the crater floor. This information leads us to conclude that Wēkiu bugs would likely occupy restored habitat on the floor of Pu'u Hau 'Oki.

3. Given sufficient time, Wēkiu bug habitat appears to recover from disturbance. Of all sites sampled during the 1997/98 arthropod assessment, habitat on the slopes below W.M. Keck Observatory that was disturbed during construction contained the highest concentration of Wēkiu bugs. This information leads us to conclude Wēkiu bugs would eventually occupy the restored habitat.

As part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology, to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors. New information may be used to modify the habitat restoration protocol to increase its effectiveness.

Response to Comment 3J:

NASA's Proposed Action for the Outrigger Telescopes Project is consistent with the recently adopted Mauna Kea Science Reserve Master Plan.

Response to Comment 3K:

Receipt of the Commentor's supplemental letter at NASA's Town Hall Meeting on October 3, 2001 has been acknowledged by a personal letter from NASA (John H. Lee) to Fred Stone dated October 30, 2001. For responses to your original comment letter, see responses above.

Response to Comment 3L:

Potential impacts of the proposed Outrigger Telescopes Project on Wēkiu bug habitat and populations were analyzed and discussed in the Draft Environmental Assessment (see Chapter 4, Environmental Consequences), and were more thoroughly explored in the Wēkiu Bug Mitigation Report. The Wēkiu Bug Mitigation Plan represents implementation of the recommendations contained in the Wēkiu Bug Mitigation Report which were based on data and recommendations in the 1982, and 1997/98 arthropod assessments (Howarth and Stone 1982; Howarth and others 1999), combined with input from entomologists familiar with Wēkiu bug biology and the best information available in published scientific literature.

A population of Wēkiu bugs was recently discovered on Pu'u Hau Kea. This *pu'u* is some distance from the W.M. Keck Observatory (WMKO) site, and was not sampled during any previous arthropod assessment. There is also information that Wēkiu bug populations declined on Pu'u Wēkiu and on the plateau north of Pu'u Hau 'Oki, even though these sites were not disturbed by telescope construction.

A full and thorough assessment of Wēkiu bug populations in specific summit localities was conducted in 1997/98 (Howarth and others 1999). The status of Wēkiu bugs on Pu'u Hau 'Oki and on Pu'u Wēkiu will be updated during Baseline Monitoring. Wēkiu bug populations on both of these cinder cones will be sampled at least twice before construction of the Outrigger Telescopes Project begins; whether or not the project is implemented. This information will be used to establish baseline conditions and to establish trends and impacts to Wēkiu bugs and their habitat, if any, due to Outrigger Telescope construction. Further monitoring of Wēkiu bug populations on the inner slopes of Pu'u Hau 'Oki and on Pu'u Wēkiu would begin at the start of construction and continue for eighteen months after restoration habitat is installed.

In addition, if Outrigger Telescopes Project permits are approved, and the project is implemented, NASA will fund a graduate student to study Wēkiu bug autecology, with the aim of gathering more information about Wēkiu bug life cycles, habitat and nutritional requirements, and breeding behaviors. New information may be used to modify the habitat restoration protocol to increase its effectiveness.

The Outrigger Telescopes Project will not lead to the extinction of the Wēkiu bug. Less than 0.009-ha (0.022-ac) of Wēkiu bug habitat will be disturbed during construction of the Outrigger Telescopes. This is about 0.008 percent of the 120-ha (300-ac) estimated size of occupied Wēkiu bug habitat (Howarth and others 1999). Several entomologists familiar with Wēkiu bug biology have reviewed the Wēkiu Bug Mitigation Report, and most have agreed that the Outrigger Telescopes Project should not have a negative impact on the Wēkiu bug if recommendations in that report are followed. It is the goal of the Wēkiu Bug Mitigation and Monitoring plans to expand Wēkiu bug habitat and enhance the Wēkiu bug population in Pu'u Hau 'Oki.

February 14, 2001

Richard J. Howard, Senior Program Executive
Office of Space Science, Code SD
NASA Headquarters
300 E. Street SW
Washington DC 20546-0001

Re: Draft Environmental Assessment, NASA/CARA Outrigger Telescopes, Mauna Kea

Mauna Kea is the highest peak in the Pacific, and for half a million years it has been pristine habitat for unique altitude-adapted flora and fauna. In 1982, when the mountain was surveyed for arthropods, some species, such as the *Nysius wekiucola* or wekiu bug, numbered in the thousands. Then the peak became a hive of astronomical industrial endeavor; within ten years the habitat was essentially destroyed and populations had crashed. Assurances of mitigation and protection provided in the EIS were ignored by DLNR and IfA in favor of construction efficiencies. In fact, due to the lack of research and population monitoring outlined in the EIS but unfunded by IfA, the once abundant wekiu bug became a candidate for Endangered Species status. Habitat essential for its survival was obliterated, and only when until scientist Dr. Fred Stone alerted DLNR chair Mike Wilson that the original habitat had been altered beyond recognition was any heed paid to the status of the fauna on the mountain.

It is with this sad history in mind that I request that a full EIS be implemented immediately, taking into account the cumulative scope of activity in place and anticipated on the mountain. I am concerned that without a thorough overview and deliberate cooperation on the part of all telescopes and their contractors, the habitat will continue to be degraded, and each entity will deny responsibility for the outcome. I am further concerned that without a clear chain of responsibility for management there will be no way to effectively protect the resources. 4A

The EA fails to adequately address the nature and destruction of the arthropod and floral habitat, fails to disclose a research plan to monitor and rehabilitate the habitat, fails to detail appropriate mitigation measures for further construction, and fails to describe the management authority responsible for compliance. 4B

My specific concerns about the Environmental Assessment will be focused on the questions and issues not sufficiently addressed, and thus require a full EIS.

Mitigation Measures, pages 96-99, alludes to a Wekiu Bug Mitigation Plan, and a monitoring program being developed. A monitoring program for all arthropod species must be included in the document for public review. Who is developing the program? How comprehensive is the program? What are the qualifications of the personnel doing the monitoring? How much will it cost? Who will pay for it? 4C

The undisclosed plan discusses the responsibilities of the contractor to remove soil and other material harboring alien pests. I am concerned that there is little discussion in the EA or the Appendix of contractor compliance. Will an independent entomologist certify compliance? At what sites? Is DLNR or DOA involved? Who will write the implementation plan? When will that be available for public comment? What are the ramifications for non-compliance? Will the contractor post a bond? Pay fines? Go to jail for non-compliance?

Who will monitor the construction activities on the mountain? To whom does the person report infractions? What actions will be taken to immediately rectify non-compliance of a contractor? 4D

On page 96 there is reference to wekiu habitat restoration. What scientific literature documents extant knowledge of the life cycle, nutritional requirements, breeding behaviors and habitat requirements of the Nysius? Do we know how to restore habitat? If not, what research will be conducted to study the insect, and how will research document the outcomes of habitat restoration trials? Eighteen months is not sufficient: how will long-term monitoring be designed and funded? 4E

With 99.7% of the original population extirpated during the past 18 years, due in part at least, to habitat destruction and alien species introduction, what will the effect of listing be on the future of the telescopes? Will designation of critical habitat affect future use of the mountain? 4F

There are glaring omissions in lines of authority outlined in the draft EA. A full disclosure of regulatory authority, accountability, and contractual compliance will be necessary to fully protect the resources. For these reasons, I call for implementation of a full Environmental Impact Study. 4G

Thank you.

Deborah Ward

Deborah Ward
P.O.Box 918
Kurtistown, HI 96760
dward@hawaii.edu

cc: Mauna Kea Management Committee
Mauna Kea Environment Committee
Department of Land and Natural Resources
Kenneth Mortimer, University of Hawaii

RESPONSES TO COMMENTS
Commentor No. 4: Deborah Ward

Response to Comment 4A:

The entire scope of activities on the Mauna Kea Science Reserve is not within the jurisdiction of NASA. However, your comment has been noted and referred to the University of Hawai'i for their consideration. It is our understanding that the recently adopted Mauna Kea Science Reserve Master Plan provides a clear chain of responsibility for managing the Mauna Kea Science Reserve.

Response to Comment 4B:

The impacts on arthropod and floral habitat at the proposed Outrigger Telescopes Project location at the W.M. Keck Observatory site are described in Section 4.1.6 of this Final Environmental Assessment.

The Wēkiu Bug Mitigation Plan (provided in Appendix D) and the Monitoring Plan (referenced in Appendix E) are summarized in this Final Environmental Assessment in Section 4.1.6. Proposing mitigation measures for further construction beyond the Outrigger Telescopes Project is not within NASA's jurisdiction; however, we have referred your recommendation to the University of Hawai'i.

The management authority responsible for compliance with proposed Wēkiu bug mitigation measures during on-site construction, installation, and operation of the Outrigger Telescopes Project would be the California Association for Research in Astronomy. The California Association for Research in Astronomy's Construction Manager, supported by an Archaeological Monitor, a Cultural Monitor, and the Entomologist, would be responsible for day-by-day implementation of the agreed upon mitigation measures throughout on-site construction and installation.

Response to Comment 4C:

The Wēkiu Bug Mitigation Plan attached as Appendix D and the Wēkiu Bug Monitoring Plan referenced in Appendix E were developed by a qualified entomologist. The University of Hawai'i is the responsible entity for implementing any long-term monitoring.

Response to Comment 4D:

The Wēkiu Bug Mitigation Plan, based on recommendations contained in the Wēkiu Bug Mitigation Report was prepared by Pacific Analytics of Albany, Oregon and is included in Appendix D in this Final Environmental Assessment. Only the Wēkiu bug is included because it is the only arthropod identified as a candidate for listing under the Endangered Species Act. Wēkiu bug monitoring, which is included in the Wēkiu Bug Mitigation Plan, is very comprehensive. A professional entomologist would be engaged by the California Association for Research in Astronomy (CARA) to implement the Wēkiu Bug Mitigation and Monitoring plans during on-site construction and installation of the Outrigger Telescopes.

CARA's Construction Manager would have overall responsibility for ensuring that the requirements of the proposed mitigation plans are implemented during on-site construction and installation. Enforcement of the Wēkiu Bug Mitigation Plan would also be the responsibility of the CARA Construction Manager. Three on-site monitors, all reporting to the CARA Construction Manager, would have day-to-day responsibility for monitoring implementation and reporting infractions to CARA's Construction Manager. The CARA Construction Manager would have the authority to issue "stop-work" orders based on a previously agreed upon set of criteria.

As noted in Section 4.1.6 of this Final Environmental Assessment, compliance with the Wēkiu Bug Mitigation Plan, including its requirements for vehicle cleaning and materials inspections, would be incorporated into the contract(s) for on-site construction and installation of the Outrigger Telescopes. Contractor personnel's noncompliance with contractual requirements could result in imposition of contractual penalties up to and including loss of work on this project.

Implementation of the Wēkiu Bug Mitigation Plan includes inspection of construction machinery and material deliveries associated with on-site construction and installation of the Outrigger Telescopes. These inspections would take place near the intersection of Saddle Road and the Mauna Kea Access Road by a qualified specialist hired by the California Association for Research in Astronomy.

Construction of the Outrigger Telescopes would be conducted under a permit issued by the State of Hawai'i Department of Land and Natural Resources. The construction Best Management Practices Plan will incorporate all relevant conditions attached to this permit.

Response to Comment 4E:

Since the discovery of the Wēkiu bug was reported in 1980 (Howarth 1983), at least six studies have provided details about the habitat requirements of Wēkiu bugs (Howarth and Montgomery 1980; Howarth and Stone 1982; Ashlock and Gagne 1983; Duman and Montgomery 1991; Polhemus 1998; Howarth and others 1999). Two of these studies included extensive sampling and assessment of habitat at the summit of Mauna Kea (Howarth and Stone 1982; Howarth and others 1999). The habitat restoration protocol is based on the best scientific information available about the habitat needs of the Wēkiu bug; during the development of the protocol all information contained in scientific literature was considered. The protocol is based on the following information.

1. Wēkiu bugs appear to prefer habitat made of loose cinder 1.3 centimeters (cm) (½ inch) in size or larger. In past studies (Howarth and Stone 1982; Howarth and others 1999), the highest concentration of Wēkiu bugs were collected in habitat consisting of 25 to 38 cm (10 to 15 inches) of 1.3 cm (½ inch) size or larger cinder, with an impenetrable ash layer below the cinder. This information leads us to conclude that restored habitat consisting of 30 to 46 cm (12 to 18 inches) of loose 1.3 cm (½ inch) size or larger cinder will be acceptable to Wēkiu bugs.

2. Wēkiu bug habitat occurs on undisturbed portions of crater floors in summit cinder cones (Howarth and Stone 1982; Howarth and others, 1999). In 1982, 6,230 Wēkiu bugs were collected on the crater floor of Pu'u Wēkiu and 430 Wēkiu bugs were collected on the crater floor of Pu'u Hau 'Oki. During the

1997/98 arthropod assessment, Wēkiu bugs were found on the crater floor of Pu'u Wēkiu and Pu'u Hau 'Oki, and on the inner slopes of Pu'u Hau 'Oki adjacent to the crater floor. Since suitable habitat does not exist on the crater floor of Pu'u Hau 'Oki, Wēkiu bugs from the adjacent inner slopes apparently migrate to the crater floor. This information leads us to conclude that Wēkiu bugs would likely occupy restored habitat on the floor of Pu'u Hau 'Oki.

3. Given sufficient time, Wēkiu bug habitat appears to recover from disturbance. Of all sites sampled during the 1997/98 arthropod assessment, habitat on the slopes below W.M. Keck Observatory that was disturbed during construction contained the highest concentration of Wēkiu bugs. This information leads us to conclude Wēkiu bugs would eventually occupy the restored habitat.

Given the information above, most experts believe that habitat restoration will succeed in expanding the current Wēkiu bug population. As part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors. New information may be used to modify the habitat restoration protocol to increase its effectiveness.

Monitoring of Wēkiu bug populations on restored habitat on the crater bottom of Pu'u Hau 'Oki and in habitat on the inner slopes of Pu'u Hau 'Oki would begin at the start of construction and extend for eighteen months after the end of Wēkiu bug restoration. Long-term monitoring beyond that time period is the responsibility of the University of Hawai'i.

Response to Comment 4F:

Listing of the Wēkiu bug under the Endangered Species Act and designation of critical habitat could affect all types of future uses of the summit region.

Response to Comment 4G:

As indicated in this Environmental Assessment including its Appendices, there are both State and Federal regulatory authorities. For example, a Conservation District Use Permit (CDUP) is issued by the State of Hawai'i Board of Land and Natural Resources; and for historic/cultural effects a Memorandum of Agreement is entered into with the State Historic Preservation Officer and the Federal Advisory Council on Historic Preservation. The University of Hawai'i, the holder of the State Permit, is responsible for ensuring that CARA complies with the conditions attached to the CDUP (UH IfA 2001a). The State Department of Land and Natural Resources is the agency responsible for enforcing compliance with the CDUP conditions.

In general, either CARA as the operator of the Outrigger Telescopes, or UH is responsible for permit compliance (UH IfA 2001b). The observatory is in compliance with all permitting requirements (UH IfA 2001b).

AHAHUI KU MAUNA

c/o Ed Stevens
76-6335 Leone Street
Kailua Kona, Hawaii 96740

February 15, 2001

Mr. Richard Howard
Senior Program Executive
Office of Space Science, Code SD
NASA Headquarters
300 E Street SW
Washington D.C. 20546-0001

Dear Mr. Howard:

Thank you for inviting **Ahahui Ku Mauna** to comment on the Draft Environmental Assessment for the Keck Outrigger Project on Mauna Kea. **Ahahui Ku Mauna** is a Hawaiian cultural group originally organized at the request of U.S. Senator Daniel K. Inouye to work with the astronomy people in resolving problematic issues of the proposed Mauna Kea Master Plan. We have dedicated ourselves to the cultural and spiritual protection of our sacred mountain, Mauna Kea.

As clearly demonstrated at several public hearings in 1998 and 1999 for the Mauna Kea Science Reserve Master Plan, our Hawaiian community strongly objected to further construction of astronomy facilities on the mountain, and wanted to see all existing structures eventually removed. **Ahahui Ku Mauna** shares these views and has expressed them to the University and Astronomy community in previous discussions with them. We see the Keck Outrigger project as yet another intrusion on an already crowded mountaintop. Your own statement on Page 33 –"More major telescopes are located on Mauna Kea than any other single mountain peak."– though intended to be positive, has the opposite effect on us. It only adds to our anguish knowing that Astronomers envision continued expansion on the summit through the following proposed projects: (1) Smithsonian's addition of 24 pads and 12 dish antennas into their existing SMA, (2) another one-meter Instructional Telescope, (3) another 8 to 10 meter Conventional Optical IR Telescope, and (4) a new technology Next Generation Large Telescope of enormous proportions. Knowing these plans are anticipated during the next 20 years, can you not see why a seemingly benign project such as the Keck Outrigger Telescopes would have such a major impact on our emotions? The Keck project, if approved, will set the precedent for continued expansion, despite the fact that Astronomers have already had more than their share of Mauna Kea with their current 13 facilities. 5A

The undisclosed plan discusses the responsibilities of the contractor to remove soil and other material harboring alien pests. I am concerned that there is little discussion in the EA or the Appendix of contractor compliance. Will an independent entomologist certify compliance? At what sites? Is DLNR or DOA involved? Who will write the implementation plan? When will that be available for public comment? What are the ramifications for non-compliance? Will the contractor post a bond? Pay fines? Go to jail for non-compliance? 4D

Who will monitor the construction activities on the mountain? To whom does the person report infractions? What actions will be taken to immediately rectify non-compliance of a contractor?

On page 96 there is reference to wekiu habitat restoration. What scientific literature documents extant knowledge of the life cycle, nutritional requirements, breeding behaviors and habitat requirements of the Nysius? Do we know how to restore habitat? If not, what research will be conducted to study the insect, and how will research document the outcomes of habitat restoration trials? Eighteen months is not sufficient: how will long-term monitoring be designed and funded? 4E

With 99.7% of the original population extirpated during the past 18 years, due in part at least, to habitat destruction and alien species introduction, what will the effect of listing be on the future of the telescopes? Will designation of critical habitat affect future use of the mountain? 4F

There are glaring omissions in lines of authority outlined in the draft EA. A full disclosure of regulatory authority, accountability, and contractual compliance will be necessary to fully protect the resources. For these reasons, I call for implementation of a full Environmental Impact Study. 4G

Thank you.

Deborah Ward

Deborah Ward
P.O.Box 918
Kurtistown, HI 96760
dward@hawaii.edu

cc: Mauna Kea Management Committee
Mauna Kea Environment Committee
Department of Land and Natural Resources
Kenneth Mortimer, University of Hawaii

Copy to
Walter Heen, Interim Director OMKM
Arthur Hoke, Chairman MKM Board
Don Hibbard, Administrator SHPD
Rolf-Peter Kudritzki, Director IFA
William Kikuchi, Senator Inouye's Office
Rose Tseng, Chancellor UH-Hilo
David Iha, Secretary - Board of Regents
Jalna Keala, Government Affairs - OHA

RESPONSES TO COMMENTS
Commentor No. 5: Ahahui Ku Mauna (Ed Stevens)

Response to Comment 5A:

Thank you. Your comments are respectfully noted.

Response to Comment 5B:

NASA has assessed your comments regarding the need for NASA to show a long-term commitment to addressing Hawaiian needs as part of the Outrigger Telescopes Project mitigation measures. In view of your comment and other related comments and recommendations received from various Native Hawaiian organizations and individuals during the Section 106 consultation process, NASA has attempted to accommodate those comments and recommendations. Accordingly, mitigation measures, based on these comments and recommendations, are reflected in the Memorandum of Agreement provided in Appendix C of this Final Environmental Assessment. Other long-term benefits derived from astronomical activities on top of the mountain are beyond the jurisdiction of NASA, and must be resolved by the State of Hawai'i.

Response to Comment 5C:

Thank you. Your comment is respectfully noted.

Response to Comment 5D:

As indicated in the Memorandum of Agreement, an Archaeologist and a Cultural Monitor will be involved with the Outrigger Telescopes Project to minimize any adverse effects on historic/cultural resources.

Response to Comment 5E:

Ahahui Ku Mauna has been given Consulting Party status.

Crede, Suzanne C.

From: Ford, Dennis G.
Sent: Tuesday, February 20, 2001 8:18 AM
To: Everingham, John M.; Crede, Suzanne C.
Subject: FW: Mauna Kea observatoriesw

-----Original Message-----
From: The Barrys [SMTP:barry@hialoha.net]
Sent: Monday, February 19, 2001 2:22 PM
To: kcomments@hq.nasa.gov
Subject: Fw: Mauna Kea observatoriesw

I am a retired engineed and live on the Big Island of Hawaii. I have had the extreme pleasure of visiting the top of Mauna Kea and touring two of the observatories. I believe very stongly that the work there must continue to expand

Perhaps thoughts should be givewn to expanding to the top of Mauna Loa. Keep up the good work.

Bob Barry

RESPONSES TO COMMENTS
Commentor No. 6: Bob Barry

Response to Comment 6A:

Thank you. NASA appreciates your supportive comments.

SIERRA CLUB, HAWAI'I CHAPTER

MĀLAMA I KA HONUA

P.O. Box 2577,
Honolulu, Hawai'i 96803
(808) 538-6616

February 19, 2001

Richard J. Howard, Senior Program Executive
Office of Space Science, Code SD
NASA Headquarters
300 E Street S.W.
Washington, DC 20546-0001

Dear Mr. Howard:

The Hawai'i Chapter of Sierra Club, which has been involved with Mauna Kea environmental matters since the mid-1970s, has reviewed the Draft Environmental Assessment (DEA) for the Outrigger Telescopes Project. Our comments follow.

Overview

After careful examination of the DEA we have concluded that given the special cultural and environmental significance of Mauna Kea, the mitigative measures proposed by NASA are insufficient to adequately protect the mountain's upper summit cones and natural ecosystems during construction and operation of the proposed outrigger telescopes. 7A Also, the non-Hawai'i alternatives to the Keck as home for the outriggers are not adequately examined. 7B Finally, the cumulative impacts of these six outriggers combined with the 15 other telescope elements anticipated for the summit region over the next twenty years have not been examined at all. 7C

For these reasons, Sierra Club draws the following conclusions:

1. Because of the special nature of Mauna Kea's summit, and the deficiencies in its DEA, we agree with Hawai'i's Office of Hawaiian Affairs that NASA and others who call for a full Environmental Impact Statement (EIS) in accordance with the requirements of the National Environmental Policy Act. 7D

2. We also believe that in that EIS, NASA should rigorously consider the "No-Action Alternative," which was given only a one paragraph analysis in the DEA. 7E

3. When the final EIS analysis is completed, the Office of Mauna Kea Management, The University of Hawai'i Board of Regents, and the Hawai'i State Land Board should evaluate the Outrigger Project in light of the need to find a compromise between those who seek removal of all structures on the summit area and those, like the University's Institute for Astronomy, which seek observatory expansions engendering a ten-fold increase in the land area to be disturbed. A moratorium on any new construction that increases the existing footprints of facilities or causes further damage to the natural environment adjacent to them would preclude approval of the Outrigger Project proposal. 7F

NASA Praised for Finally Adhering to Federal Law

We are pleased that after some initial resistance, NASA has agreed to follow United States federal law with respect to conducting an environmental review in accordance with the federal standards required by the National Environmental Policy Act (NEPA). NASA has also agreed to follow the consultation requirements and other provisions of the National Historic Preservation Act (NHPA). *This is the first time any of the federally funded projects on Mauna Kea have complied with these United States statutes.* Previously constructed observatories which have failed to comply include the Smithsonian Institution's Submillimeter Array, the Gemini North telescope and the National Radio Astronomy Observatory's Very Long Base Array. We hope your compliance with NEPA and NHPA will establish a more lawful pattern of practice among these and other observatories who rely on federal funds or other kinds of "substantial federal involvement" in building or modifying their facilities on Mauna Kea.

Any Further Industrialization of Kukahau'ula is Inappropriate

The measures contained in NASA's "Off-Site/On-Site Mitigation Cultural Resource Plans," while useful in minimizing some physical impacts of the Outriggers Project, don't mitigate the major negative impact, which is the further industrialization of the upper summit region, particularly the three cones which comprise Kukahau'ula. This area, which Native Hawaiians view as culturally significant (and sacred), has been deemed by the State Historical Preservation office as "an historical property" worthy of placing on the National Register of Historic Places. The *inherent* intrusion of more buildings, dust, sewage, hazardous waste, noise, people, laser beams, and the further alteration of Kukahau'ula's physical features and appearance (particularly from upper elevations) make further industrialization incompatible with protection of what may well be the most important landscape in the entire Hawaiian archipelago. 7G

Wekiu Mitigation Ideas are Premature and may be Harmful

The measures contained in NASA's "Draft Wekiu Bug Mitigation Plan" are well meaning but may not be able to halt the catastrophic decline of the Wekiu Bug population (a 99.7% drop from 1982 to 1997). Until detailed studies of the Wekiu life history are conducted, ad hoc mitigative measures should not be conducted. This DEA does not adequately discuss life cycle history, habitat requirement information, breeding behavior, number of offspring or any other information that lends credence to the proposed mitigative measures' ability to positively affect the Wekiu bug's population. A research plan must be devised, funded and concluded prior to implementing any restoration work. The research must observe Wekiu life cycles and all impacts to the species, test hypotheses and formulate habitat restoration procedures and principles. In support of this point, we are submitting photographic documentation of the initial damage of Puu Hauoki in August, 1986 by professional photographer Melissa J. Schelling (Ph. (808) 965-7701). It shows the massive amounts 7H

of material pushed over the edge of the cone and the damage done to the wekiu habitat by the excavation for the Keck Facility.

Mitigation Requires Strict Enforcement to Protect Wekiu Habitat from Alien Species

We do not believe the mitigative measure suggested for protecting what's left of the Wekiu Bug population can realistically be implemented without strong punitive enforcement provisions currently absent from the DEA. While the myriad mitigative measures listed are good ideas, their effectiveness depends on them being implemented a 100 percent level—and that means 100 percent enforcement. With only 0.3% of the 1982 population still evident on the mountaintop, this candidate endangered species cannot afford *any* further damage to its habitat. 7I

DEA Contains No Analysis of Cumulative Impacts

We strongly disagree with NASA's assertion that there is no need to include a cumulative impacts analysis at this time. The University of Hawai'i recently approved a twenty year "master plan" that calls for the addition of up to twenty-one new telescopes (or telescope elements) along with five "upgrades" of existing facilities located on Kukahau'ula. In addition, the plan calls for a total of 24 large submillimeter radio antennas and up to 48 telescope pads just below the Keck site, a massive project which together with the outriggers will substantially impact the visual appearance and natural features of this portion of the summit area. The complete lack of cumulative analysis must be rectified in an Environmental Impact Statement before the full extent of the Outrigger Project impact can be realistically understood and analyzed. 7J

Non-Hawai'i Alternatives to Keck are Not Adequately Analyzed

We have also concluded that NASA's DEA does not meet federally-mandated requirements for substantively analyzing alternatives to the proposed project location because the non-Hawai'i alternatives mentioned in the DEA (as facilities appropriate for outriggers) are not serious considered or analyzed. The overly rigid "screening criteria" applied to the alternatives (including questionable "programmatic feasibility" characteristics and a debatable Northern Hemisphere requirement) eliminates all telescope possibilities elsewhere in the world, essentially customized the 7K analysis to support only the Kecks in Hawai'i. At least two others facilities, Paranal in Chile and Mt. Graham in Arizona should be investigated further, even though these may engender some additional cost for adaptation of the new technology (in the case of Chile), and a large portion of the Northern Hemisphere sky would not be visible from this South American site. These disadvantages seems relatively insignificant when compared with the serious cultural and environmental constraints on Mauna Kea, the tallest peak in all of Hawai'i and Polynesia.

