University of Hawai‘i Institute for Astronomy
Haleakalā High Altitude Observatory Site
Long Range Development Plan

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http://www.ifa.hawaii.edu/haleakala/LRDP/

Prepared by

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1.0 EXECUTIVE SUMMARY

Haleakalā is one of the most important astronomical sites in the world and Haleakalā Observatories (HO), located on Pu‘u Kolekole near the summit, is the embodiment of this unique science resource. The importance of Haleakalā for the University of Hawai‘i (UH) can be measured by its long history of contributions to scientific research and by the continued attention it receives today from the UH community and its academic partners along with the National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), United States Air Force, and other domestic and international agencies.

From the astronomer's viewpoint, Haleakalā site characteristics are different from those on neighboring Mauna Kea on the Big Island, which results in somewhat different scientific objectives from the focus on Mauna Kea. In contrast to the Mauna Kea sites, astronomy at Haleakalā represents a much smaller fraction of all summit interests (approximately 1% of the summit acreage). Nevertheless, from the 1950s through the early 1970s the Haleakalā Observatories supported virtually all of the University's international astronomical research. Today it continues to play a crucial role in the University's research and education plans. It is clear that Haleakalā has a fundamental role to play in synoptic and long-term astronomical research using moderate aperture nighttime and solar telescopes.

Development on Haleakalā is fundamentally limited by the fact that the University's land parcel is 18.166 acres. Of this area, 4.5 acres are leased to the United States Army Corps of Engineers for the United States Air Force Maui Space Surveillance Complex (MSSC). The small land area means that projects located at the Haleakalā Observatories must be carefully selected to maximize the scientific productivity and benefits to the University and the State. The smaller scale of these programs means that more attention will be directed toward implementation of unique capabilities in which the University will play a leading development and operational role. Thus, University and Institute for Astronomy (IfA) planning must be aimed at reserving the limited number of sites on Haleakalā to facilities that can make the greatest scientific use of the excellent site attributes, and to those that will play a major role in the University's programs of education and public outreach.

In part because the United States Air Force Maui Space Surveillance Complex covers a significant portion of Haleakalā Observatories' usable area, HO is unique in its mutually beneficial combination of defense-related astronomical researchers and purely academic physicists and astronomers. This combination of expertise results in important benefits for our traditionally separate research communities, and we expect to enhance and further realize these opportunities in the future. Due to the IfA's extensive experience in instrumentation development, it is well poised to play a leading role in this research.
The proliferation of broadcast antennas within and adjacent to the Haleakalā Observatories remains a major concern. Radio frequency interference far exceeds the acceptable level set by the International Astronomical Union. The University is working with