DEA Fails to Take Into Account Widespread Public Opposition

In 1999 and 2000, a number of meetings were held on the Island of Hawai'i to obtain public comment on the University of Hawai'i's proposed new master plan for Mauna Kea. Many concerns were raised by the hundreds who attended, not only about the proposed plan, but also about past and future astronomical development on Mauna Kea. These included concerns about damage to the mountain's unique natural environment and cultural heritage, the visual impact of the observatories (as seen from both the mountain top and the coast), broken promises from the previous master plans, and the possibility of restrictions on public access (which had been openly advocated by the University President, the State Land Board Chair and some members of the astronomical community.) The vast majority of those attending the meetings opposed any further development of the mountain top, and some called for the removal of existing facilities (a possibility provided for in the 1965 DLNR/University of Hawai'i lease agreement). Native Hawaiians were the most upset about what had happened on the mountain and what was planned. As Office of Mauna Kea Management Interim Director, Walter Heen, recently observed: 7L

> As a native Hawaiian myself I am fully aware of the antipathy within the Hawaiian community towards the development already on the mountain and the strong belief that all the structures should be removed. Moreover, Hawaiians also believe that no further development should be allowed on the mountain. ("A Matter of Balance," *Ho'opono Mauna Kea*, Fall 2000, p.3).

Outrigger Proposal Should be Considered in Light of Need for Compromise

In trying to strike a balance between those who advocate many more telescopes on the mountain—including supporters of the new master plan's call for up to 21 more telescope elements (a ten-fold build-up in the acreage to be disturbed)—and those who favor removal of the observatories, Sierra Club suggests that the most reasonable approach would be the cessation of expansion. That is, allow those observatories currently on the mountain to continue, but prohibit the building of further structures on the mountain. While existing facilities ought to be able to upgrade their telescopes to improve them over time, such improvements should not significantly expand the footprint of the structures which currently house them, or cause further damage to the natural environment adjacent to them. Given this position, we think buildings the six outriggers is inappropriate and violates the spirit of this kind of compromise, so badly needed at this time. 7M

Mahalo for your consideration of these comments. Please feel free to contact us if we can be of any further assistance. We look forward to reviewing the full Environmental Impact Statement.

Sincerely,

Nelson Ho

Nelson Ho
Sierra Club, Hawai'i Chapter
c/o 32 Kahoa St.
Hilo, HI 96720-2206
Ph. (808) 933-2650

Response to Comment 7A:

The Outrigger Telescopes Project's historic/cultural mitigation measures are reflected in the Memorandum of Agreement (see Appendix C) and mitigation measures for the Wēkiu bug are reflected in the Wēkiu Bug Mitigation Plan (see Appendix D). In order to protect historic/cultural properties and natural resources on the project site, an Archaeologist and a Cultural Monitor will be present as provided in the Memorandum of Agreement, and an entomologist will be present as provided in the Wēkiu Bug Mitigation Plan.

Response to Comment 7B:

The non-W.M. Keck Observatory sites have been adequately addressed in this Environmental Assessment. See Section 2.3.2.

Response to Comment 7C:

NASA has provided information on the potential cumulative environmental impacts associated with the Outrigger Telescopes Project. Please see Section 4.2 of this Final Environmental Assessment.

Response to Comment 7D:

Thank you. Your comment is respectfully noted.

Response to Comment 7E:

In Section 2.2 of the Environmental Assessment, NASA defines the No-Action Alternative as no funding approval for on-site construction, installation, and operation of the Outrigger Telescopes Project. This decision would mean that the Outrigger Telescopes Project would not be built and hence there would be no direct environmental effects. The potential environmental consequences of the No-Action Alternative are discussed in Section 4.3 of this Final Environmental Assessment. This section also discusses the lost revenues to the State of Hawai'i economy as well a cessation of NASA funding for Wēkiu bug mitigation and monitoring and on-site and off-site cultural mitigation activities proposed by NASA in the Section 106 process.

The No-Action Alternative assumes that existing previously approved Keck I and Keck II Telescopes would continue to function, and operational and maintenance activities would continue as well. Previously evaluated and approved actions and in-place facilities such as the Keck I and Keck II Telescopes constitute the "baseline condition". (Note that the W.M. Keck Observatory (WMKO) site, Keck I and the telescope which would become Keck II were all assessed in the Final Environmental Impact Statement for the Mauna Kea Science Reserve Complex Development Plan, Research Corporation of the University of Hawai'i, 1982; Keck II was reevaluated in Project Description/Environmental Review-Proposed Second Telescope on the W.M. Keck Observatory Site at Mauna Kea, Hamakua, Hawai'i, UH IfA 1991). Chapter 3 of the Environmental Assessment discusses and evaluates these present conditions. Present conditions are equivalent or the same as the No-Action Alternative or condition. The cultural and environmental impacts that would result from proceeding with the Proposed

Action (*i.e.*, on-site construction, installation, and operation of the Outrigger Telescopes) are presented in Chapter 4 and the difference between baseline (or no-action) and implementation of the Proposed Action is discussed.

The Environmental Assessment accurately presents the No-Action Alternative.

Response to Comment 7F:

Thank you. Your comments are respectfully noted.

Response to Comment 7G:

Thank you. Your comment is respectfully noted.

Response to Comment 7H:

Less than 0.009-ha (0.022-ac) of Wēkiu bug habitat would be disturbed during construction of the Outrigger Telescopes. This would represent about 0.008 percent of the 120-ha (300-ac) estimated size of occupied Wēkiu bug habitat in the summit region of Mauna Kea (Howarth and others 1999). NASA has consulted with the U.S. Fish and Wildlife Service concerning the Wēkiu Bug Mitigation Report. The Wēkiu Bug Mitigation Plan (see Appendix D of this Final Environmental Assessment) represents implementation of the recommendations contained in the Wēkiu Bug Mitigation Report. It is the goal of the Wēkiu Bug Mitigation Plan to expand Wēkiu bug habitat and enhance the Wēkiu bug population in Pu'u Hau 'Oki.

The habitat restoration protocol is based on the best scientific information available about the habitat needs of the Wēkiu bug. The protocol is based on the following information.

1. Wēkiu bugs appear to prefer habitat made of loose cinder 1.3 centimeters (cm) (½ inch) in size or larger. In past studies (Howarth and Stone 1982; Howarth and others 1999), the highest concentration of Wēkiu bugs were collected in habitat consisting of 25 to 38 cm (10 to 15 inches) of 1.3 cm (½ inch) size or larger cinder, with an impenetrable ash layer below the cinder. This information leads us to conclude that restored habitat consisting of 30 to 46 cm (12 to 18 inches) of loose 1.3 cm (½ inch) size or larger cinder will be acceptable to Wēkiu bugs.

2. Wēkiu bug habitat occurs on undisturbed portions of crater floors in summit cinder cones (Howarth and Stone 1982; Howarth and others, 1999). In 1982, 6,230 Wēkiu bugs were collected on the crater floor of Pu'u Wēkiu and 430 Wēkiu bugs were collected on the crater floor of Pu'u Hau 'Oki. During the 1997/98 arthropod assessment, Wēkiu bugs were found on the crater floor of Pu'u Wēkiu and Pu'u Hau 'Oki, and on the inner slopes of Pu'u Hau 'Oki adjacent to the crater floor. Since suitable habitat does not exist on the crater floor of Pu'u Hau 'Oki, Wēkiu bugs from the adjacent inner slopes apparently migrate to the crater floor. This information leads us to conclude that Wēkiu bugs would likely occupy restored habitat on the floor of Pu'u Hau 'Oki.

3. Given sufficient time, Wēkiu bug habitat appears to recover from disturbance. Of all sites sampled during the 1997/98 arthropod assessment, habitat on the slopes below W.M. Keck Observatory that was disturbed during construction contained the highest concentration of Wēkiu bugs. This information leads us to conclude Wēkiu bugs would eventually occupy the restored habitat.

As part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology, to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors. New information may be used to modify the habitat restoration protocol to increase its effectiveness.

Response to Comment 7I:

The Wēkiu Bug Mitigation Plan and the Wēkiu Bug Monitoring Plan are very comprehensive. A professional entomologist would be involved in implementing the Wēkiu Bug Mitigation and Monitoring plans during on-site construction and installation of the Outrigger Telescopes. Implementation of the Wēkiu Bug Mitigation Plan includes inspection of construction machinery and material deliveries associated with on-site construction and installation of the Outrigger Telescopes. These inspections would take place near the intersection of Saddle Road and the Mauna Kea Access Road by a qualified specialist hired by the California Association for Research in Astronomy.

As noted in Section 4.1.6 of NASA's Environmental Assessment, compliance with the Wēkiu Bug Mitigation Plan, including its requirements for vehicle cleaning and materials inspections, would be incorporated into the contract(s) for on-site construction and installation of the Outrigger Telescopes. Contractor personnel's noncompliance with contractual requirements could result in imposition of contractual penalties up to and including loss of work on this project.

Response to Comment 7J:

See Response to Comment 7C.

Response to Comment 7K:

See Response to Comment 7B.

Response to Comment 7L:

Thank you. Your comments are respectfully noted.

Response to Comment 7M:

Thank you. Your comment is respectfully noted.

Crede, Suzanne C.

From: 'Ford, Dennis G.
Sent: Thursday, February 22, 2001 8:11 AM
To: Crede, Suzanne C.; Everingham, John M.
Subject: FW: Keck Observatory Outrigger Telescope Project

-----Original Message-----
From: LANCE PETERSEN [SMTP:iflwp@uaa.alaska.edu]
Sent: Wednesday, February 21, 2001 9:44 PM
To: kcomments@hq.nasa.gov
Subject: Keck Observatory Outrigger Telescope Project

Hello, NASA...

This project is a vital one to further the valuable research potention of the Keck Observatory. Please continue to push for this project. 8A

Prof. Lance Peterse
University of Alaska

Response to Comment 8A:

Thank you. NASA appreciates your supportive comments.

P. O. Box 1520, Pahoa, HI 96778
(808) 965-9254

February 22, 2001

Mr. Richard J. Howard
Office of Space Science
Code SD
NASA HQ
300 E. St. S.W.
Washington, D.C. 20546-0001

RE: MAUNA KEA DEA

Dear Mr. Howard:

Malama O Puna is a 501(c)(3) Hawaii non-profit corporation with over 150 member households and many nonmember supporters on the Island of Hawaii and elsewhere. We have followed with interest and concern the continued development of the summit of Mauna Kea over the years. The most recent proposal to construct six (6) Keck outrigger telescopes is much more than any members of the public ever envisioned when astronomy was first proposed.

We feel that the Draft Environmental Assessment is insufficient and fails to disclose all the biological, cultural and social impacts of the proposal. 9A
It also fails to fully address the concerns enumerated in the report by State Auditor Marion Higa.

The mountain and its summit should not be the exclusive province of the astronomical sciences. Biology, Archaeology and Hawaiian Studies are being neglected in the so-called "Science Preserve". 9B
The cultural and religious concerns of native Hawaiians are given only nominal consideration. More and more the public's viewplanes are marred by the installations.

On behalf of the membership and supporters of our organization we hereby request a full Environmental Impact Statement.

Sincerely,

René Siracusa

René Siracusa
President
Malama O Puna

N.B.~

The enclosed letter
was faxed to you on
2-22-01 at about 5 p.m
(Hawai'i time). On 2-23
I received a message on my
answer machine from your
office that the fax came
through illegible on the left
side; I attempted to re-
send from 2 different
fax machines and got a
"line error" response. So
here is my letter via "snail
mail". Please credit me with
getting it to you within the
required deadline. Thanks.

René Siracusa

Response to Comment 9A:

The Environmental Assessment has addressed the environmental impacts associated with the on-site construction, installation, and operation of the Outrigger Telescopes. The concerns expressed by the Commentor are within the jurisdiction of the State of Hawai'i, not NASA.

Response to Comment 9B:

In accordance with both the National Environmental Policy Act and the National Historic Preservation Act, it is NASA's goal that the proposed Outrigger Telescopes Project be implemented in a manner that would ensure not just good environmental stewardship but also respect for the historic/cultural traditions of Native Hawaiians. NASA has sought the counsel of a number of Native Hawaiian organizations and concerned State of Hawai'i agencies through the Section 106 process conducted in accordance with the National Historic Preservation Act. As indicated in the Memorandum of Agreement, an Archaeologist and a Cultural Monitor will be involved with the Outrigger Telescopes Project to minimize any adverse effects on historic/cultural resources.

Crede, Suzanne C.

From: Ford, Dennis G.
Sent: Thursday, February 22, 2001 3:23 PM
To: Crede, Suzanne C.; Everingham, John M.
Subject: FW: Draft Environmental Assessment for the Keck Outrigger Telescope Project

-----Original Message-----
From: Psteenburg@aol.com [SMTP:Psteenburg@aol.com]
Sent: Thursday, February 22, 2001 2:34 PM
To: kcomments@hq.nasa.gov
Cc: vllsvk@ilhawaii.net
Subject: Draft Environmental Assessment for the Keck Outrigger Telescope Project

To: Office of Space Science, Code SD

We are writing in regards to the Outrigger Telescope project which we have heard about in the news media and from friends. We live on the Big Island in Hawaii and are very interested in this particular project. We've read the Environmental Assessment, and other literature pertaining to the Interferometer project. The E.A. is well laid out and very complete. We feel that this program is eciting and important to all of us, and definitely should move forward. This project will do great things for the State of Hawaii, Science and Technology. You have our full support!! **10A**

Jim & Pam Steenburg
P.O. Box 7182
Ocean View, Hi. 96737
808-939-7472
psteenburg@aol.com

RESPONSES TO COMMENTS
Commentor No. 10: Jim and Pam Steenberg

Response to Comment 10A:

Thank you. NASA appreciates your supportive comments.

FEB 22, '01 1/4

BY FAX 202-358-3987.

COMMENTS FORM

Written public comments on environmental impacts and concerns (including historical and archeological factors) and proposed mitigation associated with the proposed Outrigger Telescopes are hereby requested.

Your comments may be written on this form and deposited in the box provided.

Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): JOHN F. VILLESVIK

Commenter's full address (street, city, state, and zip code) (required): P.O. BOX 188, NAALEHU, HI 96772

Comments: DEAR MR. HOWARD, I AM A RESIDENT OF HAWAII, HAVING LIVED ON THE BIG ISLAND SINCE 1979. HAD A MARINE STORE IN KAILUA-KONA FOR 20 YEARS, NOW RETIRED IN OCEAN VIEW, HI. SINCE '84, WE HAVE MADE MANY MANY TRIPS TO THE SUMMIT OF MAUNA KEA, SAW THE GROWTH & DEVELOPMENT FROM THE DAYS OF THE CFH & NASA OBSERVATORIES TO THE PRESENT. SINCE 1997, I HAVE ATTENDED HEARINGS FOR THE GENERAL PLANS FOR THE SUMMIT DEVELOPMENT, HEARINGS FOR THE KECK OUTRIGGER TELESCOPES, FOR THE FINAL E.A. FOR THE UNIVERSITY OF HAWAII I.F.A., AND SO ON. I HAVE GIVEN ORAL & WRITTEN TESTIMONY FOR THE DEVELOPMENTS.

I THINK THAT THE DEVELOPMENTS IN ASTRONOMY AT MAUNA KEA ARE TREMENDOUSLY EXCITING. WE ARE PRIVILEGED TO PARTICIPATE IN IT. OUR ISLAND HAS BENEFITED, BOTH ECONOMICALLY AND EDUCATIONALLY.

Additional space is available on the other side of this form.

Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☐

2/4

THE OUTREACH PROGRAMS OF KECK & GEMINI TO OUR SCHOOLS IS WONDERFUL. KECK'S INTERNSHIP WITH KOHALA HI SCHOOL K VERY REWARDING TO THE STUDENTS. THE U.H.H. HAS STARTED AN UNDERGRADUATE ASTRONOMY PROGRAM.

CUT TO THE CHASE. YOUR OUTRIGGER E.A. IS A + FOR COMPLETENESS IN ADDRESSING ALL POSSIBLE ISSUES ~~THE~~ THAT HAVE COME UP. ONLY THE MOST ADAMANT CRITIC WILL NOT ADMIT THAT NASA HAS GONE TO EXTREME LIMITS TO PROTECT THE ENVIRONMENT, PROTECT THE WEKIU BUG AND "DO THE RIGHT THING". YOUR "ORIGINS" PROJECT, AMBITIOUS, EXCITING, WILL KEEP THE U.S. ON THE CUTTING EDGE OF DISCOVERY.

THE KECK OUTRIGGER TELESCOPE PROJECT MUST BE DONE, NOT ONLY FOR THE ORIGINS PROGRAM BUT TO BRING THE KECK TO ITS ULTIMATE USEFULNESS FOR FUTURE DISCOVERY. AND MAUNA KEA STILL IS THE BEST VIEWING LOCATION IN THIS WORLD. WE HAVE AN OBLIGATION TO SCIENCE, ASTRONOMY, TO PROVIDE THE BEST TOOLS FOR THIS LOCATION, ESPECIALLY LOOKING BACK AT WHAT HAS BEEN BUILT TO DATE.

THE BENEFITS OF THE "ORIGINS" PROGRAM, FINAL MAJOR DEVELOPMENT OF THE KECK, FAR OUTWEIGH THE ENVIRONMENTAL, SOCIAL, CONCERNS OF THE OPPONENTS.

I DECIDED TO ADD A COVER LETTER THAT I SENT TO 20 + FRIENDS, WITH INFORMATION ABOUT THE E.A. & YOUR REQUEST FOR COMMENTS. THANKS FOR HANGING IN WITH ME.

JOHN F. VILLESVIK

John F Villesvik

3/4

john villesvik

From: john villesvik <vllsvk@ilhawaii.net>
To: vllsvk@kona.net
Subject: Keck Observatory Outrigger Telescope Project
Date: Sunday, February 11, 2001 20:15

February 11, 2000
Aloha Friends!

As probably all of you know, N.A.S.A has a project of adding 4 to 6 outrigger telescopes to the Keck Observatory system. They are building an Inferometer which will link the light beams of the Keck I and II telescopes. I have included literature that explains it far better than I can.

This is part of NASA's ambitious program to explore the universe to its origins, trying to answer two basic questions: (a) "Where do we come from?" and (b) "Are we alone?"

The addition of the outrigger telescopes to the Keck I and II, in addition to much other equipment already added to the telescopes to expand their usefulness and versatility, will bring the observatory to its ultimate usefulness as a tool for exploration, and keep it on the cutting edge of observation and discovery for years to come.

Without the outrigger telescopes' additions, the development of the Keck capabilities and ultimate usefulness will eventually be stopped dead. As other observatories around the world, and particularly in Chile, are developed, we will begin to lag behind, and become a lesser status in usefulness in the world of Astronomy.

The Keck will continue to function and contribute, but not as it was originally envisioned to do. While this is my own rather gloomy conclusion, it is also inferred in the draft Environmental Assessment, under "No Action Alternative", page 10.

NASA has requested your comments to the Environmental Assessment Comments

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must be received by February 23, 2001. Address as follows:

Office of Space Science, Code SD
NASA Headquarters
300 E Street, S.W.
Washington D.C., 20546-0001

You may also send comments by:
Fax: (202) 358-3987
E-mail: kcomments@hq.nasa.gov

Almost all of you have visited the summit of Mauna Kea, and the Keck Observatory. The Astronomy Reserve is awesome. Please help keep it that way. Send your comments about the project to NASA ASAP. Please keep any criticism constructive.

NASA needs to hear from us citizens. While the project may appear to be "locked up and in the bag", we cannot count on that. Please speak up.

Thank you very much.

John and Linda Villesvik
P.O. Box 188
Na'alehu HI 96772

PH (808)929-9733 FAX 929-9709

RESPONSES TO COMMENTS
Commentor No. 11: John and Linda Villesvik

Response to Comment 11A:

Thank you. NASA appreciates your supportive comments.

OFFICE OF MAUNA KEA MANAGEMENT
640 North Aohoku Place, Room 203, Hilo, Hawai'i 96720
Telephone: (808) 933-0734 Fax: (808) 933-3208

THE OFFICE OF MAUNA KEA MANAGEMENT'S COMMENTS ON NASA'S DRAFT EA REGARDING NASA'S FORTHCOMING APPLICATION TO INSTALL AND OPERATE SIX OUTRIGGER TELESCOPES IN THE PROXIMITY OF THE WMKO WITHIN THE MAUNA KEA SCIENCE RESERVE

Amidst much concern for the welfare of Mauna Kea's natural environment and cultural resources, the 1997 Legislature of the State of Hawaii requested the State Auditor to conduct an audit of the management of Mauna Kea and the Mauna Kea Science Reserve. The Auditor, in her report dated February 1998 and entitled Audit of the Management of Mauna Kea and the Mauna Kea Science Reserve , concluded, among other things, that "[o]ver the past thirty years, the University of Hawaii and the Department of Land and Natural Resources [of the State of Hawaii] have managed the Mauna Kea Science Reserve and adjacent lands in acknowledgement of the competing needs: astronomy development versus environmental protection. **However, both the university and the department failed to develop and implement adequate controls to balance the environmental concerns with astronomy development."** (Emphasis added). Given her findings , the Auditor recommended to the University of Hawaii (university) that it "develop a new methodology to measure the impact of future development on Mauna Kea."

In response, the Board of Regents (B0R) of the university adopted the Mauna Kea Science Reserve Master Plan (Plan) on June 16, 2000. The Plan establishes a single entity known as the Offrce of Mauna Kea Management (OMKM) responsible for the **comprehensive and integrated management** of Mauna Kea, together with the Mauna Kea Management Board (MKMB) to advise the OMKM, and a Kahu Kupuna Council (renamed the Kahu Ku Mauna) as additional advisors on matters of Hawaiian culture, particular related to Mauna Kea..

The Plan charges the OMKM with the duty to ensure that the natural and cultural resources of Mauna Kea are protected and preserved in perpetuity. This duty requires a new management mindset: The lands leased to the university on Mauna Kea make up a scientific reserve within a conservation district and contain numerous significant cultural and natural resources. Astronomy development cannot continue to jeopardize Mauna Kea's natural and cultural resources. The following comments to the Draft EA are informed by this new paradigm.

NUMBER OF OUTRIGGERS APPLIED FOR

From a management standpoint, NASA should limit its project application to the four outrigger telescopes for which funding currently exists since NASA cannot at this time predict with assurance when and if funding will become available or when the additional two outrigger telescopes will be built. The OMKM will not approve a proposal for the development of six outrigger telescopes given NASA's representation that it will wait to see the imaging capabilities of the first four telescopes before it seeks funding for the additional two. 12A

ONSITE CONSTRUCTION

Section 2.1.3.3 Grading Plans for Outrigger Telescope Domes and Junction Boxes and Figure 2-8

According to Section 2.1.3.3 and Figure 2-8, a potential restored wekiu habitat area exists between one of the outriggers and its heat pipe outlets. 12B

Comment: The location of the heat pipe outlet may be less than ideal given that wekiu are highly temperature sensitive and may not survive heating of even a few degrees.

Section 4.1.2 Climate/Meteorology/Air Quality

Pg. 90-91. "Cinder or ash would be moved to temporary stockpile areas and covered with tie-down tarps. Permanent placement of any excavated cinder and ash from the project area during onsite construction would be determined in consultation with USFWS and appropriate Native Hawaiian organizations."

Pg. 92. "It should be noted that for this project all excavation material not directly used as fill would be disposed of on the mountain at locations to be determined after consultation with USFWS and appropriate Native Hawaiian organizations."

Comment: The consulting groups must include the OMKM, the MKMB, and Kahu Ku Mauna, in accordance with the "integrated management" mandated by the Plan. 12C

Pg. 92. "Several design and grading concepts for Outrigger Telescopes 3 and 4 and JB-5, that would provide the necessary slope stability while minimizing potential adverse impacts to the natural and cultural resources of Pu`u Hau `Oki, have been evaluated. The current design is described in Section 2.1.3.3."

Comment: Can we assume that all evaluated concepts were in adherence to the Harding Lawson Associates design criteria that resulted from its slope stability analysis. What other concepts were evaluated? Why was the design described in Section 2.1.3.3 chosen over these others? These questions will invariably be asked during the deliberations of the OMKM and the MKMB during the design review process outlined in the Plan 12D

Pg. 92. "In order to ensure protection of environmentally sensitive areas (i.e., Wekiu bug habitat), a natural resources specialist has been retained to conduct reviews of grading and construction plans to ensure that appropriate mitigation measures would be incorporated to avoid impact to Wekiu bug habitat during on-site construction. In addition, staff of the SHPD, as well as appropriate Native Hawaiian organizations, would be afforded a reasonable opportunity to review the grading and construction plans and make recommendations to minimize potential impacts to the integrity of the Pu`u Hau `Oki cinder cone."

Comment: Who is the natural resources specialist that has been retained? The OMKM should select and direct the natural resources specialist at NASA's expense. 12E Is the term "appropriate Native Hawaiian organization" confined to the definition provided in the National Historic Preservation Act ("NHPA")? In accordance with the Plan, any and all grading and construction plans must be reviewed by the OMKM, the MKMB, and Kahu Ku Mauna. 12F

NATURAL RESOURCES

Wekiu Bug Mitigation Plan

The OMKM will participate in the implementation of the wekiu bug mitigation plan through the establishment of a consulting committee composed of representatives from, but not limited to, USFWS, Department of Land and Natural Resources, Bishop Museum, and the environmental community.

Item 9, Pg. C-5-6

Comment: Tarps held by cables might not be sufficient to withstand high velocity winds known to occur on the summit. Therefore, a more sturdy means of securing debris such as metal lids with locks is recommended. 12G

Item 11, Pg. C-6

Comment: Retrieving any debris from wekiu bug habitat must be done by an entomologist or technician hired for the mitigation project. 12H

Item 12, Pg. C-6

Comment: This section is applicable to all alien species and not just arthropods as suggested by the heading.

The OMKM must have the authority to hire personnel compensated by NASA to ensure that the precautions identified in this section are observed. This measure is recommended because there is a strong concern that in the past environmental concerns have been overlooked or ignored causing disturbance and/or destruction of natural resources, i.e., the wekiu bug. 12I

Item 13, Pg. C-7

Comment: This section is not to be construed as restricted to arthropods. All construction materials, etc. must be free of any and all alien species. The OMKM must have the authority to hire personnel compensated by NASA to inspect these materials prior to transport to the summit. This measure is recommended because there is a strong concern that in the past environmental concerns have been overlooked or ignored causing disturbance and/or destruction of natural resources, i.e., the wekiu bug.

Item 14, Pg. C-8

Comment: All personal items including lunch containers, wrappers, food, etc. must be removed by workers each and every day. 12J

Item 15, Pg. C-8.

Comment: All measures used to prevent the introduction of arthropods to the summit should also be used to prevent introduction of any alien species including plants to the summit. Any and all expenses resulting from the removal or eradication of any alien species will be borne by NASA. 12K

The ultimate goal of the plan – increase the wekiu bug population – should exhibit a commitment to increase the population rather than a mere hope. If this plan does not succeed or only partially succeeds, other alternatives should be developed and implemented. 12L

Although the mitigation plan appears adequate with respect to creating habitat, a comprehensive survey of the presence of wekiu populations within and about the Mauna Kea Science Reserve and appropriate areas of the adjacent Natural Area Reserve should be undertaken to establish a database of wekiu populations. In addition, NASA should fund a study of the wekiu bug including, but not limited to its life history, habitat requirements and food assessment. 12N

Additionally, the wekiu is an endemic Hawaiian species. Appropriate state agencies and private institutions such as the Department of Land and Natural Resources, Division of Forestry and Wildlife, the Bishop Museum, and the University of Hawaii and other appropriate institutions should be consulted.

HAWAIIAN CULTURE

Section 4.1.9 Cultural Resources

Pg. 104-105. "The SHPD has indicated that the Proposed Action would have an adverse effect on the proposed historic district [known as Pu`u Hau `Oki], but that adverse effect could be mitigated [if appropriate measures are adopted]… Some Native Hawaiian groups have identified a larger area of Mauna Kea, from the 1,829-m (6,000-ft) elevation to the summit, as a sacred landscape valued for its spiritual significance, and its view plane... Potential visual and physical impacts on the pu`u were described as important concerns rooted in the fact that many Native Hawaiians hold Mauna Kea to be sacred. Protection of the landscape and view planes among the pu`u and other cultural resources was considered important… The Advisory Council on Historic Preservation (ACHP) has indicated that Native Hawaiian groups have expressed concerns to them that the proposed facilities would limit their access to the summit area and would debase the sacred mountain."

Comment: Were all Native Hawaiian groups and organizations consulted? If not, why not? Was each Native Hawaiian group or organization meeting the NHPA definition consulted? If not, why not? These entities must necessarily be a part of the process. The OMKM, the MKMB, and the Kahu Ku Mauna must also be a part of the process. 12N

Notwithstanding the extent of such consultation, it is inaccurate to say that there is no, or at most minimal, impact from the construction activity necessary to install the four outrigger telescopes. As is pointed out in the letter regarding this matter by Mr. Tim Johns, former Chair of the Board of Land and Natural Resources, the fact that during the construction of the WMKO some of the site was leveled to provide a platform for the telescope indicates that the entire site was not disturbed by excavation. Consequently, there remains the possibility that excavation for the outrigger telescopes could disturb ancient burial sites. 12O

Moreover, when considering whether there is no significant impact on the cultural and environmental resources of Mauna Kea, one must remember that the entire mountain, not merely the summit of Mauna Kea, and not merely the astronomy precinct or the ground on which the observatories stand, is sacred to Native Hawaiians. The very spiritual nature of Native Hawaiians and the core of their reverence for their ancient belief systems are assaulted and demeaned by every intrusion onto Mauna Kea, the paramount symbol of the beginnings of Native Hawaiians' existence. Those concerns are deserving of greater in-depth analysis of the cumulative effects of the proposed project than the EA affords. They deserve more than a mere listing of the existing observatories and a discounting of the probable impact of the new observatories and their construction. Additionally, it is not enough to say that because of their difference in size from the existing twin telescopes that the outriggers will not add appreciably to the cumulative impact. The impact must be measured not merely in visual terms, or in terms of construction impacts, but in spiritual terms-in terms of the project's impact on the native psyche, on the spiritual connection between Native Hawaiians and their beloved mountain.

The issue of cumulative impact is always troublesome for those who must make planning and permitting decisions involving one or more projects within a community or area. Proponents invariably argue that their particular project will not add appreciably to the impact already imposed by existing developments. In this instance, we must look at how the total astronomy development has impacted the spirituality of Mauna Kea. 12P

The lack of understanding of Mauna Kea's true significance to Native Hawaiian well-being misinforms the on-site mitigation plan with respect to cultural and environmental resources by narrowly focusing on the obvious immediate physical and visual impacts of the project. A broader perspective must be developed to appreciate the project's overall impact on Mauna Kea's cultural and environmental resources.

The off-site mitigation plan also suffers from the same lack of understanding. As a result, the plan is utterly inadequate. The plan will not in any way mitigate the project's impact on Native Hawaiian cultural resources, on or off the summit. The educational plan, existing and proposed, is directed almost entirely toward education in astronomy and the sciences from the western viewpoint. Also, the plan seems not to be geared to providing island youth the tools to learn the skills to become astronomers or to provide the required technical support to astronomers. 12Q

Additionally, other programs that will further advance the Native Hawaiians' awareness of their connection to the study of astronomy and the place of astronomy knowledge in the history of the Native Hawaiian people should be developed and implemented. Such educational programs should provide a broad understanding of the Native Hawaiian culture, not merely in astronomy but in general, so that Native Hawaiians and the broader community will understand the strength and viability of their culture even in the modern world and will see the importance and benefit of keeping the knowledge of that culture alive and strong. The goal should not be mitigation in the traditional sense of lessening the project's effects on the Native Hawaiian culture. The goal should be to take the opportunity to use the project, and its resources, to broaden the opportunities for Native Hawaiians to gain, spiritually, and in their knowledge of the universe and their native culture. 12R

CONCLUSION

The OMKM is concerned that the Draft EA does not adequately address the project's potential for significant impact on the natural, environmental and cultural resources of the Mauna Kea Science Reserve. Given its managerial mandate and the Auditor's strong recommendation that a new methodology be developed to accurately measure the impact of future development on Mauna Kea, the OMKM is convinced that NASA must prepare an Environmental Impact Statement (EIS) to address the OMKM's and others' concerns in depth. NASA's preparation of an EIS would clearly exhibit its concern with the natural, environmental, and cultural integrity of Mauna Kea and evidence its willingness to cooperatively participate in the development of a new integrated management methodology. 12S

Thank you for the opportunity to comment. Should you have any questions, please do not hesitate to contact the OMKM.

Yours truly,

Walter M. Heen
Director, OMKM

c: MKMB
Chancellor Rose Tseng
President Mortimer

RESPONSES TO COMMENTS
Commentor No. 12: Office of Mauna Kea Management (Walter Heen)

Response to Comment 12A:

It is NASA's position that this project involves six Outrigger Telescopes; four of which are currently funded for on-site construction, installation, and operation. When funding is available, NASA intends to complete the on-site construction, installation, and operation of Outrigger Telescopes 5 and 6 at a later date.

Response to Comment 12B:

The pipe, referred to as an air pipe in this Final Environmental Assessment, vents the air from inside the facility. The air temperature coming from the pipe is close to the ambient air temperature. The difference in the temperature would be no greater than the daily temperature changes on the summit. There should be no impact to the Wēkiu bug.

Response to Comment 12C:

NASA agrees and will look to the Office of Mauna Kea Management to serve as the focal point for this activity with the Mauna Kea Management Board and Kahu Ku Mauna.

Response to Comment 12D:

All evaluated design concepts adhered to the Harding Lawson Associates criteria for slope stability. The proposed design concept was chosen because it ensured the engineering requirements for slope stability and allowed the Outrigger Telescopes to be placed within the sufficient separation to achieve the required baselines. In addition, the proposed design, after several evaluations and changes, minimized the potential impact to the Wēkiu bug habitat.

Response to Comment 12E:

CARA will select a qualified entomologist.

Response to Comment 12F:

NASA has not restricted itself to the definition provided in the National Historic Preservation Act. NASA has consulted with several Native Hawaiian organizations, a number of which have requested and been given Consulting Party status in the Section 106 process conducted in accordance with the National Historic Preservation Act. The term "appropriate Native Hawaiian organization" is used within the context of the National Historic Preservation Act.

However, Consulting Party status has been given to other parties with an active interest in the effects on summit cultural resources. In accordance with the recently adopted Mauna Kea Science Reserve Master Plan, the Office of Mauna Kea Management, the Mauna Kea Management Board, and Kahu Ku Mauna have been given the opportunity to review the grading and site development drawings.

Response to Comment 12G:

NASA will refer this recommendation to the California Association for Research in Astronomy. These types of concerns are governed by the construction Best Management Practices Plan (BMP), which is the responsibility of the CARA Construction Manager.

The draft BMP is attached as Appendix F (see Section C under Proposed Controls in the BMP).

Response to Comment 12H:

Retrieving debris from Wēkiu bug habitat would be done in consultation with the California Association for Research in Astronomy's Construction Manager, the entomologist, and the Cultural Monitor. Methods for removing any wind-blown debris would be those that minimize the amount of disturbance to Wēkiu bug habitat and are practicable.

Response to Comment 12I:

The commentor is correct that this section applies to all alien species, not just arthropods. The California Association for Research in Astronomy will retain responsibility for monitoring on-site construction and installation of the Outrigger Telescopes. The Office of Mauna Kea Management will be welcome to observe on-site construction and installation activities.

Pressure washing will be used to remove all other species of concern from construction equipment. In addition, material and equipment will be inspected near the intersection of Saddle Road and the Mauna Kea Access Road.

Response to Comment 12J:

The California Association for Research in Astronomy has addressed this concern in the Wēkiu Bug Mitigation Plan. In addition, the daily proper disposal of all perishable waste products is ensured through the signed Memorandum of Agreement provided in Appendix C, and the draft construction Best Management Practices Plan provided in Appendix F.

Response to Comment 12K:

Item 12 of the Wēkiu Bug Mitigation Plan reads "Earthmoving equipment will be free of large deposits of soil, dirt, and vegetation debris that could harbor alien arthropods". Actions taken in accordance with Item 12 of the Wēkiu Bug Mitigation Plan would be species non-specific and would also remove vegetative material from vehicles as well. The Outrigger Telescopes Project will bear the cost of removal or eradication of alien species found at the W.M. Keck Observatory site, where it is demonstrated that the introduction of such alien species were the direct result of project activities.

Response to Comment 12L:

NASA and the California Association for Research in Astronomy have committed to the Outrigger Telescopes Wēkiu Bug Mitigation Plan as proposed. In the event that the proposed mitigation measures do not prove successful, NASA and the California Association for Research in Astronomy will consider participation in future alternative mitigation activities as developed and proposed by the University of Hawai‘i.

RESPONSES TO COMMENTS
Commentor No. 12: Office of Mauna Kea Management (Walter Heen)

Response to Comment 12M:

A comprehensive survey of the Wēkiu bug in and around the Mauna Kea Science Reserve is not within the jurisdiction of NASA. However, as part of project implementation, NASA will fund a graduate student to do autecology studies and to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors. A permit has been approved for Wēkiu bug monitoring to establish baseline population estimates in the area surrounding the site of the proposed Outrigger Telescopes Project site and at a control site on Pu'u Wēkiu.

The Wēkiu Bug Mitigation Report was developed in consultation with Wēkiu bug experts and the U.S. Fish and Wildlife Service. The Wēkiu Bug Mitigation Plan represents implementation of the recommendations contained in the Wēkiu Bug Mitigation Report. The Outrigger Telescopes Project would encompass implementation of the Wēkiu Bug Mitigation and Monitoring plans. The information gained through this effort will be shared with the University of Hawai'i.

Response to Comment 12N:

NASA actively attempted to determine those Native Hawaiian organizations that had an interest in the proposed project. Other parties were either invited or requested to participate. Any parties requesting Consulting Party status have been given that status. Tables 5.1 and 5.2 in Chapter 5 of this Final Environmental Assessment provide a listing of the consultations/informal meetings that have occurred between NASA and interested parties concerning the Outrigger Telescopes Project. The Office of Mauna Kea Management, the Mauna Kea Management Board, and Kahu Ku Mauna have been involved in the process.

Response to Comment 12O:

NASA recognizes that there is a possibility that excavation could uncover potential burial sites. CARA, in consultation with the State Historic Preservation Office, will select and employ a qualified archaeologist who will be present during excavation activities. A Cultural Monitor will be on-site during excavation and installation. NASA is attempting to prevent inadvertent and improper treatment of remains by requiring a mandatory orientation program. All construction and installation workers will be advised of what to look for and how to respond to finding remains. If previously unknown archaeological properties or human remains are discovered during construction, all construction work in the immediate vicinity would stop until appropriate parties are contacted.

Response to Comment 12P:

NASA has provided information on the potential cumulative environmental impacts associated with the Outrigger Telescopes Project. Please see Section 4.2 of this Final Environmental Assessment.

Response to Comment 12Q:

NASA has conducted consultations with Hawaiian organizations under Section 106 of the National Historic Preservation Act. The purpose of those consultations was to elicit constructive input for the Outrigger Telescopes Project's mitigation measures. In view of your comment and other related comments and recommendations received from various Hawaiian organizations and individuals during the Section 106 consultation process, NASA has attempted to accommodate those comments and recommendations. Accordingly, mitigation measures, based on these comments and recommendations, are reflected in the Memorandum of Agreement provided in Appendix C of this Final Environmental Assessment.

Response to Comment 12R:

Comments and recommendations concerning education programs to advance the Native Hawaiians' awareness of their connection to the study of astronomy and the science of astronomy have been considered in the executed Memorandum of Agreement (see Appendix C).

Response to Comment 12S:

Thank you. Your comment is respectfully noted.

Crede, Suzanne C.

From: Ford, Dennis G.
Sent: Friday, February 23, 2001 11:50 AM
To: Crede, Suzanne C.; Everingham, John M.
Subject: FW: Outrigger Telescopes Project

-----Original Message-----
From: VilsvkAlan@aol.com [SMTP:VilsvkAlan@aol.com]
Sent: Friday, February 23, 2001 11:48 AM
To: kcomments@hq.nasa.gov
Subject: Outrigger Telescopes Project

To: Office of Space Science, Code SD

Re: Draft EA on Outrigger Telescopes Project.

I add my vote to those who say this project should be approved! I have personnaly visited the Keck Telescope and the summit of Mauna Loa and found it most impressive. I heard the story on the outrigger telescopes, saw the sites being prepared at Mauno Loa and understood the value of a world-wide interferometric array in exploring the questions or our origins and nature of other planets.

I have read the Environmental Assessment and material on the Interferometer project. My reaction was simply, 'My God, why would we abandon this project? Why would we exclude one of the best astronomical viewing locations in the world?' 13A

I firmly believe that the environment can be protected while continuing this necessary expansion to keep the Keck a first-class tool. Without it, the whole world community will be the loser.

Alan Villesvik
14727 43rd Ave NE Unit 8
Marysville, WA 98271
Retired -- Bell Telephone System (Information Systems)

Response to Comment 13A:

Thank you. Your comment is respectfully noted.

COMMENTS FORM

Written public comments on environmental impacts and concerns (including historical and archeological factors) and proposed mitigation associated with the proposed Outrigger Telescopes are hereby requested.

Your comments may be written on this form and deposited in the box provided.

Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): Reynolds N. Kamakawiwoole

Commenter's full address (street, city, state, and zip code) (required): P.O. Box 821 Honokaa, Hi 96727.

Comments: I am a Native Hawaiian who practice my religious rights on Mauna Kea and a member of Kahu Ku Mauna. I have been to the site where the outriggers are to be constructed. I pick the soil to feel about the construction and got the Answer - No. - There is enough desecration done by these astronomers. This mountain is our temple. Hawaiians were not allowed to built structures like this, How can Astronomers do it! I am very angry at the process - Hawaiians do not want further development - period. You have desecrate the most sacred mountain in the world, especially to Christians. No more DEVELOPMENT - STOP IT. We don't want our lands to be desecrated further. 14A

Additional space is available on the other side of this form.

Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☐

Response to Comment 14A:

Thank you. Your comments are respectfully noted.

Volcano Rainforest Retreat

Richard J. Howard, Senior Program Executive
Office of Space Science, Code SD
NASA Headquarters
300E Street S.W.
Washington, DC 20546-0001

Dear Mr. Howard,

We are writing to express our support for the Sierra Club's appeal to NASA to protect Mauna Kea summit from industrialization. Mauna Kea has a special cultural and environmental significance. We are concerned about the impact of development on the mountain.

15A

Please take the recommendation of Hawaii's Office of Hawaiian Affairs to undertake a full Environmental Impact Statement in accordance with the requirements of the National Environmental Policy Act.

Thank you for your consideration,

Kathleen and Peter Golden

Kathleen and Peter Golden
2/13/01

(808) 985-8696 · (800) 550-8696
P.O. Box 957 Volcano, Hawai'i 96785
email: volrain@bigisland.net www.volcanoretreat.com

Response to Comment 15A:

Thank you. Your comment is respectfully noted.

PHONE (808) 594-1888

FAX (808) 594-1865

STATE OF HAWAI'I
OFFICE OF HAWAIIAN AFFAIRS
711 KAPI'OLANI BOULEVARD, SUITE 500
HONOLULU, HAWAI'I 96813

February 23, 2001

Richard J. Howard
Senior Program Executive
Office of Space Science
NASA Headquarters
300 E Street, SW
Washington, D.C. 20546-0001

RE: Draft Environmental Assessment for the Outrigger Telescopes Project

Dear Dr. Howard:

Thank you for the opportunity to respond to the draft environmental assessment for the Outrigger Telescopes Project. The Office of Hawaiian Affairs is mandated to serve as the coordinating agency for the State in responding to actions affecting Native Hawaiians (Chapter 10, HRS). As such, we have previously communicated with NASA on November 16, 2000, as regards NASA's on and off site mitigation plans. Our comments in this letter will address the cultural impacts of NASA's proposed Outrigger Telescopes Project and the shortcomings of NASA's work in preparing this EA thus far.

NASA's proposed environmental assessment provides ample evidence that this project will have a significant impact on traditional and cultural properties, on a proposed National Historic Site, on the endangered *wekiu* bug, and on scarce groundwater resources to warrant the preparation of an EIS.

NASA's Proposed Mitigation Is Irrelevant to the Harms Caused to Traditional and Cultural Properties.

The EA documents the importance of Mauna Kea to Hawaiians (pp. 72-81), including legends of Mauna Kea, the importance of placenames in Hawaiian culture, specific important landscape features, burial sites, and cultural sites (such as the adze quarry).

The following concerns regarding Mauna Kea are identified in the EA:

- Maintaining the sacred quality of the summit.
- Lack of respect on the part of the astronomy program for Native Hawaiian cultural practices.
- Increased public use of the summit.

However, none of the mitigation efforts proposed in this EA actually address the harms identified and provide little protection to Native Hawaiian traditional and cultural properties. Further, because NASA's mitigation plans are vague and ambiguous at best, they seemingly vest NASA with unfettered discretion as to how and when to mitigate and cause us to question the actual effect this project will have on the summit. 16A

In particular:

➢ The current consultation process is inadequate to provide necessary community input for a mitigation plan.

NASA recommends consultation with "Native Hawaiian groups to identify methods of protecting traditional and cultural resources" (p.105) yet thus far has allowed only four Native Hawaiian groups to participate in its National Historic Preservation Act (NHPA) 106 consultations, even though many more seek inclusion. Furthermore, NASA has limited public comment at meetings held in Hawai'i (Feb 5, 7, 2001) despite widespread interest in this project. Given the importance of the decisions to be rendered and the concerns voiced in the Native Hawaiian community about the manner in which consultations have occurred thus far, we question the efficacy of future consultations, NASA's ability to consult in good faith, and the relevancy of the proposed mitigation recommendations.

➢ NASA is not in compliance with the Mauna Kea Master Plan, even though NASA cites the Plan as part of its mitigation measures.

NASA claims it has taken measures to reduce the potential area of development on Mauna Kea in response to community requests when, in fact, these measures are mandated as part of the Mauna Kea Master Plan. The Master Plan also limits future development on the mountain to no more than five telescopes yet the proposal by NASA is for six telescopes. If NASA is going to represent to the community that it is in 16B compliance with the Master Plan, then it should abide by all of the Master Plan's provisions, including the requirement of a limitation on future development.

<u>NASA has failed to adequately consider alternative proposals</u>.

NASA is required to review alternative proposals under the NEPA process. While NASA did review alternative venues for these telescopes, it did not consider fewer outriggers as an alternative. 16C

<u>NASA has failed to adequately evaluate the no-action alternative</u>.

NASA did not adequately evaluate the no-action alternative in comparison to the significant impacts this project would cause to the Native Hawaiian community. The importance of finding other life forms is never discussed and evaluated against the needs of life forms in Hawai'i, nor is the long-term cost of losing the ability to practice one's culture evaluated against the short-term loss of construction dollars. While NASA searches for other life forms in space, it is ironic that its search may extinguish an entire species of the *wekiu* bug here on earth. 16D

<u>NASA has failed to address this project's impact through its proposed on-site cultural mitigation recommendations</u>.

The on-site mitigation proposals are of little value given that they seem to have been developed prior to an adequate assessment of this project's impacts. Assuming, for the sake of argument, that NASA has adequately defined the impacts of its proposal, OHA requests additional archaeological monitoring, the hiring of a cultural monitor to assure construction protocols are established and enforced consistent with the Native Hawaiian culture, the briefing of supervisory staff before construction begins on the significance of Mauna Kea to Native Hawaiians and their culture, more input into NASA's construction plans, and the ability to evaluate NASA's on site mitigation plan in a timely fashion and to suggest needed changes. (For a more detailed discussion of this item, please review our letter to NASA of Nov. 16, 2000). 16E

<u>NASA has failed to address this project's impact through its proposed off-site cultural mitigation recommendations.</u>

The off-site mitigation suffers from the same fate as the on-site mitigation plan inasmuch as it, too, seems to have been developed without an adequate assessment of this project's impacts. The proposal is conceptual in nature and provides little substance to which the community can react. It also contains no nexus to the impacts it purports to mitigate. While education may be an appropriate compensatory mitigation, how does it mitigate for the loss of sacred viewplanes, or the ability to maintain traditional practices? The vagueness of the off-site mitigation plan shows that much more community involvement is needed before adequate mitigation for the adverse cultural impact can be assessed by the Native Hawaiian community or by NASA. (For a more detailed discussion of this item, please review our letter to NASA of Nov. 16, 2000).

<u>NASA has failed to mitigate against the possible extinction of the Wekiu Bug.</u>

OHA questions the efficacy of using an untested mitigation procedure to protect the nearly extinct *wekiu* bug. Rather than adopt a speculative procedure which may be of little or no value in protecting the *wekiu* bug, OHA suggests NASA relocate outrigger telescopes 2 and 3 or eliminate these outriggers altogether. 16F

<u>NASA's has failed to address the significant impact of its wastewater collection, treatment and disposal proposals on Native Hawaiian cultural practices and beliefs.</u>

The EA proposes to dispose of wastewater at Pu'u Hau 'Oki cinder cone, a place believed by Native Hawaiians to be the residence of the goddess Poli'ahu and the sacred burial place of ancient Hawaiians. NASA's proposed disposal practice is disrespectful to the beliefs of Native Hawaiians, defiles Native Hawaiian ancestral remains, and demonstrates a callous disregard for Native Hawaiian beliefs. The EA should assess this disposal practice as a significant impact and mitigate its effects by transporting all wastes to an off-mountain waste repository. 16G

<u>NASA has failed to adequately assess impacts of this project on hydrology and water quality.</u>

The EA suggests there is no groundwater under Mauna Kea, yet local residents can trace streams and *auwai* flowing from the mountain, thus indicating the presence of groundwater reserves underlying Mauna Kea. NASA must evaluate the effect of its proposed activities on these underground natural water reservoirs by accomplishing a more thorough hydrological and water quality review. Until NASA takes adequate steps to define those water resources jeopardized by this development, no adequate assessment or mitigation is possible. 16H

<u>NASA has failed to assess the cumulative effects of this project.</u>

NASA has stated that this project will have no cumulative effects in relation to other projects on Mauna Kea because no funds are available for development over the next five years. This conclusion is shortsighted because of its limited time frame and is inconsistent with the Mauna Kea Master Plan, intended to guide development on the mountain over the next 20 years. Until this project is evaluated within the context of the Mauna Kea Master Plan, NASA has not addressed its role in articulating the cumulative effects of development on Mauna Kea. Furthermore, the site-specific cumulative impacts of Keck I and Keck II on Pu'u Hau Oki have never been evaluated even though construction has been completed. 16I

<u>NASA must complete a full EIS under applicable environmental laws.</u>

Based upon the known significant impacts of this project and the lack of adequate and relevant mitigation measures, OHA urges NASA to prepare a full EIS to discover and assess all possible impacts early in the planning process and to ensure the environmental review includes adequate community input. To do otherwise, is to circumvent the spirit of our environmental laws and to cause irreparable harm to a place sacred to Native Hawaiians. 16J

The Ninth Circuit Court of Appeals recently observed that "...the relevant NEPA timing regulations, the plain language of the act, and applicable precedents all unequivocally require NEPA analysis to be undertaken early enough so that it can serve practically as an important contribution to the decision-making process and will not be used to rationalize or justify decisions already made." <u>Metcalf v. Daly</u>, 214 F.3d 1135, 1142 (9th Cir. 2000) (quoting 40 C.F.R. § 1502.5) (explaining that caselaw and the CEQ regulations require that environmental analysis under NEPA "must be timely, and it must be taken objectively and in good faith, not as an exercise in form over substance, and not as a subterfuge designed to rationalize a decision already made"); <u>see also</u> <u>Weslands Water District v. U.S. Department of the Interior</u>, 850 F. Supp. 1388 (E.D. Cal. 1994) (agency's alleged unavoidable conflict between the secrecy and timing of ESA consultation and NEPA's requirements did not excuse failure to prepare an EIS).

Under NEPA, an agency must prepare an EIS for all "major Federal actions significantly affecting the quality of the human environment . . . ." 42 U.S.C. § 4332(2)(C). The regulations promulgated by Council on Environment Quality establish criteria for determining when a full EIS is required: These criteria include:

* "Impacts that may be both beneficial and adverse. <u>A significant impact may exist</u> even if the Federal agency believes that on balance the effect will be beneficial," 40 C.F.R. § 1508.27(b)(1);

* "<u>Unique characteristics of the geographic area</u> such as the <u>proximity to historic or cultural resources</u> . . . or <u>ecologically critical areas</u>," <u>id.</u> § 1508.27(b)(3);

* "The degree to which the effects on the quality of the human environment are likely to be <u>highly controversial</u>," <u>id.</u> § 1508.27(b)(4);

* "The degree to which the possible effects on the human environment are <u>highly uncertain</u> or involve unique and unknown risks," <u>id.</u> § 1508.27(b)(5);

* "The degree to which <u>the action may establish a precedent for future actions with significant effects</u> or represents a decision in principle about a future consideration," <u>id.</u> § 1508.27(b)(6);

* "<u>Whether the action is related to other actions with individually insignificant but cumulatively significant impacts</u>. Significance exists if it is reasonable to anticipate at cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts," <u>id.</u> § 1508.27(b)(7);

* "<u>The degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places</u> or may cause loss or destruction of significant scientific, cultural or historical resources," <u>id.</u> § 1508.27(b)(8);

* "The degree to which the action may <u>adversely affect an endangered or threatened species</u> or its habitat that has been determined to be critical under the Endangered Species Act of 1973, <u>id.</u> § 1508.27(b)(9); and

* Whether the action threatens a <u>violation of . . . requirements imposed for the protection of the environment</u>, <u>id.</u> § 1508.27(b)(10).

Given all that has been discussed in this letter and these criteria, there is no other reasonable conclusion – the impacts of this project (and the cumulative impacts of Keck I and II) on sacred and important cultural resources are significant. <u>See Colorado River Indian Tribes v. Marsh</u>, 605 F. Supp. 1425, 1430 n. 3 (C.D. Cal. 1985) (EIS can be required based on impacts to cultural sites alone) (<u>quoting</u> 42 U.S.C. § 4331(b)(4)). (NEPA requires the federal government to "preserve important historic, cultural and national aspects of our national heritage"); 40 C.F.R. § 1508.8 ("'Effects' include ecological . . ., aesthetic, historical, cultural, economic, social or health. . . .").

In addition, impacts on the *Wekiu* bug also provide an independent basis for significance. <u>Blue Mountains Biodiversity Project v. Blackwood</u>, 161 F.3d 1208, 1213-14 (9th Cir. 1998). (Where Forest Service's EA did not show that no significant impact on area's fish populations would result from proposed action, an EIS was required); <u>Foundation for North American Wild Sheep v. U.S. Dept. of Agriculture</u>, 681 F.2d 1172, 1180 (9th Cir. 1982) (impacts to sensitive species, the bighorn sheep, a significance factor requiring preparation of EIS).

<u>Conclusion.</u>

An EIS is warranted [1] because this project will have significant impacts on traditional and cultural properties, on a proposed National Historic Site, on the endangered *wekiu* bug, and on scarce groundwater resources.

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[1]OHA need not prove that significant environmental impacts <u>will</u> occur, only that the project <u>may</u> cause significant degradation. <u>See Blue Mountains Biodiversity Project v. Blackwood</u>, 161 F.3d 1208, 1216 (9th Cir. 1998) ("An EIS is required . . . whenever

If you have further questions, please call Pua Aiu, Policy Analyst at 594-1931.

Sincerely,

Colin Kippen Jr.

Colin Kippen, Jr.
Deputy Administrator, Hawaiian Rights Division

cc: **BOT**
Administrator

'substantial questions are raised as to whether a project may cause significant [environmental] degradation'") (quoting Idaho Sporting Congress v. Thomas, 137 F.3d 1146, 1149 (9th Cir. 1998), cert denied, Malheur Lumber Corp. v. Blue Mountains Biodiversity Project, 527 U.S. 1003 (1999); LaFlamme v. F.E.R.C., 852 F.2d 389, 397 (9th Cir. 1988) ("plaintiff need not show that significant effects will in fact occur;" an EIS is required "if substantial questions are raised as to whether a project . . . may cause significant degradation of some human environmental factor") (citation omitted); Blue Ocean Preservation Society v. Watkins, 767 F. Supp. 1518 (D. Haw. 1991) (same).

RESPONSES TO COMMENTS

Commentor No. 16: Office of Hawaiian Affairs (Colin Kippen, Jr.)

Response to Comment 16A:

NASA has conducted consultations with Hawaiian organizations on the Outrigger Telescopes historic/cultural resource mitigation measures. NASA has given "Consulting Party" status to each organization that requested to participate as a Consulting Party.

At the beginning of the project four Hawaiian organizations were participating as Consulting Parties: the Hawai'i Island Burial Council, Hui Mālama I Nā Kūpuna O Hawai'i Nei, Office of Hawaiian Affairs, and the Royal Order of Kamehameha I. Since that time, two more Native Hawaiian organizations requested and were given Consulting Party status; Ahahui Ku Mauna and Mauna Kea Anaina Hou. In addition, NASA has consulted with and invited the Office of Mauna Kea Management, the Mauna Kea Management Board, and Kahu Ku Mauna to participate in the development of the Memorandum of Agreement. The results of our consultation are reflected in the Memorandum of Agreement provided in Appendix C which lists all the Signatories and all other parties collectively referred to as "Consulting Parties".

A formal Section 106 meeting was held in Hilo on February 1, 2001. In addition, NASA held another Section 106 meeting in Hilo on January 16 and 17, 2002. NASA held two open house meetings in February 2001, in Hawai'i (Hilo and Kona) and held four Town Hall meetings in October 2001 (Kona, Waimea, and Hilo) which were attended by individuals, and organizations and members of the general public who stated their position, asked questions, expressed concerns and support and learned more about the Outrigger Telescopes Project.

NASA representatives have met, formally and informally, with Hawaiian (including Native Hawaiian) groups that have expressed interest in this project. Tables 5.1 and 5.2 in Chapter 5 of this Final Environmental Assessment provide a listing of the consultations/informal meetings that have occurred between NASA and interested parties concerning the Outrigger Telescopes Project. In addition, several interested groups asked NASA if the comment period could be extended for reviewing the Draft Environmental Assessment. In every case, NASA granted an extension.

Response to Comment 16B:

The proposed Outrigger Telescopes Project is compliant with the recently adopted Mauna Kea Science Reserve Master Plan. The Mauna Kea Science Reserve Master Plan envisioned the Outrigger Telescopes.

Response to Comment 16C:

The addition of four telescopes to the Keck-Keck Interferometer would allow astronomers to obtain higher resolution images of astronomical objects by allowing the object under study to be viewed at different angles. A minimum of four Outrigger Telescopes would need to be added to the Keck-Keck Interferometer to achieve the science objectives of the project. The number of telescopes and their relative separations and orientations are important in making high-resolution images of astronomical objects. The greater the number of different separations (called baselines), the greater the number of points (analogous to pixel elements) that are produced in the final image. Thus an interferometer consisting of two telescopes would have only one baseline and would have the ability to produce a detailed image of only a small portion of an object (analogous to only one pixel in a picture having any information – most of the picture would be black). If four telescopes were added to the interferometer (as with the proposed Outrigger Telescopes), and particularly if the four additional telescopes had different orientations to the interferometer, a total of 15 different baselines would be created. With the 15 baselines, each with a different length and orientation, detailed images of different portions of the object could then be obtained, (*i.e.*, the TV picture would now have 15 different pixels lit up), and the information obtained characterizing the object would be that much more detailed and of scientific value. Adding the fifth and sixth Outrigger Telescopes would almost double the resolution, further increasing the scientific value of that information. Refer to Sections 1.3 and 2.3 for more details.

Response to Comment 16D:

In Section 2.2 of the Environmental Assessment, NASA defines the No-Action Alternative as no funding approval for on-site construction, installation, and operation of the Outrigger Telescopes Project. This decision would mean that the Outrigger Telescopes Project would not be built and hence there would be no direct environmental effects. The potential environmental consequences of the No-Action Alternative are discussed in Section 4.3 of this Final Environmental Assessment. This section also discusses the lost revenues to the State of Hawai'i as well a cessation of NASA funding for Wēkiu bug mitigation and monitoring and on-site and off-site cultural mitigation activities proposed by NASA in the Section 106 process.

The No-Action Alternative assumes that existing previously approved Keck I and Keck II Telescopes would continue to function, and operational and maintenance activities would continue as well. Previously evaluated and approved actions and in-place facilities such as the Keck I and Keck II Telescopes constitute the "baseline condition". (Note that the W.M. Keck Observatory (WMKO) site, Keck I and the telescope which would become Keck II were all assessed in the Final Environmental Impact Statement for the Mauna Kea Science Reserve Complex Development Plan, Research Corporation of the University of Hawai'i, 1982; Keck II was reevaluated in Project Description/Environmental Review-Proposed Second Telescope on the W.M. Keck Observatory Site at Mauna Kea, Hamakua, Hawai'i, UH IfA 1991). Chapter 3 of the Environmental Assessment discusses and evaluates these present conditions. Present conditions are equivalent or the same as the No-Action Alternative or condition. The cultural and environmental impacts that would result from proceeding with the Proposed Action (*i.e.*, on-site construction, installation, and operation of the Outrigger Telescopes) are presented in Chapter 4 and the difference between baseline (or no-action) and implementation of the Proposed Action is discussed.

The Environmental Assessment accurately presents the No-Action Alternative. The implementation of this project will not extinguish the Wēkiu bug nor destroy its habitat.

Response to Comment 16E:

The mitigation measures are reflected in a Memorandum of Agreement (see Appendix C). The Outrigger Telescopes Project will have, as part of project personnel, a Cultural Monitor, an Archaeologist, and an entomologist on-site during the excavation and construction of the Outrigger Telescopes. Both the on-site and off-site mitigation measures as provided for in the Memorandum of Agreement, are the results of consultations with the Federal Advisory Council on Historic Preservation, the State of Hawai'i Historic Preservation Office, the Office of Mauna Kea Management, and other Hawaiian organizations.

Response to Comment 16F:

The habitat restoration protocol is based on the best scientific information available about the habitat needs of the Wēkiu bug. NASA has consulted with U.S. Fish and Wildlife Service concerning the Wēkiu Bug Mitigation Report. The protocol is based on the following information.

1. Wēkiu bugs appear to prefer habitat made of loose cinder 1.3 centimeters (cm) (½ inch) in size or larger. In past studies (Howarth and Stone 1982; Howarth and others 1999), the highest concentration of Wēkiu bugs were collected in habitat consisting of 25 to 38 cm (10 to 15 inches) of 1.3 cm (½ inch) size or larger cinder, with an impenetrable ash layer below the cinder. This information leads us to conclude that restored habitat consisting of 30 to 46 cm (12 to 18 inches) of loose 1.3 cm (½ inch) size or larger cinder will be acceptable to Wēkiu bugs.

2. Wēkiu bug habitat occurs on undisturbed portions of crater floors in summit cinder cones (Howarth and Stone 1982; Howarth and others, 1999). In 1982, 6,230 Wēkiu bugs were collected on the crater floor of Pu'u Wēkiu and 430 Wēkiu bugs were collected on the crater floor of Pu'u Hau 'Oki. During the 1997/98 arthropod assessment, Wēkiu bugs were found on the crater floor of Pu'u Wēkiu and Pu'u Hau 'Oki, and on the inner slopes of Pu'u Hau 'Oki adjacent to the crater floor. Since suitable habitat does not exist on the crater floor of Pu'u Hau 'Oki, Wēkiu bugs from the adjacent inner slopes apparently migrate to the crater floor. This information leads us to conclude that Wēkiu bugs would likely occupy restored habitat on the floor of Pu'u Hau 'Oki.

3. Given sufficient time, Wēkiu bug habitat appears to recover from disturbance. Of all sites sampled during the 1997/98 arthropod assessment, habitat on the slopes below W.M. Keck Observatory that was disturbed during construction contained the highest concentration of Wēkiu bugs. This information leads us to conclude Wēkiu bugs would eventually occupy the restored habitat.

As part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology, to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors. New information may be used to modify the habitat restoration protocol to increase its effectiveness.

The positions of Outrigger Telescopes 2 and 3 are a configuration that provides the required optical resolution while minimizing disturbance to Wēkiu bug habitat. The positions of the Outrigger Telescopes were investigated during the design phase of the project, and some were relocated to reduce habitat disturbance. Outrigger Telescope 1, for example, was moved 4 meters (13 feet) closer to the Observatory to reduce Wēkiu bug habitat disturbance. Junction Box 5 was moved during the design phase to reduce disturbance to Wēkiu bug habitat and to reduce the overall footprint of the area. Outrigger Telescopes 2 and 3 are crucial to the proper functioning of the interferometer and cannot be eliminated.

Response to Comment 16G:

The Outrigger Telescopes Project would add only a small amount of waste to the existing WMKO waste handling system. The Outrigger Telescopes Project would use the existing wastewater collection, treatment, and disposal processes that presently exist at the W.M. Keck Observatory.

Response to Comment 16H:

NASA has evaluated the hydrology associated with Pu'u Hau 'Oki. The ground and surface water sections of the Environmental Assessment have been expanded to encompass these observations. See Sections 3.5 and 4.1.5 and Appendix H.

Response to Comment 16I:

NASA has provided information on the potential cumulative environmental impacts associated with the Outrigger Telescopes Project. Please see Section 4.2 of this Final Environmental Assessment.

Response to Comment 16J:

Thank you. Your comment is respectfully noted.

To: Mr. Kenneth M. Kumor, NASA NEPH Coordinator
Environmental Management Division/Code JE
NASA Headquarters
300 E. Street, SW
Washington DC 20546
Phone: 202-358-1112
Fax: 202-358-2861
E-mail: kkumor@hq.nasa.gov

To: Mr. Rick Howard, Program Executive
Advanced Technology & Mission Studies Division
Office of Space Science
NASA Headquarters
300 E. Street, SW
Washington, DC 20546
Phone: 202-358-0898
Fax: 202-358-3096
E-mail rhoward@hq.nasa.gov

Date: March 16, 2001

From: The Hawai'i Island Burial Council
C/O State of Hawai'i - Department of Land and Natural Resources
State Historic Preservation Division, Burial Sites Program
33 South King Street, Suite 155
Honolulu, Hawai'i 96813
Phone: 808-887-8145
E-mail: ku@kalo.org

Re: The NASA Draft Environmental Assessment for the Outrigger Telescopes Project, Mauna Kea, Hawai'i nei.

Aloha Mr. Kumor and Mr. Howard,

The Hawai'i Island Burial Council (HIBC) would like to thank you for this opportunity to comment on the December 2000 Draft Environmental Assessment (DEA) for the Outrigger Telescopes Project - Mauna Kea, Hawai'i nei. As you know the HIBC only meets once a month and therefore we sincerely appreciate your willingness to extend our comment period until March 30th.

A review of the document produced many concerns regarding the significant impacts to the traditional, cultural, religious and natural resources of Mauna Kea. We believe that the Draft EA does not adequately address or mitigate the significant impacts that will be incurred by this project, for the following reasons:

- The Draft EA and Section 106 On and Off site mitigation measures are vague and appear perfunctory. 17A
- The Draft EA does not justify why further development is needed nor why further desecration of Mauna Kea should be tolerated. 17B
- The Draft Wekiu Bug Mitigation Plan attenuates the true danger of the Wekiu bug and is based on a wishful hypothetical premise. The plan is not convincing as an avenue for recovery; and in fact could lead to the complete extinction of the species. 17C
- The Draft EA is inadequate because it omits "past" and "present" as components in the definition of cumulative impacts. Federal law (40 CRF 1508.7) defines cumulative impacts as the "incremental, environmental impacts of the action when added to other past, present, and foreseeable future actions." 17D
- The Draft EA does not consider the scale and complexity of Mauna Kea's hydrology, and therefore the mitigation measures do not adequately address the significant and cumulative impacts this project will have on the island's water resource. 17E
- The Draft EA does not evaluate the hazardous materials intrinsic to this project, and therefore the mitigation measures do not adequately address the existing and potentially significant and cumulative impacts this project will have on the cultural and environmental resources of Mauna Kea. 17F
- The Draft EA does not adequately evaluate the solid waste containment systems and therefore the mitigation measures do not address the significant and cumulative impacts to the beliefs of the Native Hawaiian people and to the cultural and environmental resources of Mauna Kea. 17G

- The Draft EA does not address the cultural significance of the landscape and therefore the mitigation measures do not address the significant impacts and loss of cultural and traditional use of this landscape. 17H

- The Section 106 consultation process is not inclusive enough to identify and assess the cultural impacts to the historic, traditional and cultural properties of Mauna Kea. 17I

In conclusion, it is the HIBC's position that, after careful review of the Draft Environmental Assessment for the Outrigger Telescopes Project, a full Environmental Impact Statement (EIS) is required. Furthermore, we concur with the Office of Hawaiian Affairs that the "proposed environmental assessment provides ample evidence that this project will have a significant impact on traditional and cultural properties, on a proposed National Historic site, on the endangered Wekiu bug, and on scarce ground water resources to warrant the preparation of an EIS." 17J

Mahalo nui loa for your time and considerations,

Nālei Pate-Kahakalau

Nālei Pate-Kahakalau
Chairman, Hawai'i Island Burial Council

RESPONSES TO COMMENTS

Commentor No. 17: Hawai'i Island Burial Council (Nālei Pate-Kahakalau)

Response to Comment 17A:

As a result of consultations, the mitigation measures have been updated and are reflected in the Memorandum of Agreement (see Appendix C). The Outrigger Telescopes Project will have, as part of project personnel, a Cultural Monitor, an Archaeologist, and an entomologist on-site during the excavation and construction of the Outrigger Telescopes. Both the on-site and off-site mitigation measures, as provided for in the Memorandum of Agreement, are the results of consultations with the Federal Advisory Council on Historic Preservation, the State of Hawai'i Historic Preservation Office, the Office of Mauna Kea Management, and other Hawaiian organizations.

Response to Comment 17B:

The addition of four telescopes to the Keck-Keck Interferometer would allow astronomers to obtain higher resolution images of astronomical objects by allowing the object under study to be viewed at different angles. A minimum of four Outrigger Telescopes would need to be added to the Keck-Keck Interferometer to achieve the science objectives of the project. Adding the fifth and sixth Outrigger Telescopes would almost double the resolution, thereby further increasing the scientific value of the observations. Refer to Sections 1.3 and 2.3 for more details.

Response to Comment 17C:

The Wēkiu bug mitigation is derived from the Wēkiu Bug Mitigation Report (Pacific Analytics 2000). The recommendations in the Wēkiu Bug Mitigation Report are based on data gathered during the 1982, and 1997/98 arthropod assessments (Howarth and Stone 1982; Howarth and others 1999), combined with input from entomologists familiar with Wēkiu bug biology and the best information available in published scientific literature. NASA has consulted with the U.S. Fish and Wildlife Service concerning the Wēkiu Bug Mitigation Report. This report was used to develop the Wēkiu Bug Mitigation and Monitoring plans (see Appendices D and E).

The Outrigger Telescopes Project will not lead to the extinction of the Wēkiu bug. Less than 0.009-ha (0.022-ac) of Wēkiu bug habitat would be disturbed during construction of the Outrigger Telescopes. This would represent about 0.008 percent of the 120-ha (300-ac) estimated size of occupied Wēkiu bug habitat in the summit region of Mauna Kea (Howarth and others 1999). It is the goal of the Wēkiu Bug Mitigation and Monitoring plans to expand Wēkiu bug habitat and enhance the Wēkiu bug population in Pu'u Hau 'Oki.

The habitat restoration protocol is based on the best scientific information available about the habitat needs of the Wēkiu bug. The protocol is based on the following information.

1. Wēkiu bugs appear to prefer habitat made of loose cinder 1.3 centimeters (cm) (½ inch) in size or larger. In past studies (Howarth and Stone 1982; Howarth and others 1999), the highest concentration of Wēkiu bugs were collected in habitat consisting of 25 to 38 cm (10 to 15 inches) of 1.3 cm (½ inch) size or larger cinder, with an impenetrable ash layer below the cinder. This information leads

us to conclude that restored habitat consisting of 30 to 46 cm (12 to 18 inches) of loose 1.3 cm (½ inch) size or larger cinder will be acceptable to Wēkiu bugs.

2. Wēkiu bug habitat occurs on undisturbed portions of crater floors in summit cinder cones (Howarth and Stone 1982; Howarth and others, 1999). In 1982, 6,230 Wēkiu bugs were collected on the crater floor of Pu'u Wēkiu and 430 Wēkiu bugs were collected on the crater floor of Pu'u Hau 'Oki. During the 1997/98 arthropod assessment, Wēkiu bugs were found on the crater floor of Pu'u Wēkiu and Pu'u Hau 'Oki, and on the inner slopes of Pu'u Hau 'Oki adjacent to the crater floor. Since suitable habitat does not exist on the crater floor of Pu'u Hau 'Oki, Wēkiu bugs from the adjacent inner slopes apparently migrate to the crater floor. This information leads us to conclude that Wēkiu bugs would likely occupy restored habitat on the floor of Pu'u Hau 'Oki.

3. Given sufficient time, Wēkiu bug habitat appears to recover from disturbance. Of all sites sampled during the 1997/98 arthropod assessment, habitat on the slopes below W.M. Keck Observatory that was disturbed during construction contained the highest concentration of Wēkiu bugs. This information leads us to conclude Wēkiu bugs would eventually occupy the restored habitat.

As part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology, to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors. New information may be used to modify the habitat restoration protocol to increase its effectiveness.

Response to Comment 17D:

NASA has provided information on the potential cumulative environmental impacts associated with the Outrigger Telescopes Project. Please see Section 4.2 of this Final Environmental Assessment.

Response to Comment 17E:

NASA has evaluated the hydrology associated with Pu'u Hau 'Oki. The ground and surface water sections of the Environmental Assessment have been expanded to encompass these observations. See Sections 3.5 and 4.1.5 and Appendix H.

Response to Comment 17F:

The discussion on hazardous materials usage has been updated in this Final Environmental Assessment. See Sections 3.9.3 and 4.1.9.3.

Response to Comment 17G:

Sections 3.9.3 and 4.1.9.3 have updated the discussion on solid waste containment systems. The Outrigger Telescopes Project will not involve any new solid waste containment systems. The existing infrastructure at the W.M. Keck Observatory would be used.

Response to Comment 17H:

Section 3.10.4 of the Environmental Assessment describes cultural values and traditional practices associated with Mauna Kea based on a series of oral history interviews with Native Hawaiians conducted from 1996 to 1999. Potential effects on historic/cultural properties and to the cultural landscape are identified in Section 4.1.9.

Response to Comment 17I:

NASA has conducted consultations with Hawaiian organizations on the Outrigger Telescopes historic/cultural resource mitigation measures. NASA has given "Consulting Party" status to each organization that requested to participate as a Consulting Party.

At the beginning of the project four Hawaiian organizations were participating as Consulting Parties: the Hawai'i Island Burial Council, Hui Mālama I Nā Kūpuna o Hawai'i Nei, Office of Hawaiian Affairs, and the Royal Order of Kamehameha I. Since that time, two more Native Hawaiian organizations requested and were given Consulting Party status: Ahahui Ku Mauna and Mauna Kea Anaina Hou. In addition, NASA has consulted with and invited the Office of Mauna Kea Management, the Mauna Kea Management Board, and Kahu Ku Mauna to participate in the development of the Memorandum of Agreement. The results of our consultations are reflected in the Memorandum of Agreement provided in Appendix C which lists all the Signatories and all other parties collectively referred to as "Consulting Parties".

A formal Section 106 meeting was held in Hilo on February 1, 2001. In addition, NASA held another Section 106 meeting in Hilo on January 16 and 17, 2002. NASA held two open house meetings in February 2001 in Hawai'i (Hilo and Kona) and held four Town Hall meetings in October 2001 (Kona, Waimea, and Hilo) which were attended by individuals, and organizations and members of the general public who stated their position, asked questions, expressed concerns and support and learned more about the Outrigger Telescopes Project.

NASA representatives have met, formally and informally, with Hawaiian (including Native Hawaiian) groups that have expressed interest in this project. Tables 5.1 and 5.2 in Chapter 5 of this Final Environmental Assessment provide a listing of the consultations/informal meetings that have occurred between NASA and interested parties concerning the Outrigger Telescopes Project. In addition, several interested groups asked NASA if the comment period could be extended for reviewing the Draft Environmental Assessment. In every case, NASA granted an extension.

Response to Comment 17J:

Thank you. Your comment is respectfully noted.

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

GILBERT S. COLOMA-AGARAN, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
JANET E. KAWELO
LINNEL NISHIOKA

STATE OF HAWAII

DEPARTMENT OF LAND AND NATURAL RESOURCES

HISTORIC PRESERVATION DIVISION
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BOATING AND OCEAN RECREATION
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
LAND
STATE PARKS

March 21, 2001

LOG NO: 27104 ✓
DOC NO: 0103HM01

Mr. Kenneth M. Kumor
Federal Preservation Officer
Environmental Management Division/Code JE
NASA Headquarters
300 E. Street, SW
Washington, DC 20546

Dear Mr. Kumor:

Subject: **Comments on Draft Environmental Assessment and Section 106 Consultation - Outrigger Telescope Project, Mauna Kea (National Aeronautics and Space Administration), Ka'ohe, Humuula, Hawaii Island**
TMK: 4-4-15: 9

Thank you for submitting for our review the Draft Environmental Assessment (EA) for the Outrigger Telescopes Project. We also appreciate your meeting with our staff members Pat McCoy and Holly McEldowney on January 31, 2001. This meeting was held to continue official Section 106 (NHPA) consultation with our office. In the meeting we discussed points raised in our letter of 26 October 2000, which responded to your letter initiating consultation. In addition we were asked to participate in the meetings held to consult with native Hawaiian organizations which were held on Hawaii Island on February 1, and 2, 2001. These were attended by Holly McEldowney and Kalaʻau Wahilani of our History and Culture Branch. These meetings helped clarify, in particular, the intention of the proposed off-site mitigation measures. We apologize that our review has been delayed.

This letter serves two purposes. The primary purpose is to discuss some issues pertaining to the preparation of the potential Section 106 Memorandum of Agreement (MOA) for this project. Some points are a reiteration of those raised during our discussions or in previous correspondence. The project descriptions provided in the Draft EA and our meetings have given us a better understanding of the project and the issues that need to be addressed in the MOA. The second purpose of this letter is to review and comment on information presented in the EA. These more detailed comments are presented in Attachment 1.

MOA Issues and Potential Stipulations

Historic Properties Affected and "Adverse Effect" Determinations

We all appear to agree that the cluster of summit cones (Kukahauʻula) and the proposed Mauna Kea Summit Region Historic District are eligible for inclusion in the National Resister and that the proposed telescopes will or could have an "adverse effect" on this property and the historic district. As discussed in our meetings, however, the EA also identifies at least two other areas which will be used during the project's construction phase. These should be addressed specifically in the MOA. One is the construction staging area at Hale Pohaku that is located near a historic property (a shrine). This property and its setting could be affected if staging activities affect areas beyond the designated use area. The other is the area to be used for stockpiling cinder excavated during construction. As we understand it, this will probably be the previously disturbed area south of the James Clerk Maxwell Telescope and the Caltech Sub millimeter Observatory. This area may also be used as a stockpile/laydown area (page 44). As this area is within the historic district, its use could have an effect on the landscape which is part of the district. We would expect these to be addressed in the opening paragraphs of the MOA and in stipulations where needed. 18A

On-Site Mitigation Measures

The "Draft On-Site Cultural Resources Mitigation Measures" (Appendix B-2) and other mitigation measures discussed in the Draft EA appear to provide a comprehensive basis from which MOA stipulations and commitments can be fashioned. With the cinder cone itself being part of a historic property and one which is located within the historic district, a wide range of construction and use activities could have an "adverse effect." We assume that these various measures will be included in the MOA directly, in detailed plans referenced by the MOA, or plans that will be prepared for specified review when sufficient information becomes available. We note that the July 31, 2000, draft of the "On-Site Cultural Resource Management Measures" calls for the preparation of a total of eight plans of one kind or another. Also some mitigation measures proposed in the Wekiu Bug Mitigation Plan would be appropriate measures to protect the cinder cone and the historic district. We assume that any differing proposals will be reconciled and the appropriate ones included in the MOA. 18B

Off-Site Mitigation Measures

As we now understand it, the proposed off-site mitigation measures are being viewed as part of the Section 106 process and as compensation for "adverse effects" which can not be mitigated in the view of some members of the Hawaiian Community. Thus the proposed off-site mitigation will be devised primarily, but not exclusively, to benefit members of the native Hawaiian Community. The initial off-site mitigation proposal and that discussed at our meetings focused almost entirely on potential educational programs because NASA already has an extensive education program from which this effort could benefit. If an educational program is developed for this purpose, we are unlikely to have many specific comments on these measures because our expertise is not in this field and it is primarily a matter to be settled with the Hawaiian community. As signatories to the MOA, our office will need to be informed as the measures become defined and are implemented. As we stated previously, we ask that any aspect of the educational program which specifically addresses the prehistory and history of Mauna Kea utilize, at least in part, information and interpretive materials prepared for the Mauna Kea Historic Preservation Plan. We would also want to review educational materials that discuss the prehistory and history of Mauna Kea or historic preservation issues. 18C

At the February 2, 2001, meeting, we suggested a possible component for the educational program. The goal of this component would be to include students in on-going field studies and management work on Mauna Kea. This would give students, many of whom would be native Hawaiians, an opportunity to learn about the natural and cultural history of Mauna Kea and those professions which either study or manage these resources. It would also give them a chance to gain an intimate familiarity with the mountain that can only be achieved through 18D extended personal experience. In turn this could enhance their personal understanding of the mountain's cultural past. We visualize this effort being structured like an internship program. It could be coordinated with the Office Mauna Kea Management which will, presumably, have some level of oversight for all studies and management activities occurring in the Science Reserve and with the Natural Area Reserve System (NARS) which manages a major segment of the summit region.

Wekiu Bug Mitigation Plan

As the habitat restoration component of the Wekiu Bug Mitigation Plan is clearly incorporated in the Draft EA for this project and portions of it are being funded by NASA, we believe it should be considered part of this federal undertaking and therefore subject to Section 106. As the restoration area is part of a historic property and could potentially affect that property, the restoration actions should be included in the MOA. 18E

In January 2001, we commented on a site approval plan prepared for the proposed Wekiu Bug Habitat Restoration Project (Ltr. Hibbard to McLaren, January 10, 2001). The plan is apparently being revised based on our comments and some subsequent discussions. Our comments on this plan appear to apply, in large part, to the project described in the Draft EA. We are, however, somewhat confused in that the restoration effort described in the Draft EA appears to include only that which lies to the east of the Subaru Observatory lease boundary and in areas directly disturbed by construction of the Keck Outriggers. The previously reviewed proposal seemed to encompass a broader area of previously damaged surfaces on the floor and northern slope of the crater. Has the effort been segmented for the purposes of the Draft EA? 18F

Consultation with Native Hawaiian Organizations

We assume that the first draft of the MOA will incorporate, to the extent possible, concerns raised by native Hawaiian organizations during your consultation efforts. At this point in the process, it is probably important to ask organizations specifically how they would want to participate in the MOA, if at all, and to reach a mutual understanding on what a "reasonable time" is for plan reviews or other kinds of comment periods. 18G

The consultation effort to date is briefly described in the Draft EA but it is not clear what has been specifically learned through this effort or which of the concerns raised during the process can be reasonably addressed. The thoughts and opinions of native Hawaiians presented in the text were primarily gathered and summarized during previous efforts, particularly the preparation of the Mauna Kea Master Plan. This point is made clearly in the text. In a number of ways, however, these previous efforts should have provided a useful guide for the project specific consultations now being conducted by NASA and should have helped consultation progress more expeditiously. It is not clear in the text how these previous studies were used in formulating a consultation strategy or if the concerns raised conform to those previously recorded. Some of this might be clarified in the final document. 18H

Signatories to the MOA

During our discussions, it seemed apparent that the University of Hawaii, through the Institute for Astronomy and/or the Office of Mauna Kea Management, has a significant role in monitoring compliance with some of the probable MOA stipulations or plans generated by the MOA. This is particularly true of the long-term commitments. Some of this oversight would occur during any construction activity on Mauna Kea because of the lease agreements and by virtue of the University of Hawaii being the leaseholder of the Science Reserve. We therefore 18I suggest that NASA invite the University of Hawaii to be one of the signatories to the MOA. The Section 106 regulations say that the "agency official should invite any party that assumes a responsibility under a memorandum of agreement to be a signatory" [CFR 800.6(c)(2)(iii)].

If you have any questions, please call Patrick McCoy, our Hawaii Island Archaeologist, at (808) 9692-8029 or Holly McEldowney of our History and Culture Branch at (808) 692-8028.

Aloha,

Gilbert Coloma-Agaran
State Historic Preservation Officer

c. Colin Kippen, Deputy Administrator, OHA
Bob McLaren, IFA, University of Hawaii
Stephanie Nagata, Office of Mauna Kea Management
Tom McCulloch, Advisory Council on Historic Preservation

Attachment 1

Draft Environmental Assessment for the Outrigger Telescopes
National Aeronautics Space Administration, December 2000

General Comments

Office of Mauna Kea Management

We feel it would be beneficial to the future use of the mountain if the preparation and implementation of the proposed mitigation measures were coordinated with the Office of Mauna Kea Management. We are assuming that it will have some long-term, oversight responsibilities in terms of setting standards for a whole range of activities occurring on Mauna Kea and then monitoring compliance with these standards. This could be a good opportunity for the Office to address, with specific examples, how various actions occurring on the mountain could be approached consistently and what their role will be in these matters. We have in mind actions such as establishing standards for interpretive and educational signs; the construction and coloration of retaining walls; the control and collection debris; and dealing with various types of emergencies. 18J

Distinction Between Archaeological Sites and Traditional Cultural Resources

Throughout the Draft EA, the general discussion of cultural resources is divided under the headings of "Archaeological Sites" and "Cultural Resources" (See pages 9, 10, 72, 78-81, 104-106). We understand that this is an attempt to distinguish between sites that are clearly man-made and those largely unaltered resources which are of cultural significance. This is confusing, however, because resources that would be considered "historic properties" under the National Historic Preservation Act (NHPA) are included in both sections. Discussions relating to Section 106 compliance sometimes occur in one section but not the other. We suggest combining all historic property concerns under one heading and have the other section deal with cultural values, traditional practices, or culturally significant resources that are not directly associated with historic properties. Some of these distinctions are made on pages 72 and 73 but their general use is still somewhat confusing. 18K

Specific Comments

Page 9, para. 5 (Archaeological Sites). If this section addresses historic properties, as we think it should, the discussion should start by addressing the issue of the cinder cone being part of a historic property which is located within a historic district. It could be noted later that no archaeological site (i.e., surface or subsurface remains) have been identified, but it should be clear from the opening sentence that there is a historic property concern. 18L

Page 9, para. 5 (Archaeological Sites). Past grading also reduces the probability that other kinds of subsurface deposits are present, not just burials. We understand why burials would be emphasized in this context, but the other possibility should also be mentioned. 18M

Page 9, para. 5 (Archaeological Sites). It is said that monitoring will "prevent the inadvertent disturbance of remains." Technically this is not the case. During monitoring remains are usually discovered during the act of being disturbed. Monitoring minimizes damaged and provides an opportunity to treat the remains appropriately. 18N

Page 9, para. 5 (Archaeological Sites). During consultation meetings, it was clear that some members of native Hawaiian organizations might wish to be given the opportunity to monitor excavations in "sensitive construction areas." 18O

Page 10, para. 4. The statement is made that a formal mitigation measure will have SHPD review and comment on the grading and on-site construction plans. The Draft On-Site Cultural Resources Mitigation Measures (Appendix B-2) says the Office of Hawaiian Affairs (OHA) and the Hawaii Island Burial Council would also be given this opportunity. Consultation with other native Hawaiian organizations may indicate that others would like to be given this opportunity also. 18P

Page 25, para. 1 (Overview). As mentioned in our general comments, use of the Hale Pohaku staging area should be assessed for its potential effect on historic properties. (See also page 29, para. 5) 18Q

Page 55, Table 2-3. We suggest some wording changes in that part of the table dealing with cultural resources. Under "Proposed Action," it says that the SHPD considers the "summit cinder cones a historic district." This should be considers "summit cinder cones a historic property within a historic district." We realize space is limited. Under "No Action," should the off-site mitigation measures also be mentioned as they are discussed in the text in full. 18R

Page 72, paras. 4, 5, 6, and 8 (Resource Definitions). This discussion should be reworked to more clearly define what a "traditional cultural property" is and that this kind of property is eligible for inclusion in the National Register. The definition of "traditional cultural resources" in paragraph 6 is that of a traditional cultural property as given in National Register Bulletin 38. This specifically deals with eligibility of properties to the National Register. What is missing is a discussion of culturally important practices, resources or values that are not associated with a tangible feature and site. 18S

Page 73, para. 1 (Historical Setting). The dates given here for the arrival of the first settlers to Hawaii are significantly earlier than those in general usage. The dates between 400 A.D. and 800 A.D. are more commonly cited. More caution should be used in portraying the Hawaii Loa legends as the primary Hawaiian tradition concerning initial settlement. 18T

Page 73, para. 3. Reference to dunnite/gabbro being used for octopus fishing gear sinkers should be reworded or moved. Its placement gives the impression that this resource is located within the adze quarry complex. It is, instead, near Hale Pohaku and at the periphery of the very broad area in which quarry material and flaked basalt are found. Known use of the quarry dates back to at least 1100 A.D. 18U

Page 74, para. 3. The wording on the 1982 survey which covered part of Pu'u Hau 'Oki is confusing because the sentence emphasizes the 22 archaeological sites recorded during the survey instead of the current project area. It might also be made clearer that the two surveys did not find surface features. Shouldn't it be mentioned that these 22 sites where shrines? 18V

Page 74, para. 4. The statement that our 1995 survey indicated that telescope construction had not damaged previously recorded sites is somewhat odd because almost the entire survey was conducted in areas where no telescope construction has taken place and, in fact, was a considerable distance from existing telescopes. Perhaps the reference is to 18W verification that construction for the Submillimeter Array did not damage any sites? If so, this should be clarified.

Page 74, Summary of Oral Interviews. This heading should probably include the word consultation as the following discussions make it clear that consultation was part of this effort. This applies also to the heading "Summary of Oral Interviews" on page 76, paragraph 6. 18X

Page 76, para. 3. It may be a bit misleading to say that "Mauna Kea, the landscape itself, is believed to be a sacred ancestor." While various deities and gods can take the form of tangible objects and these deities and gods can be considered ancestors, the tangible objects are generally not considered ancestral in themselves. 18Y

Page 78, para. 3. One of the recommendations said to have been raised during the consultation process was that "[S]ampling of sites should be limited..." It isn't clear what this means. Does this mean the excavation of sties or the collection of materials from sites or does it refer to all, non-altering forms of recording information on sites. 18Z

Page 78, para. 12. This discussion gives the impression that Pu`u Hau `Oki (as part of the summit cluster) is not individually eligible for the National Register because it is a contributing property to the historic district. We believe that this pu`u, as part of the summit cluster, is eligible. 18AA

Page 79, paras. 3-6. If this section discusses the cultural environment of the project area, it should include sites found in the NARS. The division between the Science Reserve and the NARS does not coincide with any natural or cultural division of the mountain. In fact, parts of the NARS are fairly close to the project area. The two areas should be treated equally in this discussion. 18BB

Page 79, para. 4. The statement is made that most of the shrines are located on the northern or eastern slopes near an elevation of 13,000 ft. There are two problems with this generalization. First, there is a substantial concentration of shrines between the summit cones and Pu`u Lilinoe. This is on the southern or southeastern slope. Second, placing the shrines near the 13,000-ft. contour may be reasonable for most of the shrines on the northern slope, but the range is somewhat lower on the eastern and southern slopes (12,600 to 12,800 ft.). 18CC

Page 81, para. 4 (Architectural Resources). While no architectural properties have been identified within the Science Reserves, this Draft EA also addresses the use of the Hale Pohaku staging area. The stone cabins at Hale Pohaku are over 50 years old and should be considered historic properties. These should be mentioned although it is unlikely the project will affect these buildings. This comment also applies to page 104, paragraph 4. 18DD

Page 91, para. 1. It should be stated that the placement of excavated cinder from the project area will be addressed in the Section 106 MOA and that the MOA will also specify who will be consulted on this decision. This comment also applies to the statement made on page 92, paragraph 8. 18EE

Page 93, para. 2. What kind of permanent barriers are being proposed for the slope break? Any such barriers should be addressed in the Section 106 MOA. 18FF

Page 93, para. 3 and page 94, para. 1. As we discussed in earlier comments on the Site Approval Plan for the Wekiu bug habitat restoration work, our office wishes to be given the opportunity to review the plans and design specifications for the proposed education signs. We also hope that consideration will be given to how these signs will conform to standards for all signs on the summit cones and in the Science Reserve. 18GG

Page 99, para. 1. Reference is made to "the proposed Section 106 on-site mitigation plan (Appendix B)." No mention is made of Section 106 in the "Draft On-Site Cultural Resources Mitigation Measures" in Appendix B. 18HH

Page 101, para. 4 and 7. In discussing the impact of debris (e.g., construction material, trash), only the Wekiu bug habitat is mentioned. Loose debris would also have an impact on the historic property and potentially the district. This should be added. 18II

Page 105, para. 9. This paragraph seems to imply that Section 106 is, in itself, a separate mitigation measure. It might be explained that the MOA resulting from the Section 106 process will include some of the mitigation measures mentioned such as monitoring, construction crew briefings, and "best management practices." 18JJ

Page 107, para. 1. The adverse effects discussed here are said to be on the historic district. More directly, they are on the cinder cone itself which is considered part of a historic property. 18KK

RESPONSES TO COMMENTS
Commentor No. 18: Department of Land and Natural Resources/State Historic Preservation Division (Gilbert Coloma-Aragan)

Response to Comment 18A:

The Memorandum of Agreement and subsequent portions of the Environmental Assessment have been updated to include Hale Pōhaku and the stockpile/laydown areas.

Response to Comment 18B:

The Memorandum of Agreement provided in Appendix C includes the mitigation measures as appropriate.

Response to Comment 18C:

Thank you. Your comment is respectfully noted. Based on the Memorandum of Agreement found in Appendix C, the Office of Mauna Kea Management, in consultation with the State Historic Preservation Division, has a responsibility for developing the interpretive materials.

Response to Comment 18D:

Thank you for your suggestion. NASA believes this idea merits consideration and we will forward it to the Office of Mauna Kea Management and through them to the local working group.

Response to Comment 18E:

To the extent that Wēkiu bug habitat restoration efforts could potentially affect the historic property, such effects are addressed in the Memorandum of Agreement (see Appendix C).

Response to Comment 18F:

The proposed Wēkiu bug habitat restoration area proposed by the Outrigger Telescopes Project would include a portion of the crater bottom illustrated in this Environmental Assessment, not the entire crater bottom. The crater bottom habitat restoration is identical to the actions approved in Site Plan Approval SPA-01-03, which was granted by DLNR to UH on October 31, 2000. In addition, the Wēkiu bug habitat at Outrigger Telescope 2/Junction Box 5 disturbed by on-site construction and installation would also be restored. If enough suitably-sized cinder were available from excavation, an area around Outrigger Telescope 1 would be restored. No other proposals for habitat restoration are being made by the Outrigger Telescopes Project and its Wēkiu Bug Mitigation Plan. The Outrigger Telescopes Project habitat restoration proposal is not being segmented. This proposal constitutes all the Wēkiu bug restoration activities being proposed for the Outrigger Telescopes Project.

Response to Comment 18G:

Thank you. Your comment is respectfully noted. All Consulting Parties were afforded an opportunity to review and comment on the Memorandum of Agreement.

RESPONSES TO COMMENTS

Commentor No. 18: Department of Land and Natural Resources/State Historic Preservation Division (Gilbert Coloma-Aragan)

Response to Comment 18H:

Tables 5.1 and 5.2 in Chapter 5 of this Final Environmental Assessment provide a listing of the consultations and meetings that have occurred between NASA and interested parties concerning the Outrigger Telescopes Project. The result of the consultations are reflected in the Memorandum of Agreement (see Appendix C of this Final Environmental Assessment).

NASA has considered the previously existing documentation.

Response to Comment 18I:

The University of Hawai'i is a signatory to the Memorandum of Agreement (see Appendix C).

Response to Comment 18J:

NASA and the Outrigger Telescopes Project Office have consulted with the Office of Mauna Kea Management. The Office of Mauna Kea Management has reviewed and commented on NASA's Draft EA, and NASA has consulted with the Office of Mauna Kea Management throughout the Section 106 consultation process. See the Memorandum of Agreement (see Appendix C). The Office of Mauna Kea Management will also participate in the review of Project plans such as grading and site development, and is welcome to observe on-site construction and installation activities.

Response to Comment 18K:

The distinction between archaeological sites and traditional cultural resources has been clarified.

Response to Comment 18L:

This Section has been restructured.

Response to Comment 18M:

The sentence has been changed to read: ". . .burials or other subsurface artifacts. . . . "

Response to Comment 18N:

We agree and the text now reads: "The archaeologist will also be present on site to monitor these areas during excavation to minimize damage to inadvertently disturbed remains or subsurface artifacts."

Response to Comment 18O:

Native Hawaiian organizations who have expressed an interest in the Outrigger Telescopes Project and who have been given Consulting Party status (under the National Historic Preservation Act) in the Memorandum of Agreement will be afforded an opportunity to monitor and review the work during on-site construction activities. However, for safety purposes, all construction site visits must be coordinated through the California Association for Research in Astronomy's Construction Manager's Office.

RESPONSES TO COMMENTS
Commentor No. 18: Department of Land and Natural Resources/State Historic Preservation Division (Gilbert Coloma-Aragan)

Response to Comment 18P:

The proposed grading and site development drawings were provided to all the Consulting Parties for a 45-calendar day review and comment. See Appendix C for the Memorandum of Agreement.

Response to Comment 18Q:

We agree. See Comment Response to 18A.

Response to Comment 18R:

See updated text in Table 2.3. Mitigation measures have been addressed under the No-Action alternatives.

Response to Comment 18S:

Text has been updated in Section 3.10.1.

Response to Comment 18T:

Text has been updated to reflect these facts in Section 3.10.2.

Response to Comment 18U:

Text referring to dunnite/gabbro has been moved. See Section 3.10.2.

Response to Comment 18V:

Text has been corrected to reflect this in Section 3.10.3.

Response to Comment 18W:

The sentence has been deleted.

Response to Comment 18X:

The interviews conducted by Mr. Maly were not specific to the Outrigger Telescopes Project, thus we cannot portray them as part of the Section 106 consultation process.

Response to Comment 18Y:

The sentence is changed to read: ". . .the landscape itself is considered sacred as it is believed to be home of the gods or ancestral deities."

Response to Comment 18Z:

The sentence has been changed to read: "Archaeological sampling of sites should be limited and plans developed in consultation with knowledgeable cultural practitioners".

Response to Comment 18AA:

Text has been updated in Section 3.10.5.

RESPONSES TO COMMENTS

Commentor No. 18: Department of Land and Natural Resources/State Historic Preservation Division (Gilbert Coloma-Aragan)

Response to Comment 18BB:

The text has been updated to reflect your comment about the Mauna Kea Ice Age Natural Reserve.

Response to Comment 18CC:

Text has been updated. See Section 3.10.5.

Response to Comment 18DD:

NASA will bear in mind the State Historic Preservation Division's recommendation to consider the stone cabins at Hale Pōhaku as historic properties for purposes of the proposed project. However, the Outrigger Telescopes Project will have no effect on the cabins.

Response to Comment 18EE:

Thank you. Your comment is respectfully noted. The placement of the excavated cinder not necessary for backfill or Wēkiu bug habitat restoration will be determined in consultation with the Hawai'i State Historic Preservation Office, and the Office of Mauna Kea Management prior to the start of construction. See the Memorandum of Agreement in Appendix C of this Final Environmental Assessment.

Response to Comment 18FF:

While there are retaining walls to preserve the slope break, and temporary barriers there during construction, the previously considered permanent barriers are no longer being proposed. There are guardrails between Outrigger Telescopes 1 and 5, 5 and 6, and 6 and 2, but these are not at the slope break. See revised Section 4.1.4.

Response to Comment 18GG:

The State Historic Preservation Division and the Office of Mauna Kea Management will be involved in the review of the design specifications and plans for the signs.

Response to Comment 18HH:

The on-site and off-site historic/cultural mitigation measures are reflected in the Section 106 Memorandum of Agreement (see Appendix C). The text has changed to reflect that the relevant document is now the Memorandum of Agreement.

Response to Comment 18II:

The mitigation measures include best management practices to avoid blowing trash and construction material onto the surrounding slopes of Pu'u Hau 'Oki and elsewhere on the summit. See Appendix F for the draft construction Best Management Practices Plan.

Response to Comment 18JJ:

Thank you. Your comment is respectfully noted; the text has been revised to reflect the comment. See Section 4.1.10.

As indicated previously, historic property protection measures are addressed in the Memorandum of Agreement resulting from the Section 106 process.

Response to Comment 18KK:

The text has been revised. See Section 4.1.10.

Conservation Council for Hawai'i

www.conservation-hawaii.org

30 March 2001

Richard J. Howard
Senior Program Executive
Office of Space Science
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Dear Mr. Howard:

The Conservation Council for Hawai`i would like to thank you for this opportunity to comment on the December 2000 Draft Environmental Assessment for the Outrigger Telescope Project - Mauna Kea.

A review of the document produced many concerns regarding significant impacts to natural resources of Mauna Kea. These concerns are outlined in the response included below.

Concerns Regarding the NASA Draft Environmental Assessment for the Outrigger Telescope Project

Failure to Prove Need

It is our understanding that the Outrigger Telescope Project is meant to augment the Keck I and Keck II Interferometer. However, the Draft EA reports that the Keck I and Keck II Interferometer have not been completed, and that no scientific data has been collected with this interferometry technology to date. It is difficult for us to support a proposal that expands upon untested science when its presumed benefits are weighed against very real threats to an endangered species, existing burials and the wealth of natural and cultural resources occurring on Mauna Kea. 19A

- NASA has failed to justify the need for expansion or further development.

The Wekiu Bug Mitigation Plan

The Wekiu bug population has been diminished by 99.7% in just 14 or 15 years leaving a population that is 0.3% of the original. These numbers demand serious and immediate response and recovery efforts.

On page 63, the Draft EA states: "The causes of the Wekiu bug population decline are not known." It is established that any loss of habitat of a species eventually impacts that species negatively. On page C-1 of its Wekiu Bug Mitigation Plan, Pacific Analytics states, "It is the intention and hope ... that the Wekiu bug population will actually increase, due to protection and restoration of potentially favorable habitat." The theory behind this proposed plan, to create a new habitat and hope the Wekiu bug will go there and survive, is flawed for two principal reasons:

1.) There is no empirical data outlining what the bugs' behaviors are and how they might respond to the creation of a new habitat, and

2.) The test would be done in parallel with the construction, which will destroy the bugs' original habitat.

It is both just and reasonable that, until further study is conducted and hard data produced (and verified) to prove that the Wekiu would respond to such a theoretical model, we err on the side of caution. The HIBC is unable to accept a theoretical model that could, in and of itself, diminish the whole species. 19B

- There is no compensation for extinction.
- There is a difference between experimentation and mitigation.
- There is no evidence that NASA's proposed mitigation plan would save the Wekiu bug.
- CCH does not support the Wekiu Bug Mitigation Plan as presented in the Draft EA. Clearly the plan fails to address the minimum standard of protection for a species in need of maximum protection. We request that a Federal Environmental Impact Statement pursuant to NEPA be conducted to further evaluate this precious and rare species.

Hydrology, Hazardous Materials and Solid Waste Containment Systems.

The Draft EA states (pg. 93) "On-site construction and installation of the proposed project, including the potential for a hazardous substance spill, would not impact ground water resources...."

Mauna Kea is a distinct aquifer system that is linked to other separate, but related, aquifer boundary systems. The East and West Mauna Kea aquifer systems alone produce a sustainable yield of 409 - 444 million gallons per day (mgd). The Mauna Kea aquifer boundary systems also feed the Kohala (at 154 mgd) and NE Mauna Loa (21-56 mgd), SE Mauna Loa (291 mgd), SW Mauna Loa (130 mgd), and NW Mauna Loa (740 mgd) aquifer systems.

(*N.B. please see Atlas of Hawai'i by Juvik and Juvik, third edition.*)

These aquifer systems are fed by a complex combination of hydrological effects that originate from the summit and move downward. These effects include, but are not limited to, shallow subsurface streams, high level springs, the diurnal fog precipitation that occurs throughout the year, the freeze and thaw cycles of buried fossil ice (found a few feet below the surface), permafrost, snowmelt and even rainfall.

While Lake Waiau is the most prominent surface water feature on the Mountain, there are numerous smaller ponds found in the summit cinder cones formed from perching. These also feed the subsurface streams.

The Mauna Kea aquifer systems, subsystems and general hydrology contribute to nearly the entire island of Hawai'i- not only is the hydrology complex, it is massive.

Although the Draft EA does mention the basal waters contained far below the summit region, it ignores the fact that these basal systems are part of the larger hydrological systems of the Mountain. While it may seem that the known surface streams occurring 1000-2000 ft. downstream from the summit development are safe from contamination in the event of hazardous spill, there is no data to support this assumption. According to the Draft EA, the percolation rate for water is 20 inches per hour downstream; if this were true, it would take approximately 52 days for the contamination to reach these streams. It is possible that contamination would not reach the streams at all, but this cannot be determined from the information provided in the Draft EA. 19C

- The Draft EA does not address the complex nature of the hydrology of Mauna Kea, nor does it adequately address the significant and cumulative impacts the proposed project would have on the cultural and environmental resources of Mauna Kea.

Hazardous Materials

In March 2000, in consultation with NASA, the Hawai'i Island Burial Council expressed concern regarding the use of hazardous materials, including but not limited to, mercury, ethylene glycol, and hydraulic fluid. At that time, the Council requested from NASA a full disclosure of "...the hazardous materials, including the amounts, safety precautions, and waste disposal..." (*N.B. Please see HIBC March 2000 minutes)* used at the WMKO facility. To date they have not received this information. 19D

The Draft EA states (pg.69) "There have been no mercury spills at the WMKO." The Council is in receipt of a letter from the WMKO Director Dr. Fred Chaffee, which is addressed to Nelson Ho of the Big Island Chapter Sierra Club and cites that mercury spills did, in fact, occur on two separate occasions in 1995. Inconsistent or conflicting reports do not engender trust in this process. 19E

Although the Draft EA does provide a much more comprehensive list of the hazardous materials usage, handling, storage and disposal, it does not provide information on an emergency plan or a disaster plan as is required by OSHA. Nor does it list the reportable quantities of all materials (i.e. according to the State Department of Health the reportable quantities of Mercury are 1lb). The amount of Mercury used by the WMKO is 30lbs according to the EA. 19F

- What are the emergency response and the disaster response plans for elemental Mercury and other hazardous materials?

The Draft EA states, "It is common practice for concentrated hazardous substances to be diluted by WMKO headquarters staff and disposed of by a licensed waste-handling contractor."

- Who are these licensed contractors? 19G

It is our understanding from the Draft EA that this license permits the removal and disposal of the following compounds (for which you have listed both the amounts disposed of and reportable quantities used):

1.) Aluminum Chloride,
2.) Aluminum Sulfate,
3.) Copper Chloride,
4.) Copper Sulfate,
5.) Potassium Hydroxide.

We have no information on carbon disulfide.

- What are the reportable quantities of this substance?

We understand that carbon disulfide is added to the residual compounds produced as waste from the aluminum removal process. We understand that this is done to "heavy out" the biologically active copper in the "rinse water", so that it will not enter the waste water system and may be removed as a solid waste from the septic tank. 19H

Regarding the elemental mercury, in spite of existing policies, elemental mercury could still be accidentally introduced into the wastewater system if the rubber ring guide containing the mercury was to be punctured or burst as a result of some unforeseen event. We presume that any open drains on the observation deck below the telescope would communicate directly or indirectly with the wastewater drainage system. 19I

Furthermore, mercury spilled on the observing and basement floors could enter the opening where the earth ground wires enter the cinder layers (as was pointed out by a former telescope employee at the HIBC meeting March 2000). It should be noted that there is no specific antidote for mercury poisoning. A lethal dose is irreversible.

- The Draft EA does not adequately address the hazardous materials used for this project, nor does it adequately address the existing and potentially significant and cumulative impacts this project might have on the cultural and environmental resources of Mauna Kea.

Wastewater Collection, Treatment and Disposal

Because Mauna Kea summit resides in a Conservation District, the WMKO wastewater disposal system must be in compliance with the State Health Department regulations for this District. The Draft EA states "The WMKO wastewater disposal system has been approved by the State Department of Health." The State Wastewater regulations however, forbid any substances other than human and regular waste from entering the septic tank systems. State of Hawai'i Clean Water regulations require any project that is 5 acres or greater to obtain a National Pollutant Discharge Elimination System (NPDES) permit.

- Does your agency have a special permit to introduce hazardous substances into the wastewater system? 19J

- Does your agency have a NPDES permit?

The Draft EA states "Wastewater enters the two-stage septic tank where bacteria digest bio-solids that settle to the bottom of the tank. The wastewater then flows from the septic tank into a 6-m (20ft.) deep seepage pit that drains into deep subsurface cinder."

- Could you define or describe this seepage pit? For instance, is this "pit" an open hole in the ground or a lined and contained vault? 19K

- In the event that any hazardous materials other than the "rinse-water" from the aluminizing process were to be introduced into the septic/seepage tank system, what emergency procedures have been established to deal with this scenario? For example, what would the procedures be if mercury were introduced into the system through the open drain system? 19L

The high altitude and freezing conditions create special problems in systems that might, under normal circumstances, be fine.

- Have the sanitation systems been inspected since they were put in? 19M

- What is the date of the last sanitary system inspection, who conducted this inspection and what technology was used? It is common in many states for sanitation systems to be inspected using video inspection technology.

- Why was this method of waste disposal selected over complete removal of all waste materials from the Mountain? 19N

- The Draft EA does not disclose the Emergency Response and Disaster Response Plans for this project. To date, we have no proof of compliance and have seen no documentation of inspection reports or evaluations by the pertinent agencies. 19O

- The Draft EA does not adequately address the Hydrology, Hazardous Materials and Solid Waste containment systems for the Project, which can and does significantly impact the traditional, cultural and environmental resources of Mauna Kea.

Summary

In summary, we believe that the Draft EA does not adequately address or mitigate the significant impacts that will be incurred by this project, for the following reasons:

- The Draft EA does not justify why further development is needed.

- The Draft EA Wekiu Bug Mitigation Plan attenuates the true danger of the Wekiu bug and is based on a wishful hypothetical premise. The plan is not scientifically convincing as an avenue for recovery; and in fact could lead to the complete extinction of the species.

- The Draft EA is inadequate because it omits "past" and "present" as components in the definition of cumulative impacts. Federal law (40 CRF 1508.7) defines cumulative impacts as the "incremental, environmental impacts of the action when added to other past, present, and foreseeable future actions." 19P

- The Draft EA does not consider the scale and complexity of Mauna Kea's hydrology, and therefore the mitigation measures do not adequately address the significant and cumulative impact this project will have on the island's water resource.

- The Draft EA does not evaluate the hazardous materials intrinsic to this project, and therefore the mitigation measures do not adequately address the existing and potentially significant and cumulative impacts this project will have on the cultural and environmental resources of Mauna Kea.

- The Draft EA does not adequately evaluate the solid waste containment systems and therefore the mitigation measures do not address the significant and cumulative impacts to the beliefs of the Native Hawaiian people and to the cultural and environmental resources of Mauna Kea.

Conclusion

It is the Council's position that, after careful review of the Draft Environmental Assessment for the Outrigger Telescopes Project, a full Environmental Impact Statement (EIS) should be conducted. We concur with the Office of Hawaiian Affairs that the "proposed environmental assessment provides ample evidence that this project will have a significant impact on traditional and cultural properties, on a proposed National Historic Site, on the endangered Wekiu bug, and on scarce ground water resources to warrant the preparation of an EIS." 19Q

Thank you for your consideration of these comments. Please feel free to contact us if we can be of any further assistance. We look forward to reviewing the full Environmental Impact Statement.

Sincerely,

K Blue

Karen Blue
Executive Director
Conservation Council for Hawai`i
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FAXED AT 11PM 3/30/01 HST

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To RICHARD J. HOWARD	From KAREN BLUE
Co. NASA	Co. CONSERVATION COUNCIL FOR HI
Dept. OFFICE OF SPACE SCIENCE	Phone # 808-286-2449
Fax # 202-358-2861	Fax # 808-968-0896

Response to Comment 19A:

The addition of four telescopes to the Keck-Keck Interferometer would allow astronomers to obtain even higher resolution images of astronomical objects by allowing the object under study to be viewed at different angles. A minimum of four Outrigger Telescopes would need to be added to the Keck-Keck Interferometer to achieve the science objectives of the project. Adding the fifth and sixth Outrigger Telescopes would almost double the resolution, thereby further increasing the scientific value of the observations. Refer to Section 1.3 for more details.

Response to Comment 19B:

The recommendations in the Wēkiu Bug Mitigation Report are based on data gathered during the 1982, and 1997/98 arthropod assessments (Howarth and Stone 1982; Howarth and others 1999), combined with input from entomologists familiar with Wēkiu bug biology and the best information available in published scientific literature. NASA has consulted with the U.S. Fish and Wildlife Service concerning the Wēkiu Bug Mitigation Report. This report was used to develop the Wēkiu Bug Mitigation and Monitoring plans (see Appendices D and E).

The Outrigger Telescopes Project will not lead to the extinction of the Wēkiu bug. Less than 0.009-ha (0.022-ac) of Wēkiu bug habitat would be disturbed during construction of the Outrigger Telescopes. This would represent about 0.008 percent of the 120-ha (300-ac) estimated size of occupied Wēkiu bug habitat in the summit region of Mauna Kea (Howarth and others 1999). It is the goal of the Wēkiu Bug Mitigation and Monitoring plans to expand Wēkiu bug habitat and enhance the Wēkiu bug population in Pu'u Hau 'Oki.

The habitat restoration protocol is based on the best scientific information available about the habitat needs of the Wēkiu bug. The protocol is based on the following information.

1. Wēkiu bugs appear to prefer habitat made of loose cinder 1.3 centimeters (cm) (½ inch) in size or larger. In past studies (Howarth and Stone 1982; Howarth and others 1999), the highest concentration of Wēkiu bugs were collected in habitat consisting of 25 to 38 cm (10 to 15 inches) of 1.3 cm (½ inch) size or larger cinder, with an impenetrable ash layer below the cinder. This information leads us to conclude that restored habitat consisting of 30 to 46 cm (12 to 18 inches) of loose 1.3 cm (½ inch) size or larger cinder will be acceptable to Wēkiu bugs.

2. Wēkiu bug habitat occurs on undisturbed portions of crater floors in summit cinder cones (Howarth and Stone 1982; Howarth and others, 1999). In 1982, 6,230 Wēkiu bugs were collected on the crater floor of Pu'u Wēkiu and 430 Wēkiu bugs were collected on the crater floor of Pu'u Hau 'Oki. During the 1997/98 arthropod assessment, Wēkiu bugs were found on the crater floor of Pu'u Wēkiu and Pu'u Hau 'Oki, and on the inner slopes of Pu'u Hau 'Oki adjacent to the crater floor. Since suitable habitat does not exist on the crater floor of Pu'u Hau 'Oki, Wēkiu bugs from the adjacent inner slopes apparently migrate to the

crater floor. This information leads us to conclude that Wēkiu bugs would likely occupy restored habitat on the floor of Pu'u Hau 'Oki.

3. Given sufficient time, Wēkiu bug habitat appears to recover from disturbance. Of all sites sampled during the 1997/98 arthropod assessment, habitat on the slopes below W.M. Keck Observatory that was disturbed during construction contained the highest concentration of Wēkiu bugs. This information leads us to conclude Wēkiu bugs would eventually occupy the restored habitat.

As part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology, to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors. New information may be used to modify the habitat restoration protocol to increase its effectiveness.

<u>Response to Comment 19C:</u>

NASA has evaluated the hydrology associated with Pu'u Hau 'Oki. The ground and surface water sections of this Final Environmental Assessment have been expanded to encompass these observations. See Sections 3.5 and 4.1.5 and Appendix H.

<u>Response to Comment 19D:</u>

The hazardous materials section has been updated in the text (see Sections 3.9.3 for present conditions and 4.1.9.3 for potential impacts).

Both the Draft and the Final Environmental Assessment have been sent to the Hawai'i Island Burial Council. In addition, the Royal Order of Kamehameha I has also received a Draft and Final Environmental Assessment.

No mercury will be used in the Outrigger Telescopes Project.

<u>Response to Comment 19E:</u>

The available information at the time of the issuance of the draft EA indicated that no mercury spills had occurred at the site. Further investigation by CARA indicated that in fact two mercury spills had occurred and the W.M. Keck Observatory Director issued a letter to that effect. The letter is attached to the commentor's letter and is referenced in this Final Environmental Assessment. Since issuance of the Director's letter, a thorough record search has resulted in identifying a third spill. None of the mercury spills (two spills under 10 ml and one spill under 100 ml) resulted in any of the mercury seeping into the ground or the septic system. All of the spills occurred in 1995, and since then no spills have occurred.

These spills precipitated the creation of a mercury spill procedure, including the availability of a mercury spill kit to contain and clean up a spill. A special vacuum cleaner is included in the spill kit to remove mercury without at the same time creating a hazardous vapor. All waste containers and materials used in the spill clean-up process are preserved, allowing the mercury to settle without vaporizing, prior to disposal by Unitek Solvent Services.

No mercury will be used in the Outrigger Telescopes Project.

Response to Comment 19F:

CARA has a comprehensive Emergency Response Plan dealing with a variety of emergencies (fire, storm, earthquake, etc.) that could occur at both the summit and Waimea Headquarters. The plan has sections addressing cryogen accidents, general spills (including glycol and hydraulic fluid), and mercury spills. There is a CARA Safety Officer, and many employees share the safety responsibility. Training programs occur periodically throughout the year. Past mercury spills did not result in any of the mercury entering the ground or septic systems.

Response to Comment 19G:

Unitek Solvent Services, Inc., disposes of hazardous substances. Phillip Services Corporation disposes of machine grease.

Response to Comment 19H:

Mirror washing effluents at the WMKO site are no longer released to the WMKO septic system.

Carbon disulfide is not used at the W.M. Keck Observatory. Mirror washing effluents are collected, removed, and transported off the site.

Response to Comment 19I:

See Response to Comment 19E. No mercury would be used in the Outrigger Telescopes Project. Although there have been three spills (two spills under 10 ml and one spill under 100 ml) associated with the Keck Telescopes, the Outrigger Telescopes use no mercury. The only drain of any kind in the Keck domes is in an exhaust pit. There is no path from main or basement floors to the grounding grid. The ground wire conduit for the emergency generator is sealed.

Response to Comment 19J:

All permits for the W.M. Keck Observatory site on Mauna Kea are held either by the California Association for Research in Astronomy or the University of Hawai'i. The observatory is in compliance with all permitting requirements (UH IfA 2001b).

Response to Comment 19K:

The existing seepage tank is 2.7 meters (9 feet) in diameter by 3.7 meters (12 feet) deep hole, the sides of which are lined with perforated concrete rings (2.4 meters (8 ft) inside diameter). The seepage tank is capped with a reinforced concrete lid with a 31-centimeter (12-inch) plug. Effluents entering the seepage tank percolate directly into the underlying cinder.

Response to Comment 19L:

See Response to Comment 19F.

RESPONSES TO COMMENTS

Commentor No. 19: Conservation Council for Hawaii (Karen Blue)

Response to Comment 19M:

The sanitation system was inspected and serviced on June 13, 2001 by J & Al's Pumping Service. The sanitation system is visually inspected annually.

Response to Comment 19N:

Septic tanks and cesspools were the standard wastewater systems for all observatories on Mauna Kea when the Keck Telescope facilities were built. Consequently, the Outrigger Telescopes will use the standard wastewater systems. No new systems are anticipated.

Response to Comment 19O:

As provided in Response to Comment 19F, the California Association for Research in Astronomy has a Comprehensive Emergency Response Plan.

Response to Comment 19P:

NASA has provided information on the potential cumulative environmental impacts associated with the Outrigger Telescopes Project. Please see Section 4.2 of this Final Environmental Assessment.

Response to Comment 19Q:

Thank you. Your comment is respectfully noted.

To: Mr Richard Howard
Senior Program Executive
Office of Space Sciences/Code SD
NASA Headquarters
300 E. Street, SW
Washington, DC 20546

Aloha Mr. Kumor,

The Royal Order of Kamehameha I would like to thank you for this opportunity to comment on the Draft Environmental Assessment for the Outrigger Telescope Project- Mauna Kea, Moku O Keawe. The extension granted by your agency allowed us to prepare our comments in accordance with the protocols to which we are bound as chiefs.

To ensure a thorough review of the document, we commissioned Mauna Kea Anaina Hou to research the issues addressed in the draft assessment. Although it is a legal requirement that environmental reviews be written in language easily understood by the average person, the criteria used by your agency to comply with that part of the law did not take the average Native Hawaiian into account. With the help of Mauna Kea Anaina Hou, we were able to understand the issues within our own, cultural, context. To this end, we strongly support the inclusion of this group in the 106 consultation process pursuant to the National Historic Preservation Act regarding your project. 20A

The Royal Order of Kamehameha I was founded in 1865 by His Majesty King Kamehameha V in accordance with the principals by which Kamehameha I ruled the Hawaiian Islands. Like all things Hawaiian, the organization was deeply affected by the aggression of western culture and suffered through a period of quiet oppression. At the same time, it has maintained a continuity that makes its role in modern politics unique. The Royal Order of Kamehameha I (ROOK I) takes its charter to preserve and protect the resources of the Hawaiian people seriously and is currently involved in the process of asserting its authority to fulfill this sacred obligation.

Introduction

Mauna Kea is the highest and most renowned temple and Wahi Pana (sacred place of worship) of the Native Hawaiian people. Its summit region is known as Wao Akua - the sacred realm of the Creator The significance of the Mountain is acknowledged in oral histories througnout all of Polynesia. It is the burial ground of our highest born and most sacred ancestors, it is a temple for worshipping Akua (Creator), Na Akua (Divine Deities), and Na Aumakua (the Divine Ancestors)

For the last 32 years, astronomy has existed on our sacred mountain - Mauna Kea. Indeed, with the largest telescopes ever built occupying the Mountain, it has become known as the world's premiere astronomy center.

Since 1968, when the development first began, there has been resistance from the people of Hawai'i. It must be recognized however, that this world-class astronomy center was built against the wishes of the Native Hawaiian people and with no recognition of Mauna Kea's significance to them as Hawai'i's host culture. The recent University of Hawai'i Master Plan proposal, which promotes further development, generated adamant public outcry from all sectors of the community. Resistance, therefore, has not waned. 20B

Although the sacred nature of Mauna Kea has been recognized by the State Historic Preservation Office (SHPO) through the identification and listing of the summit region as an Historic District and the summit cluster of cinder cones as an Historic Property, no Section 106 consultations pursuant to the National Historic Preservation Act were ever conducted for the any development on Mauna Kea that used federal funds. Further, the Section 106 consultations conducted for the proposed development have been woefully inadequate.

Concerns Regarding the Section 106 Consultation Process

The ROOK I would like to express concern regarding the Section 106 consultation process pursuant to the National Historic Preservation Act being conducted by your agency. In February (2-1-2001) of this year NASA conducted meetings which were to include the Hawai'i Island Burial Council (HIBC), The Office of Hawaiian Affairs (OHA), the Royal Order of Kamehameha, and the Department of Hawaiian Home Lands (DHHL), State of Hawai'i Historic Preservation Office (SHPO) and referred to these meetings as Section 106 consultations.

While the ROOK I was prepared to attend these meetings and participate in the process, the restrictions imposed on the first meeting by your agency, at the eleventh hour, contravened the protocols to which our organization is bound and defied the spirit of the law that mandates the consultation process. As a result, we could not participate. Although the extension of the comment period was a step in the right direction, this situation can not be remedied until NASA adopts ground rules that honor the order's protocols. Within these protocols, the order has the authority to convene a process that is inclusive and allows for participation at the grassroots level. Neither the University of Hawai'i, nor their selected representatives, can speak for the Hawaiian people. The people speak for themselves and their chiefs listen. While NASA obviously operates on the premise that government is obligated to listen to the people but is free to dismiss their concerns, the chiefs who comprise the Royal Order can not

In the winter of last year, the ROOK I conducted a culturally appropriate public hearing on the issue of developing Mauna Kea. We take this opportunity to notify NASA that, in comparison, the process your agency is conducting is not appropriate; and further, that the results of NASA's process cannot be construed to be the results of a Section 106 consultation process.

To date, the process is incomplete. Until such time as the federally mandated Section 106 process proceeds, the public record stands. The Native Hawaiian community, in all hearings regarding both the Mauna Kea Master Plan and your agency's project, has expressed adamant opposition to any further desecration and or development of the Mauna Kea summit or slopes. 20C

- **In concurrence with the mandate given by the Hawaiian people, the Ali'i Nui and Grandmaster of the Royal Order of Kamehameha I, Gabriel Makuakane, has decreed that "There shall be no further development of any kind on Mauna Kea."** 20D

- The ROOK I does not believe the Section 106 process being conducted by your agency is inclusive enough to identify and mitigate the impacts this project will have on a sacred, historical, traditional and cultural property. 20E

<u>Concerns Regarding the NASA Draft Environmental Assessment for the Outrigger Telescope Project</u>

A review of the document produced many concerns regarding significant impacts to the traditional, cultural, religious and natural resources of Mauna Kea These concerns are outlined in the response included below

Origins, Purpose and Need

In Section 1.3, NASA describes the Outrigger Telescope Project as a key element to its "Origins" program, the purpose of which is to explore questions regarding "our" cosmic origins and the possibility of life beyond earth. Your agency also states in this section that there is currently a project underway to connect the Keck I and Keck II facilities as an interferometer. It is our understanding that when this current project is complete it will allow the collection of data to fulfill the first two objectives of the "Origins" Program.

Origins?

The ROOK I would like to establish a very important point of reference. The Native Hawaiian peoples have an ancient (millennia old) understanding of man's origin and his relationship to the cosmology of the Universe. While our cosmological understanding stands outside the dominant worldview, it is nonetheless a valid and established empirical model. It led to voyages across the vast Pacific Ocean to the far reaches of the earth thousands of years ago, before many other societies even understood the earth was round. The voyages made by our ancestors were no less of an achievement than space travel is today. Indeed neither the average person nor the above average person today could enter the wa'a (canoe) and find Aotearoa without instrumentation or proper training in the age-old navigational lore of the Pacific Island peoples. 20F

While the search for better understanding into the Universe and our human relationship to the heavens is a noble endeavor and should be supported, Native Hawaiians cannot support it at the expense their own heritage. Nor can we support any activities that would impede our continued knowledge and practice of astronomy and cosmology. Recognize that our understanding of this relationship is rooted and derived from the sacred land of Mauna Kea in its pristine state- the very land under discussion today. The modern world tends to overlook and, in some cases, even overwrite these ancient models and proven beliefs when these methods, if perpetuated and better considered, would lead to a more comprehensive understanding of humankind's origins and these diverse relationships to the Universe.

Failure to Prove Need

It is our understanding that the Outrigger Telescope Project is meant to augment the Keck I and Keck II Interferometer. However, the Draft EA reports that the Keck I and Keck II Interferometer has not been completed, and that no scientific data has been collected with this interferometry technology to date. It is difficult for the ROOK I to support a proposal that expands upon untested science when its presumed benefits are weighed against very real threats to an endangered species, existing burials and the wealth of natural and cultural resources occurring on Mauna Kea 20G

- NASA has failed to justify the need for expansion or further development

The Weikiu Bug Mitigation Plan

In the days of old when the chiefs and konohiki determined that any species was being overtaken a kapu was placed upon that species until it recovered. Under this kapu system no one was allowed to touch that species; violation of the kapu was punishable by death.

> "According to the Kumulipo (Chant of Creation), before man was created all other living things were created. When the process of creation was complete the gods too were complete and walked the Earth with man. It is believed that all living things, no matter how big or small, have purpose and make the complete whole. When a living thing ceases to exist than the process of creation is unbalanced and begins to unravel."
>
> *Testimony by Kealoha Pisciotta - HIBC Commissioner*

The Weikiu bug population has been diminished by 99.7% in just 14 or 15 years leaving a population that is 0.3% of the original. These numbers demand serious and immediate response and recovery efforts.

On page 63, the Draft EA states: "The causes of the Weikiu bug population decline are not known." It is established that any loss of habitat of a species eventually impacts that species negatively. On page C-1 of its Weikiu Bug Mitigation Plan, Pacific Analytics states "It is the intention and hope ... that the Weikiu bug population will actually increase, due to protection and restoration of potentially favorable habitat." The theory behind this proposed plan, to create a new habitat and hope the Weikiu bug will go there and survive, is flawed for two principal reasons:

1.) There is no empirical data outlining what the bugs' behaviors are and how they might respond to the creation of a new habitat, and

2.) the test would be done in parallel with the construction, which will destroy the bugs' original habitat.

It is both just and reasonable that, until further study is conducted and hard data produced (and verified) to prove that the Wekiu would respond to such a theoretical model, we err on the side of caution. The ROOK I is unable to accept a theoretical model that could, in and of itself, diminish the whole species.

- There is no compensation for extinction
- There is a difference between experimentation and mitigation.
- There is no evidence that NASA's proposed mitigation plan would save the Weikiu bug.
- ROOK I does not support the Weikiu Bug Mitigation Plan as presented in the Draft EA. Clearly the plan fails to address the minimum standard of protectior for a species in need of maximum protection. We request that a Federal Environmental Impact Statement pursuant to NEPA be conducted to further evaluate this precious and rare species 20H

<u>Sacred Landscapes and Visual Aesthetics</u>

Na Pu'u

The Pu'u (cindercones) of Mauna Kea are sacred... they are sacred because they mark certain celestial events and because they are the divine kinolau (body forms) of the deities and they mark important events recorded in the geneologies. Changing the surface and digging into these cinder cones is an act of desecration and alters the landscape of Mauna Kea. This desecration prohibits Native Hawaiians' ability to read the celestial signs and desecrates the divine deities. This desecration has occurred for over 32 years 20I

"When you talk about digging in the earth, we talk about Pele, Poli'ahu, we talk about for our Native Hawaiians that's our blood That's the same thing as our physical body."

Testimony by Keolalani Hanoa - HIBC Commissioner

"The telescopes...are actually an obstruction of sight. Now when our kahuna go up there, they cannot turn 360 degrees and see all the places... they have to walk around the telescopes and that's inappropriate."

Testimony by Kalahua Eaton

Visual Aesthetics

The visual vistas cannot only be evaluated from the ground view looking upward but must also include the perspectives from the summit area itself. Further, these evaluations cannot ignore the Native Hawaiians' relationship to the sacred landscape.

- Alterations to the sacred landscape of Mauna Kea prohibits, changes and impedes our traditional and cultural practices.

- Alterations to the sacred landscape destroy reference points critical to the potency of Native Hawaiian oral traditions No one has the right to change our genealogies.

- ROOK I does not support any further alterations to the landscape and view planes of Mauna Kea 20J

Hydrology, Hazardous Materials and Solid Waste Containment Systems.

Hydrology - WAIWAI - Water

The nearest term to wealth in the Hawaiian language is waiwai. The word for water in Hawaiian is wai. This relationship shows the cultural respect and importance the Hawaiian people attributed to water and its essence.

The divine Kanekawaiola, revered in the traditions as the creator and protector of all fresh water, holds a special place in the traditions of Mauna Kea because of the "waters of life" generated there. Poliahu, although best known for her snowy kinolau (divine manifestation and bodily forms), is also of the water.

Contemporary Native Hawaiian practitioners' journey to the Mountain to gather its healing waters. This water is used for medicine, blessings and cleansings and is valued because of its purity. As the snow and ice melt, they become part of a system of underground, inland, shoreline and deep ocean waters that all originate atop Mauna Kea. Hawaiian oral histories document the extent to which Hawaiians understood and valued this important resource. It is said that water from Mauna Kea runs through the ancient 'auwai' systems (waterways for taro irrigation) that are still preserved in Hilo today.

The Draft EA states (pg. 93) "On-site construction and installation of the proposed project, including the potential for a hazardous substance spill, would not impact ground water resources.. "

Mauna Kea is a distinct aquifer system that is linked to other separate, but related, aquifer boundary systems. The East and West Mauna Kea aquifer systems alone produce a sustainable yield of 409 - 444 million gallons per day (mgd). The Mauna Kea aquifer boundary systems also feed the Kohala (at 154 mgd) and NE Mauna Loa (21-56 mgd), SE Mauna Loa (291 mgd), SW Mauna Loa (130 mgd), and NW Mauna Loa (740 mgd) aquifer systems.
(N.B. please see Atlas of Hawai'i by Juvik and Juvik, third edition.)

These aquifer systems are fed by a complex combination of hydrological effects that originate from the summit and move downward. These effects include, but are not limited to, shallow subsurface streams, high level springs, the diurnal fog precipitation that occurs throughout the year, the freeze and thaw cycles of buried fossil ice (found a few feet below the surface), permafrost, snowmelt and even rainfall

While Lake Waiau is the most prominent surface water feature on the Mountain, there are numerous smaller ponds found in the summit cinder cones formed from perching. These also feed the subsurface streams.

The Mauna Kea aquifer systems, subsystems and general hydrology contribute to nearly the entire island of Hawai'i- not only is the hydrology complex, it is massive.

Although the Draft EA does mention the basal waters contained far below the summit region, it ignores the fact that these basal systems are part of the larger hydrological systems of the Mountain. While it may seem that the known surface streams occurring 1000-2000 ft. downstream from the summit development are safe from contamination in the event of hazardous spill, there is no data to support this assumption. According to the Draft EA, the percolation rate for water is 20 inches per hour downstream, if this is true, it would take approximately 52 days for contamination to reach these streams. It is possible contamination would not reach the streams at all; but this cannot be determined from the information provided in the Draft EA. 20K

- The Draft EA does not address the complex nature of the hydrology of Mauna Kea, nor does it adequately address the significant and cumulative impacts the proposed project would have on the cultural and environmental resources of Mauna Kea.

Hazardous Materials

The Mauna Kea Anaina Hou has brought to our attention two very important concerns regarding hazardous materials and solid-waste systems.

In March 2000, in consultation with NASA, the Hawai'i Island Burial Council expressed concern regarding the use of hazardous materials, including but not limited to, mercury, ethylene glycol, and hydraulic fluid. At that time, the HIBC requested from NASA a full disclosure of "...the hazardous materials, including the amounts, safety precautions, and waste disposal..." (*N.B. Please see HIBC March 2000 minutes*) used at the WMKO facility. To date they have not received this information. The ROOK I first became aware of this issue at the March meeting, and we are alarmed that NASA has not responded to the HIBC's request. 20L

The Draft EA states (pg.69) "There have been no mercury spills at the WMKO." The ROOK I is in receipt of a letter from the WMKO Director Dr. Fred Chaffee which is addressed to Nelson Ho of the Big Island Chapter Sierra Club and cites that mercury spills did, in fact, occur on two separate occasions in 1995 20M

(*N.B Please see attached letter from WMKO*). These Inconsistent or conflicting reports do not engender trust in this process, as far as ROOK I is concerned.

The Draft EA does provide a much more comprehensive list of the hazardous materials usage, handling, storage and disposal. The Draft EA however, does not provide information on an emergency plan or a disaster plan as is required by OSHA. Nor does it list the reportable quantities of all materials (i.e. according to the State Department of Health the reportable quantities of Mercury are 1lb). The amount of Mercury used by the WMKO is 30lbs according to the EA. 20N

- What are the emergency response plans and the disaster response plans for elemental Mercury and other hazardous materials?

The Draft EA states, "It is common practice for concentrated hazardous substances to be diluted by WMKO headquarters staff and disposed of by a licensed waste-handling contractor."

- Who are these licensed contractors? 20O
- By whom are they licensed?

It is our understanding from the Draft EA that this license permits the removal and disposal of the following compounds (for which you have listed both the amounts disposed of and reportable quantities used):

1.) Aluminum Chloride,
2.) Aluminum Sulfate,
3.) Copper Chloride,
4.) Copper Sulfate.
5.) Potassium Hydroxide.

We have no information on carbon disulfide

- What are the reportable quantities of this substance?

We understand that carbon disulfide is added to the residual compounds produced as waste from the aluminum removal process. We understand that this is done to "heavy out" the biologically active copper in the "rinse water", so that it will not enter the waste water system and may be removed as a solid waste from the septic tank. 20P

Regarding the elemental mercury, in spite of existing policies, elemental mercury could still be accidentally introduced into the wastewater system if the rubber ring guide containing the mercury was to be punctured or burst as a result of some unforeseen event. We presume that any open drains on the observation deck below the telescope would communicate directly or indirectly with the wastewater drainage system.

Furthermore, mercury spilled on the observing and basement floors could enter the opening where the earth ground wires enter the cinder layers. It should be noted that there is no specific antidote for mercury poisoning. A lethal dose is irreversible. Policies do not prevent accidents, nor do they prevent natural disasters. 20C

- The Draft EA does not adequately address the hazardous materials used for this project, nor does it adequately address the existing and potentially significant and cumulative impacts this project might have on the cultural and environmental resources of Mauna Kea.

Wastewater Collection, Treatment and Disposal

Although Mauna Kea is sacred in its entirety, the summit holds a special status. The disposal of human waste and hazardous waste on the summit profanes the sanctity of the land.

> "When Mauna Kea started up there, I asked Nelson Ho of the Sierra Club, when he goes up that mountain find out where all of the human waste is going. All the waste you folks have up there is going right into our sacred land, our sacred place, our sacred wahi pana..."
>
> *Testimony by Auntie Pele Hanoa*

> "We derive a super sense of spirituality and enlightenment from this place (Mauna Kea)... We also bury our highest born there."
>
> *Testimony by Kala'au Wahilani - State Burials Program Coordinator* 20R

> "The Mountain is a burial site. There are many bones placed there."
>
> *Testimony by Mr. Ed Stevens*

> "That whole Mountain is a cemetery."
>
> *Testimony by Auntie Hanah Reeves*

Mauna Kea is a burial ground. Known burials exist there. The fact that no evidence of disturbance has been produced doesn't change the fact that it is a burial ground - the absence of evidence is not evidence of absence. The thought of human wastewater and toxins flowing over the bones of our Hawaiian ancestors is outrageous and is desecration of the highest order.

Because Mauna Kea summit resides in a Conservation District, the

WMKO wastewater disposal system must be in compliance with the State Health Department regulations for this District The Draft EA states "The WMKO wastewater disposal system has been approved by the State Department of Health." The State Wastewater regulations however, forbid any substances other than human and regular waste from entering the septic tank systems. State of Hawai'i Clean Water regulations require any project that is 5 acres or greater to obtain a National Pollutant Discharge Elimination System (NPDES) permit. 20S

- Does your agency have a special permit to introduce hazardous substances into the wastewater system?
- Does your agency have a NPDES permit?

The Draft EA states "Wastewater enters the two-stage septic tank where bacteria digest bio-solids that settle to the bottom of the tank The wastewater then flows from the septic tank into a 6-m (20ft) deep seepage pit that drains into deep subsurface cinder."

- Could you define or describe this seepage pit? For instance, is this "pit" an open hole in the ground or a lined and contained vault? 20T
- In the event that any hazardous materials other than the "rinse-water" from the aluminizing process were to be introduced into the septic/seepage tank system, what emergency procedures have been established to deal with this scenario? For example, what would the procedures be if mercury were introduced into the system through the open drain system? 20U

The high altitude and freezing conditions create special problems in systems that might, under normal circumstances, be fine.

- Have the sanitation systems been inspected since they were put in?
- What is the date of the last sanitary system inspection, and who conducted this inspection and what technology was used? It is common in many states for sanitation systems to be inspected using video inspection technology. 20V
- Why was this method of waste disposal selected over complete removal of all waste materials from the Mountain? 20W

- The Draft EA does not disclose the Emergency Response and Disaster Response Plans for this project. To date, we have no proof of compliance 20X and have seen no documentation of inspection reports or evaluations by the pertinent agencies.

- The Draft EA does not adequately address the Hydrology Hazardous Materials and Solid Waste containment systems for the Project, which can, and do, significantly impact the traditional, cultural and environmental resources of Mauna Kea.

Summary

In summary, we believe that the Draft EA does not adequately address or mitigate the significant impacts that will be incurred by this project, for the following reasons:

- The Draft EA does not justify why further development is needed.
- The Draft EA Wekiu Bug Mitigation Plan is in direct violation of the traditional practice for species protection and could result in the extinction of the species.
- The Draft EA does not consider traditional rights to gather pristine water resources on the slopes and summit of Mauna Kea. Further, by diminishing the complexity of the Mountain's hydrology, the mitigation measures do not adequately address the project's significant and cumulative impacts and can not protect the resources that, by birthright, belong to the Native Hawaiian people. 20Y
- The Draft EA does not fully evaluate the hazardous materials that would be used by the project. The proposed mitigation measures for handling such materials are therefore inadequate and incomplete.
- The Draft EA does not adequately address the impact of solid waste disposal on traditional beliefs and sensibilities regarding the sacred nature of the Mountain and defecation as an act of desecration.
- The Draft EA does not address the cultural significance of the landscape and therefore the mitigation measures do not address the significant impacts and loss of cultural and traditional use of this landscape.

Conclusion

The ROOK I position has already been articulated regarding further development. However, in order for your agency to be in compliance with it's only laws a full Environmental Impact Statement (EIS) is required. We concur with the Office of Hawaiian Affairs, Hawai'i Island Burial Council, the Native Hawaiian Community and the general public that the impacts outlined in the assessment are significant and worthy of a more in-depth review. We also look forward to the opportunities for public input the EIS process affords. 20Z

We are in agreement with Mr Chaffee's statement "...how we proceed in the future is far more important then what has happened in the past." *(N.B. please see attached Mr. Chaffee's letter to Sierra Club dated - Feb 13, 2001).*

If your agency wishes to move forward and not repeat the omissions, failures, and mistakes of the past, then you must embrace the true Spirit of Aloha, in which protocol demands that everyone take responsibility for your actions now and in the future.

The Environmental Impact Statement would be a first step and is an essential part of that future.

An EIS would pay minimum homage to the spirit of Aloha by providing a minimum standard of protection. It is our hope that the efforts at this juncture will be those that raise the standard of Aloha, by providing the maximum protections for all parties concerned.

Aloha,
On behalf of the Royal Order of Kamehameha I Moku O Mamalahoa,

Kuauhau Mamo Naliko Markel

Kaka'olelo Ali'i Sir Robert McKeen Jr.

Ali'i Aimoku Ali'i Sir Paul Neves K.G.C.K

Royal Order of Kamehamena I
Moku O Mamalahoa.
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*N.B. This report was commissioned by the Royal Order of Kamehameha I Moku O Mamalahoa Heiau O Mamalahoa Helu 'Elua, and compiled by Mauna Kea Anaina Hou, any use of the information contained in this report must obtain express written consent of the above mentioned bodies.

The W. M. Keck Observatory

California Association for Research in Astronomy

Frederic H. Chaffee
Director

February 13, 2001

Mr. Nelson Ho
Sierra Club, Big Island Chapter
32 Kahoa Street
Hilo HI 96720-2206

Dear Nelson:

Thank you for your letter of January 22, 2001, regarding the proposed Outrigger Project and for expressing your concerns regarding "old business." Thank you, too, for meeting with Rolf-Peter Kudritzki and me on February 2 to discuss these concerns and to explore with us positive ways to move forward to avoid future distrust and misunderstandings.

As to the specifics of the two events about which you expressed concern:

1. Work stoppage during Keck I construction because bones were unearthed: I am perplexed regarding the date of purported work stoppage at the Keck I construction site as "sometime in 1991," since the site work for Keck I began in August 1985, and was completed in October 1986. Similarly, Keck II site work wasn't begun until July 1992, and was completed in October of the same year. Thus, 1991 was a "quiet" construction year on the Keck site. Nevertheless, I had our archivist search our monthly records for the entire periods of Keck I and Keck II construction to see if there was reference to any work stoppage for any reason. The only reported stoppages were due to weather; nowhere did I find any reference to stoppages for any other reason.

   I also called Jerry Smith, the then-Project Manager for the Keck Observatory, who retired in 1996, asking him if he remembered any report of bones or any other archeologically significant artifacts, having been unearthed during the construction of the observatory, and he was emphatic that no such events were ever reported either orally or in writing.

   In light of this investigation, I feel as certain as I can, given that the reported event occurred 10 years ago—5 years before my arrival in Hawaii—that no bones or other significant artifacts were unearthed during the construction of the Keck Observatory. I sincerely hope that this matter can be put firmly to rest.

2. Mercury spill in 1995: This report has more substance, as two mercury spills did occur during the cleaning and realuminization process for the Keck II secondary mirror which uses a mercury-filled "bladder" for its support in the telescope (a very standard support technique used at many observatories).

a. The mirror must be removed from its support when it is realuminized, and when this was done on August 10, 1995, a minor spill (about a teaspoon) occurred from the bladder in the summit aluminizing room. According to the written report by our safety officer after the incident, "Approximately three quarters of a teaspoon were suctioned by aspirator into a plastic container and small residual amounts stuck to dust and debris were collected and disposed of in an appropriately marked container. A mercury absorbent paste was then spread over the entire spill area and beyond for about two feet, then removed. Mercury detectant powder was then spread and checked two days later: no residual traces of mercury were evident." As is our standard practice, the collected hazardous material was disposed of by Unitek Environmental of Honolulu.

b. On September 15, 1995, in the process of reinstalling the secondary mirror into the Keck II telescope, when the Hg bladder was receiving its final "top-off," at least 100 ml of Hg was spilled from the bladder vent tube onto the floor of the secondary mirror module. Cleanup, with crews fully suited and masked appropriately, took several days because of the many nooks and crannies in the module. In all, 100 ml were recovered, collected in an appropriate container, and disposed of by Unitek Environmental of Honolulu.

As a result of lessons learned during this episode, our Emergency Response Plan for dealing with mercury spills was carefully reviewed and rewritten. It is mandatory that all personnel handling the secondary mirror during future realuminizings be orally briefed on these procedures, read them carefully, and follow them to the letter.

I hope this information is helpful to you and the Sierra Club. Rest assured that we take these matters very seriously at the Observatory.

As I expressed to you in our meeting, I believe that how we proceed in the future is far more important than trying to reconstruct or pin blame for past events. Since the above-mentioned events, the Directorships at both Keck and IfA have changed hands. As I also mentioned, I am a lifetime Sierra Club member, and Rolf Kudritzki's affiliation with the Green Party goes back many years. This means we both share, at a very deep level, a respect for and determination to protect the environment on Mauna Kea, both physical and cultural. The thoroughness with which we propose to protect both is, I hope, evident by the very stringent controls we put forth in the Federal Environmental Assessment for the Outrigger Telescopes Project.

Let us all pledge that the new millennium will be a time of collaboration between the Observatories, the Sierra Club, Native Hawaiians and all others concerned with the sanctity of Mauna Kea. I am determined that the Outrigger Telescopes Project will serve as a model of such a collaboration.

Aloha,

Fred

Frederic H Chaffee

xc: Rolf-Peter Kudritzki

RESPONSES TO COMMENTS

Commentor No. 20: Royal Order of Kamehameha I (Kuauhau Mamo Naliko Markel; Kaka'olelo Ali'i Sir Robert McKeen Jr.; Ali'i Aimouku Ali'i Sir Paul Neves K.G.C.K.)

Response to Comment 20A:

NASA made a conscientious effort to make the language in the Draft Environmental Assessment and this Final Environmental Assessment as simple to read and understand as possible. We are mindful that in any document that describes a scientific endeavor, scientific terms are simply unavoidable. NASA is striving to use words to make the document as reader-friendly as possible.

As requested, NASA has given Consulting Party status to Mauna Kea Anaina Hou.

Response to Comment 20B:

NASA has conducted consultations with Hawaiian organizations on the Outrigger Telescopes historic/cultural resource mitigation measures. NASA has given "Consulting Party" status to each organization that requested to participate as a Consulting Party.

At the beginning of the project four Hawaiian organizations were participating as Consulting Parties: the Hawai'i Island Burial Council, Hui Mālama I Nā Kūpuna o Hawai'i Nei, Office of Hawaiian Affairs, and the Royal Order of Kamehameha I. Since that time, two more Native Hawaiian organizations requested and were granted Consulting Party status; Ahahui Ku Mauna and Mauna Kea Anaina Hou. In addition, NASA has consulted with and invited the Office of Mauna Kea Management, the Mauna Kea Management Board, and Kahu Ku Mauna to participate in the development of the Memorandum of Agreement. The results of our consultation are reflected in the Memorandum of Agreement provided in Appendix C which lists all the Signatories and all other parties collectively referred to as "Consulting Parties".

A formal Section 106 meeting was held in Hilo on February 1, 2001. In addition, NASA held another Section 106 meeting in Hilo on January 16 and 17, 2002. NASA held two open house meetings in February 2001 in Hawai'i (Hilo and Kona) and held four Town Hall meetings in October 2001 (Kona, Waimea, and Hilo) which were attended by individuals, and organizations and members of the general public who stated their position, asked questions, expressed concerns and support and learned more about the Outrigger Telescopes Project.

NASA representatives have met, formally and informally, with Hawaiian (including Native Hawaiian) groups that have expressed interest in this project. Tables 5.1 and 5.2 in Chapter 5 of this Final Environmental Assessment provide a listing of the consultations and meetings that have occurred between NASA and interested parties concerning the Outrigger Telescopes Project. In addition, several interested groups asked NASA if the comment period could be extended for reviewing the Draft Environmental Assessment. In every case, NASA granted an extension.

Response to Comment 20C:

NASA has consulted with Hawaiian organizations including Native Hawaiian organizations. Such consultations resulted in the Memorandum of Agreement (see Appendix C). See Response to Comment 20B.

RESPONSES TO COMMENTS

Commentor No. 20: Royal Order of Kamehameha I (Kuauhau Mamo Naliko Markel; Kaka'olelo Ali'i Sir Robert McKeen Jr.; Ali'i Aimouku Ali'i Sir Paul Neves K.G.C.K.)

NASA has abided by the prescribed Advisory Council rules for consultation under the National Historic Preservation Act. The Advisory Council has participated with NASA, in two formal Section 106 meetings, on February 1, 2001, and January 16 and 17, 2002.

NASA has also attended meetings with the Office of Hawaiian Affairs, the Royal Order of Kamehameha I, and two meetings with the Hawai'i Island Burial Council. NASA has listened to the concerns of these organizations and has made revisions to the Environmental Assessment and the Section 106 Memorandum of Agreement based on their recommendations.

Response to Comment 20D:

The views expressed by the Royal Order of Kamehameha I about no further development on Mauna Kea are respectfully noted.

Response to Comment 20E:

NASA has considered the views of the Royal Order of Kamehameha I and respectfully refers to the Memorandum of Agreement. See also Response to Comment 20B.

Response to Comment 20F:

Thank you for your comments on your important point of reference. NASA appreciates the history and the use of astronomy by Native Hawaiians.

Response to Comment 20G:

At the time the Draft Environmental Assessment was made public, the commentor was correct, *i.e.*, the Keck Telescopes had not been combined. However, the two Keck Telescopes were combined for the first time as an Interferometer on the night of Monday, March 12, 2001, and became the world's most powerful optical observing system. This first light attempt was a complete success. The first results were obtained on a faint-star (HD 61294) in the constellation Lynx.

The Outrigger Telescopes would need to be added to the Keck-Keck Interferometer to achieve the science objectives. See Section 1.3 of this Environmental Assessment for more details.

The addition of four telescopes to the Keck-Keck Interferometer would allow astronomers to obtain higher resolution images of astronomical objects by allowing the object under study to be viewed at different angles. A minimum of four Outrigger Telescopes would need to be added to the Keck-Keck Interferometer to achieve the science objectives of the project. Adding the fifth and sixth Outrigger Telescopes would almost double the resolution, thereby improving the quality of the scientific observations. Refer to Sections 1.3 and 2.3 for more details.

Response to Comment 20H:

The recommendations in the Wēkiu Bug Mitigation Report are based on data gathered during the 1982, and 1997/98 arthropod assessments (Howarth and Stone 1982; Howarth and others 1999), combined with input from entomologists familiar with Wēkiu bug biology and the best information available in published scientific literature. NASA has consulted with the U.S. Fish and Wildlife Service concerning the Wēkiu Bug Mitigation Report. This report was used to develop the Wēkiu Bug Mitigation and Monitoring plans (see Appendices D and E).

The Outrigger Telescopes Project will not lead to the extinction of the Wēkiu bug. Less than 0.009-ha (0.022-ac) of Wēkiu bug habitat would be disturbed during construction of the Outrigger Telescopes. This would represent about 0.008 percent of the 120-ha (300-ac) estimated size of occupied Wēkiu bug habitat in the summit region of Mauna Kea (Howarth and others 1999). It is the goal of the Wēkiu Bug Mitigation and Monitoring plans to expand Wēkiu bug habitat and enhance the Wēkiu bug population in Pu'u Hau 'Oki.

The habitat restoration protocol is based on the best scientific information available about the habitat needs of the Wēkiu bug. The protocol is based on the following information.

1. Wēkiu bugs appear to prefer habitat made of loose cinder 1.3 centimeters (cm) (½ inch) in size or larger. In past studies (Howarth and Stone 1982; Howarth and others 1999), the highest concentration of Wēkiu bugs were collected in habitat consisting of 25 to 38 cm (10 to 15 inches) of 1.3 cm (½ inch) size or larger cinder, with an impenetrable ash layer below the cinder. This information leads us to conclude that restored habitat consisting of 30 to 46 cm (12 to 18 inches) of loose 1.3 cm (½ inch) size or larger cinder will be acceptable to Wēkiu bugs.

2. Wēkiu bug habitat occurs on undisturbed portions of crater floors in summit cinder cones (Howarth and Stone 1982; Howarth and others, 1999). In 1982, 6,230 Wēkiu bugs were collected on the crater floor of Pu'u Wēkiu and 430 Wēkiu bugs were collected on the crater floor of Pu'u Hau 'Oki. During the 1997/98 arthropod assessment, Wēkiu bugs were found on the crater floor of Pu'u Wēkiu and Pu'u Hau 'Oki, and on the inner slopes of Pu'u Hau 'Oki adjacent to the crater floor. Since suitable habitat does not exist on the crater floor of Pu'u Hau 'Oki, Wēkiu bugs from the adjacent inner slopes apparently migrate to the crater floor. This information leads us to conclude that Wēkiu bugs would likely occupy restored habitat on the floor of Pu'u Hau 'Oki.

3. Given sufficient time, Wēkiu bug habitat appears to recover from disturbance. Of all sites sampled during the 1997/98 arthropod assessment, habitat on the slopes below W.M. Keck Observatory that was disturbed during construction contained the highest concentration of Wēkiu bugs. This information leads us to conclude Wēkiu bugs would eventually occupy the restored habitat.

As part of project implementation, NASA will fund a graduate student to study Wēkiu bug autecology, to gather more information about habitat requirements, life cycle, nutritional requirements, and breeding behaviors. New information may be used to modify the habitat restoration protocol to increase its effectiveness.

RESPONSES TO COMMENTS

Commentor No. 20: Royal Order of Kamehameha I (Kuauhau Mamo Naliko Markel; Kaka'olelo Ali'i Sir Robert McKeen Jr.; Ali'i Aimouku Ali'i Sir Paul Neves K.G.C.K.)

Response to Comment 20I:

Thank you. Your comment is respectfully noted.

Response to Comment 20J:

As the design and development planning have evolved over the past year, NASA has made design changes to maintain the present contour and shape of the cinder cone and to utilize colors, where practicable, to blend into the terrain. We have taken measures to reduce the size of the disturbance on the summit.

Response to Comment 20K:

NASA has evaluated the hydrology associated with Pu'u Hau 'Oki. The ground and surface water sections of the Environmental Assessment have been expanded to encompass these observations. See Sections 3.5 and 4.1.5 and Appendix H.

Response to Comment 20L:

The hazardous materials section has been updated in the text (see Sections 3.9.3 for present conditions and 4.1.9.3 for potential impacts). Both the Draft and the Final Environmental Assessment have been sent to the Hawai'i Island Burial Council. In addition, the Royal Order of Kamehameha I has also received a Draft and Final Environmental Assessment.

Response to Comment 20M:

The available information at the time of the issuance of the draft EA indicated that no mercury spills had occurred at the site. Further investigation by CARA indicated that in fact two mercury spills had occurred and the W.M. Keck Observatory Director issued a letter to that effect. The letter is attached to the commentor's letter and is referenced in this Final Environmental Assessment. Since issuance of the Director's letter, a thorough record search has resulted in identifying a third spill. None of the mercury spills (two spills under 10 ml and one spill under 100 ml) resulted in any of the mercury seeping into the ground or the septic system. All of the spills occurred in 1995, and since then no spills have occurred.

These spills precipitated the creation of a mercury spill procedure, including the availability of a mercury spill kit to contain and clean up a spill. A special vacuum cleaner is included in the spill kit to remove mercury without at the same time creating a hazardous vapor. All waste containers and materials used in the spill clean-up process are preserved, allowing the mercury to settle without vaporizing, prior to disposal by Unitek Solvent Services.

No mercury will be used in the Outrigger Telescopes Project.

Response to Comment 20N:

CARA has a comprehensive Emergency Response Plan dealing with a variety of emergencies (fire, storm, earthquake, etc.) that could occur at both the summit and

Waimea Headquarters. The plan has sections addressing cryogen accidents, general spills (including glycol and hydraulic fluid), and mercury spills. There is a CARA Safety Officer, and many employees share the safety responsibility. Training programs occur periodically throughout the year. Past mercury spills did not result in any of the mercury entering the ground or septic systems.

Response to Comment 20O:

Unitek Solvent Services, Inc., disposes of hazardous substances. Phillip Services Corporation disposes of machine grease.

Response to Comment 20P:

Mirror washing effluents at the WMKO site are no longer released to the WMKO septic system.

Carbon disulfide is not used at the W.M. Keck Observatory. Mirror washing effluents are collected, removed, and transported off the site.

Response to Comment 20Q:

Although there have been three spills (two spills under 10 ml and one spill under 100 ml) associated with the Keck Telescopes, the Outrigger Telescopes use no mercury. The only drain of any kind in the Keck domes is in an exhaust pit. There is no path from main or basement floors to the grounding grid. The ground wire conduit for the emergency generator is sealed.

Response to Comment 20R:

The testimony was respectfully noted.

Response to Comment 20S:

All permits for the W.M. Keck Observatory site on Mauna Kea are held either by CARA or by the University of Hawai'i. The observatory is in compliance with all permitting requirements.

Response to Comment 20T:

The existing seepage tank is 2.7 meters (9 feet) in diameter by 3.7 meters (12 feet) deep hole, the sides of which are lined with perforated concrete rings (2.4 meters (8 ft) inside diameter). The seepage tank is capped with a reinforced concrete lid with a 31-centimeter (12-inch) plug. Effluents entering the seepage tank percolate directly into the underlying cinder.

Response to Comment 20U:

As was stated in Comment Response to 20N, there is a comprehensive Emergency Response Plan for CARA in dealing with a variety of emergencies (fire, storm, earthquake, etc.) that could occur at both the summit and Waimea Headquarters. The primary focus of the plan is on human safety; a secondary focus is equipment safety. The plan has sections addressing cryogen accidents, general spills (including glycol and hydraulic fluid), and mercury spills. There is a CARA Safety Officer, who coordinates and administers the safety programs, and all employees undergo training periodically throughout the year.

As stated previously, no mercury will be used in the Outrigger Telescopes Project.

Response to Comment 20V:

The sanitation system was inspected and serviced on June 13, 2001 by J & Al's Pumping Service. The sanitation system is visually inspected annually.

Response to Comment 20W:

Septic tanks and cesspools were the standard wastewater systems for all observatories on Mauna Kea when the Keck Telescope facilities were built. Consequently, the Outrigger Telescopes will use the standard wastewater systems. No new systems are anticipated.

Response to Comment 20X:

Please see Response to Comment 20N regarding CARA's Emergency Response Plan. With respect to hydrology, please see Sections 3.5 and 4.1.5 of this Final Environmental Assessment, which contain updated information on the hydrology of Mauna Kea. Hazardous materials and solid waste are addressed in Sections 3.9.3 and 4.1.9.3.

Response to Comment 20Y:

This section has been rewritten to reflect our current understanding of the hydrolgoy associated with Pu'u Hau 'Oki (see Response to Comment 20K. See Sections 3.5 and 4.1.5 of the Environmental Assessment and Appendix H for expanded text on ground and surface water resources.

Response to Comment 20Z:

Thank you. Your comment is respectfully noted.

Comments from Hui Mālama I Nā Kūpuna O Hawai`i Nei Regarding Draft Environmental Assessment for Outrigger Telescopes Project (December 2000)
April 10, 2001

Introduction

Hui Mālama I Nā Kūpuna O Hawai`i Nei (Group Caring for the Ancestors of Hawai`i, "Hui Mālama") was born in 1988 in response to the removal of over 1,100 ancestral Native Hawaiian remains from the sand dunes of Honokahua, on the island of Maui, prior to construction of the Ritz Carlton Hotel. Founded by Edward and Pualani Kanahele, the principal focus of Hui Mālama is the care and protection of ancestral Native Hawaiians and funerary objects by returning iwi (bones) and moepū (funerary objects) to their families, to replant them, and to provide perpetual care and protection for burial and reburial sites. Hui Mālama members shall be well versed in ceremonial protocols relating to the treatment of ancestral remains, providing ceremonial reinterment services upon request, or as deemed necessary.

The secondary focus of Hui Mālama is to seek the repatriation of sacred objects and cultural patrimony as part of an ongoing effort to assist with the renewal of traditional spiritual practices that recognize the need for the continued involvement of ancestors and ancestral deities in the daily lives of contemporary Native Hawaiians.

Furthermore, Hui Mālama members shall teach their children the importance of caring for ancestral remains and the importance of the interdependence between the living and the dead for the purpose of insuring the protection of their bones and the perpetuation of the importance of the responsibility to mālama i nā kūpuna.

The overall mission of Hui Mālama is to restore and maintain the ancestral foundation of the Native Hawaiian people by assisting families to resume the historic responsibilities to care for the ancestors, to strengthen the sense of Hawaiian self-identity, and to perpetuate the Hawaiian race and culture.

Comments to Draft Environmental Assessment

Hui Mālama understands that this draft environmental assessment (DEA) is different from the environmental assessment (EA) being prepared by the University of Hawai`i. Moreover, that the DEA is being prepared to support NASA's decision-making regarding whether to continue to fund the Outrigger Telescopes Project. Hui Mālama therefore requests that it be sent the EA and 21A allowed to comment on that document also. Due to the sacred nature of Mauna Kea, Hui Mālama's ultimate recommendation with regard to the DEA and the EA is that a full blown environmental impact statement be prepared in order to properly assess the imperative impact to the cultural and spiritual resources of this important place. 21B

Hui Mālama understands that the two basic questions being asked in NASA's Origins Program is "where do we come from?" and "are we alone?" NASA in turn should understand that our oral history as recorded in chants in particular the Kumulipo provide Kānaka `Ōiwi (Native Hawaiians) with layers upon layers of answers to questions about our origins that we find more than satisfies our own curiosity as to where we come from--we come from pō, from ao and from Hāloa. Given the current state of emergency that Kānaka `Ōiwi find ourselves in with challenges to our federal and state programs and our very existence as a result of the illegal taking of our sovereign authority and lack of recognition by the United States and other international partners, we are compelled to set aside the question whether we are alone as being irrelevant to our very survival.

Hui Mālama is intrigued by the statement that, "NASA, however, will not take final action on this Outrigger Telescopes Project until the decision-making process under NEPA has been completed. It is anticipated that on-site construction and installation would begin in mid-2001." The DEA is dated December 2000 and construction is anticipated for mid-2001, merely seven months following the issuing of the DEA which does not afford sufficient time for a complete and comprehensive review which would lead to proper decision-making under NEPA. There is already a clear indication by the agency that an environmental impact statement is unnecessary and that the consultation period will be brief and Kānaka `Ōiwi concerns, no matter what they are, will be mitigated and if that is not possible, simply ignored. Hui Mālama hopes this is not the case and an appropriate timetable is provided to fully assess all impacts. 21C

The permanent nature of the proposed telescope structures is extremely troubling to Hui Mālama. The existing Keck telescope structures and the disturbance it caused the `āina and the people already degrades and undermines the sanctity of Mauna Kea. Keck serves the scientific interests of the world at the expense of the spiritual interests of Kānaka `Ōiwi for whom these islands were created for by our deities and for whom Mauna Kea holds an important place in our spiritual psyche. We are again reminded that as the indigenous but colonized people of the pae `āina, our fundamental cultural values including spirituality are outweighed by the colonizer's values, be it scientific, economic or both.

Some may argue that further consideration must be given to alternative sites for the Outrigger Project. The problem for NASA of course is that Native people in 21D other parts of the honua (planet) probably attach similar sacred importance to elevated areas that meet NASA's project requirements. We know that this is certainly true at Mt..Graham in Arizona. Another way to look at this situation is to question the true importance of the two questions whose answers are being sought by NASA if to do so would first require desecration to the fundamental beliefs of living Native people and an undermining of their ancestral values. Think interplanetary balanced by the impacts locally. If the former outweigh the latter, than maybe the question is not that important.

Contrary to what is stated on page 8, the on site construction, installation and operation of the Outrigger Telescopes will-- not may-- result in environmental impacts including negative cultural, spiritual and historic impacts that can only be mitigated by not conducting any further construction at Pu`u Hau `Oki and the summit region or any other part of Mauna Kea and more importantly, by removing the current Keck Telescope and related structures. Hui Mālama strongly disagrees that mitigation measures would effectively address the impacts resulting in an acceptable project. <u>We respectfully urge NASA to respect the cultural traditions of Kānaka `Ōiwi and refrain from funding this project.</u>

With respect to archaeological sites, although it is true that extensive impacts from the construction of Keck I and Keck II reduced the probability of discovering burials during proposed on-site construction activities associated with the proposed Outrigger Telescopes, it must be accurately stated that what was really reduced was the probability of finding *in situ* burial sites. Experience has shown Hui Mālama, that construction related activities can result in the destruction of burial sites such that what is discovered after the activities are fragments of iwi kūpuna (ancestral remains) spread throughout the project area. This tragic result has occurred despite the presence of archaeological monitors which is only to say that the presence of such monitors is not in and of itself a complete guarantee that iwi kūpuna will not be negatively impacted and therefore desecrated.

In addition, the DEA needs to be corrected in that only the complete absence of Hawaiian burials or the failure to construct can truly "prevent the inadvertent disturbance of remains." By its very nature, an inadvertent disturbance is just that--- accidental. The presence of a qualified archaeologist will not prevent a bulldozer blade from cutting into a burial, or an excavator from ripping through iwi kūpuna. The monitoring archaeologist can only halt the work once the iwi are negatively impacted. If the project has multiple excavations occurring that outnumber the archaeological monitors, then the effectiveness of mitigating impacts are greatly reduced. Absent from this proposed mitigation, is the lack of Hawaiian cultural expertise. The monitoring archaeologist will not have a doctorate degree and more often than not will not have a master's degree in archaeology. Moreover, the archaeologist will not be knowledgeable in Hawaiian 21E cultural values and practices relating to mālama i nā iwi kūpuna (care of ancestral remains). Inherent in the western view of historic preservation is the misguided believe that the utilization of an archaeologist addresses not only archaeological needs but cultural needs as well. This is simply untrue. While many archaeologists over the years have become much more aware of and respectful to Hawaiian traditions, this is not an adequate substitute for cultural expertise.

Although Hui Mālama is unable to certify the statement that the proposed project "would have no impact on known archaeological sites," we raise a much more important point. Pu`u Hau `Oki is part of a larger cultural landscape whose sacred nature is a sum total of the condition of all of its parts. Hence, the sacredness is undermined by the current activities at the site and the proposed Outrigger Project.

Hui Mālama agrees with the State Historic Preservation Division (SHPD) findings relating to this area of Mauna Kea and the determination that the proposed project will result in "adverse effects." We respectfully disagree with SHPD that these adverse effects can be mitigated. The cultural expertise possessed by SHPD Culture and History staff is acknowledged. However, the perspective of practitioners is separate and distinct from that of knowledge and awareness of such practices. Hui Mālama is comprised of cultural practitioners especially our Kumu Pualani Kanaka`ole Kanahele who has repeatedly stated that Mauna Kea must be left in her natural state. As stated above, the current existence of the Keck I and II telescopes atop Mauna Kea undermines the mana (spiritual essence) of this wahi kūpuna. Therefore, any placement of additional structures only serves to further desecrate the mana of this sacred place. 21F

There is a fundamental difference here which is somewhat systemic to the historic preservation process under federal law. The concerns Hui Mālama raises herein are principally spiritual in nature. However, the proposed mitigation measures address only the physical realm and do not extend into the spiritual. Noise reduction, slope stabilization, prevention of accidental dispersal, etc. do not address the trauma and interference represented by the presence of a structure that is not intended to honor Mauna Kea, but instead seeks to have Mauna Kea serve it. The relationship is inverted and therefore from our perspective, subverted. Once again, the only effective mitigation measure to preserve the mana of Mauna Kea is not to proceed with the proposed project and to instead remove all existing structures off the mountain. 21G

Kānaka `Ōiwi are not urging that the two fundamental questions NASA hopes to address by the proposed project be answered on our sacred places. If the questions are that important to others, then part of the kuleana (responsibility) in seeking to answer those questions must be the responsibility to find a place that is suitable and does not offend fundamental spiritual beliefs of indigenous peoples like us—put the structures somewhere else.

In summary, Hui Mālama urges NASA to adopt the no-action alternative for the reasons stated above.

RESPONSES TO COMMENTS

Commentor No. 21: Hui Malama I Nā Kūpuna o Hawai'i Nei (Edward Halealoha Ayau)

Response to Comment 21A:

We have forwarded your request to receive a copy of the State Environmental Assessment to the University of Hawai'i.

Response to Comment 21B:

Thank you. Your comment is respectfully noted.

Response to Comment 21C:

Thank you. Your comment is respectfully noted.

Response to Comment 21D:

The screening criteria applied in the Alternatives section are appropriate, reflecting the science requirements and engineering considerations of the interferometer.

Response to Comment 21E:

The Archaeologist will be hired by the California Association for Research in Astronomy in consultation with the State Historic Preservation Office and the Office of Mauna Kea Management. As part of the on-site mitigation measures reflected in the Memorandum of Agreement, the California Association for Research in Astronomy will have a Cultural Monitor present during on-site construction and installation and an Archaeologist will be present during excavation activities. All construction and installation workers will be advised of what to look for and how to respond to finding remains. If previously unknown archaeological properties or human remains are discovered during construction, all construction work in the immediate vicinity would stop until appropriate parties are contacted. One archaeological monitor will be adequate for the relatively small area requiring excavation for this project at the WMKO site.

Response to Comment 21F:

Thank you. Your comment is respectfully noted.

Response to Comment 21G:

Comments and recommendations from the Native Hawaiian organizations and other interested parties were taken into account during the development of the Memorandum of Agreement. The results of those consultations are reflected in the Memorandum of Agreement (see Appendix C).

APPENDIX J

RESPONSE TO COMMMENTS RECEIVED AT THE OPEN HOUSE MEETINGS

TABLE J-1. LISTING OF OPEN HOUSE COMMENTORS

Commentor Number	Date of Comment	Organization	Individual Presenting Comments
1	02/07/01	none stated	Lawrence Goff
2	02/07/01	none stated	Virginia Lane
3	02/07/01	none stated	Alex Alcantar
4	02/07/01	none stated	James Allen
5	02/07/01	none stated	Lorraine Higltkin
6	02/07/01	none stated	Dennis Stillings
7	02/07/01	none stated	H.G. Adams
8	02/07/01	none stated	Blaze Rexroat
9	02/07/01	none stated	Caitlyn Evans
10	02/07/01	none stated	Zelda Langdale
11	02/07/01	none stated	Camille Alden
12	02/07/01	none stated	C. Eoalls
13	02/07/01	none stated	Susan Harrison Evans, Esq.
14	02/07/01	none stated	Peter Evans
15	02/07/01	none stated	Linda Horton
16	02/07/01	none stated	Kaliko McDonald
17	02/07/01	none stated	Maurice Boissiere
18	02/05/01	none stated	Sueko Sakai
19	02/07/01	none stated	John F. Villesvik

COMMENTS FORM

Written public comments on environmental impacts and concerns (including historical and archeological factors) and proposed mitigation associated with the proposed Outrigger Telescopes are hereby requested.

Your comments may be written on this form and deposited in the box provided.

Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): Lawrence Goff

Commenter's full address (street, city, state, and zip code) (required):
PO 3132, Kona HI 96745

Comments:

Excellent presentation of all facets of Keck Observatory and ongoing Projects.

Super display. Everyone was very friendly and helpful.

Additional space is available on the other side of this form.

Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☐

Response to Comment 1A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): Virginia Lane

Commenter's full address (street, city, state, and zip code) (required):
P O Box 3132, Kona, HI 96745

Comments:

Fantastic. I really appreciate the time and effort. All the people were super.

Thank You.

Additional space is available on the other side of this form.

Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☐

Response to Comment 2A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): Alex Alcantar

Commenter's full address (street, city, state, and zip code) (required):
P.O. 5165 Kailua Kona HI

Comments: Full speed ahead!
Thank you for bringing this event to Kona!

Additional space is available on the other side of this form.

Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☐

Response to Comment 3A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

Written public comments on environmental impacts and concerns (including historical and archeological factors) and proposed mitigation associated with the proposed Outrigger Telescopes are hereby requested.

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Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): JAMES ALLEN.

Commenter's full address (street, city, state, and zip code) (required): PO BOX 390926 KEAUHOU HI 96739.

Comments:

- I FEEL THAT AS LONG AS NO FURTHER DAMAGE IS DONE TO THE MTN TOP THEN THIS SHOULD GO AHEAD.
- I BELIEVE THAT THERE SHOULD BE SIGNS / INTERPRETIVE INFORMATION AVAILABLE TO ALL VISITORS.
- SHOULD THIS OBSERVATORY/IES EVER BECOME OBSOLETE THEY SHOULD BE REMOVED AND THE LAND RETURNED TO PRE-OBSERVATORY CONDITIONS.
- ALL SPECIES SHOULD BE PROTECTED BY WHATEVER MEANS POSSIBLE.

Additional space is available on the other side of this form.

Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. [X]

RESPONSES TO COMMENTS
Commentor No. 4: James Allen

Response to Comment 4A:

Thank you. NASA appreciates your supportive comments.

Response to Comment 4B:

Signs have been proposed which will tell visitors about the Wēkiu Bug and its habitat, and the historic/cultural resources on Mauna Kea.

Response to Comment 4C:

End of life concerns are addressed in the sublease for the W.M. Keck Observatory.

Response to Comment 4D:

Environmental concerns are addressed in the Environmental Assessment.

COMMENTS FORM

Written public comments on environmental impacts and concerns (including historical and archeological factors) and proposed mitigation associated with the proposed Outrigger Telescopes are hereby requested.

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Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): LORRAINE NIGHKIN

Commenter's full address (street, city, state, and zip code) (required):
PO BOX 563 HOLUALOA HI 96725

Comments:
It has been a very wonderful experience. I enjoyed the exhibits - all very informative.
It is so important to expand the horizons of children - to interest them in space which is their future.
Thank you.

Additional space is available on the other side of this form.

Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☐

Response to Comment 5A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

Written public comments on environmental impacts and concerns (including historical and archeological factors) and proposed mitigation associated with the proposed Outrigger Telescopes are hereby requested.

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Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): DENNIS STILLINGS

Commenter's full address (street, city, state, and zip code) (required): ______

Comments: In the spirit of Traditional Native Hawaiian Sacred astronomy should be promoted. The Outrigger Telescopes should be installed

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Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☐

RESPONSES TO COMMENTS
Commentor No. 6: Dennis Stillings

Response to Comment 6A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

Written public comments on environmental impacts and concerns (including historical and archeological factors) and proposed mitigation associated with the proposed Outrigger Telescopes are hereby requested.

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Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): H. G. Adams

Commenter's full address (street, city, state, and zip code) (required): 32 Wildwood Ave. West Orange NJ 07052

Comments: It appears to me that the addition of 4 small telescopes close to the Keck Telesope would have a minimal impact on the environment.

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Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☒

RESPONSES TO COMMENTS
Commentor No. 7: H.G. Adams

Response to Comment 7A:

Environmental concerns have been addressed in the grading and site development plans as documented in this Environmental Assessment.

COMMENTS FORM

Written public comments on environmental impacts and concerns (including historical and archeological factors) and proposed mitigation associated with the proposed Outrigger Telescopes are hereby requested.

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Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): Blaze Rexroat

Commenter's full address (street, city, state, and zip code) (required): P.O. Box 85 Kailua-Kona, HI 96745.

Comments: Your idea for this display is smart and thoughtful, you should think about doing this often.

Additional space is available on the other side of this form.

Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☐

RESPONSES TO COMMENTS
Commentor No. 8: Blaze Rexroat

Response to Comment 8A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): Caitlyn Evans

Commenter's full address (street, city, state, and zip code) (required): 86-[illegible]438 Middle Keei rode

Comments:
I Like The planetarium very much. I Like the models very much. I like the posters very much I Like the movie very much.

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Response to Comment 9A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

Written public comments on environmental impacts and concerns (including historical and archeological factors) and proposed mitigation associated with the proposed Outrigger Telescopes are hereby requested.

Your comments may be written on this form and deposited in the box provided.

Or, you may send your comments to Mr. Richard J. Howard, Senior Program Executive, Office of Space Science, Code SD, NASA Headquarters, 300 E Street SW, Washington, D.C. 20546-0001. Comments must be provided in writing and received by NASA on or before 4:30 PM Eastern Standard Time February 23, 2001; fax (202-358-3987) or e-mail (kcomments@hq.nasa.gov).

Commenter's name (required): ZELDA LANGDALE

Commenter's full address (street, city, state, and zip code) (required):
120 WASHINGTON ST. KLAMATH FALLS, OR 97601

Comments: Not only educational + enlightening but an obviously heartfelt sensitivity to the cultural + environmental concerns of the island. Another example of cooperation between government and people it represents. Makes me proud!

Additional space is available on the other side of this form.

Place an X in this box if you wish to receive copies of future environmental planning documents on the proposed Outrigger Telescopes that NASA distributes to the public. ☐

Response to Comment 10A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): Carmille Alden

Commenter's full address (street, city, state, and zip code) (required):
813 W BATAAN, RIDGECREST CA 93555

Comments: GREAT! KEEP UP THE GOOD WORK! WONDERFUL PRESENTATION!

Additional space is available on the other side of this form.

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Response to Comment 11A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): [illegible]

Commenter's full address (street, city, state, and zip code) (required):
78-131 [illegible] Kailua Kona HI 96740

Comments:

This exhibit should have been seen by every 5th grader in town

Additional space is available on the other side of this form.

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Response to Comment 12A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): Susan Harrison Evans, Esq.

Commenter's full address (street, city, state, and zip code) (required):

83-5438 Middle Keei Rd, Capt Cook, HI

Comments:

I loved the exhibits and written materials. The children enjoyed the Planetarium immensely. The open house provided the entire family with a much better understanding of the facilities and plans for the future. The models of the telescopes were especially interesting to me. Programs such as this help the community outreach/relations aspect of your program. Perhaps more advance planning with local schools so that more children could attend would be a good idea next time.

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RESPONSES TO COMMENTS

Commentor No. 13: Susan Harrison Evans, Esq.

Response to Comment 13A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): Peter Evans

Commenter's full address (street, city, state, and zip code) (required):
83-5438 MIDDLE KEEI RD. CAPT COOK, HI 96704

Comments:
THE INFEROMETER IS A MARVEL OF ENGINEERING AND A TESTAMENT TO MANS NEVER ENDING QUEST TO SOLVE THE MYSTERY OF THE UNIVERSE. THANK YOU FOR THE EXHIBITS AND GOOD LUCK IN ALLOWING THE PUBLIC BOTH TO ~~SEE~~ VISUALIZE AND HOPEFULLY SEE THE OUTRIGGER PROJECT TO ITS FRUITION. IT WILL BE A BENEFIT TO MANKIND.

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Response to Comment 14A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): LINDA HORTON

Commenter's full address (street, city, state, and zip code) (required):
218 The Shores at Waikoloa, Waikoloa, HI

Comments:
The exhibits and personnel were very informative + did an excellent job of answering questions about the telescopes themselves + their impact on the Summit.
While the ~~cultural~~ impact on the Hawaiians + Their culture must be given careful consideration, the scientific knowledge obtainable at this site will benefit all of mankind. This is undeniably the best viewing site on earth. There has to be room for compromise with The native peoples. Go for it!

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RESPONSES TO COMMENTS
Commentor No. 15: Linda Horton

Response to Comment 15A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): Kaliko McDonald

Commenter's full address (street, city, state, and zip code) (required): P.O. BOX 85 Kailua-Kona HI 96745

Comments: This is the most coolest thing that ever happened to me. I just love the free things that we can get. I hope this goes on every year. If it does I want to come every chance that I get.

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RESPONSES TO COMMENTS
Commentor No. 16: Kaliko McDonald

Response to Comment 16A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): Maurice Boissiere

Commenter's full address (street, city, state, and zip code) (required):
76-4362 LEILANI ST. KAILUA-KONA 96740

Comments:
Congratulations!! This is a great use of public money to educate the public - young & old on the benefits of the science being done at Mauna Kea.

I know about the environmental & historical preservation concerns but I am sure a balanced approach is feasible to developing the astronomy on Mauna Kea even further. I'm only sorry that all of the 6 outrigger scopes could not be done at this time.

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Response to Comment 17A:

Thank you. NASA appreciates your supportive comments.

COMMENTS FORM

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Commenter's name (required): Sueko Sakai

Commenter's full address (street, city, state, and zip code) (required): 161-A Panaewa St. Hilo, Hawaii 96720

Comments: I want you to know that what Andrew Perala is doing with the children of these islands is absolutely wonderful. I had an opportunity to work with a learning disabled high school student, an attempt to broaden his learning experience, and Andrew Perala provided a hopeful learning experience for him & any child. What excites me about Andrew is that his work with the children is quite fruitful as exemplified in the Kamehameha pre-schoole are into astronomy, the children's W.M. Keck Observatory's webpage his responding to my expectations to open new learning experience for a L.D. high school student, and perhaps something else. Today I learned about a few of those something else are, namely, the children from Kauai are visiting W.M. Keck Observatory. What was most exciting was to meet Andrew. His personality is warm & friendy, knowledgeable & sensitive, and full of positive energies. Andrew Perala is certainly an asset to have at Keck Observatory, and more importantly for our country, for obvious reasons. What is reflected in Perala is Keck's philosophy. Thanks for being a positive factor in our society.

S. Sakai

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RESPONSES TO COMMENTS
Commentor No. 18: Sueko Sakai

Response to Comment 18A:

Thank you for your support of the education programs.

COMMENTS FORM

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Commenter's name (required): JOHN E VILLESVIK

Commenter's full address (street, city, state, and zip code) (required): P.O. BOX 188 NAALEHU HI 96772.

Comments: I HAVE BEEN FOLLOWING THE DEVELOPMENT OF THE ASTRONOMY CENTER ON MAUNA KEA FOR SEVERAL YEARS. HAD A STORE IN KAILUA KONA FOR 20 YEARS - HAVE ATTENDED HEARINGS & GIVEN TESTIMONY. I FAVOR THE DEVELOPMENT OF THE OUTRIGGER TELESCOPES. IF THEY ARE DENIED & NOT INSTALLED, THE KECKS WILL NOT REACH THEIR FULL POTENTIAL & ~~EVEN~~ THE NASA PROGRAMS, INDEED ALL OTHER PROGRAMS WILL DIE. WE ARE THE PREMIER VIEWING SITE IN THE WORLD, WE WILL LOOSE OUR COMPETITIVE EDGE TO THE OTHER LOCATIONS IN THE WORLD SPROUTING OBSERVATORIES, SUCH AS CHILE.

THE E.A. FOR THE OUTRIGGER TELESCOPES IS ONE HELLUVA COMPLETE DOCUMENT/STUDY. WHAT YOU PROPOSE FOR THE WEKIU (SP) BUG IS OUTSTANDING & SHOWS GREAT CONCERN FOR DOING THE RIGHT THING.

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I VISITED YOUR SHOW & EXHIBITION IN KONA TODAY (WED 2/7) - IT WAS VERY INFORMATIVE, INTERESTING, & SHOULD HAVE GAINED A LOT OF SUPPORT FOR THE PROJECT. ONLY THE MOST HARDENED FANATIC WOULD BE UNMOVED.

THANK YOU FOR YOUR EFFORTS. YOU HAVE MADE HAWAII A BETTER PLACE TO LIVE & WORK. COUNT ME IN!

JOHN F. VILLESVIK

John F Villesvik

RESPONSES TO COMMENTS
Commentor No. 19: John F. Villesvik

Response to Comment 19A:

Thank you. NASA appreciates your supportive comments.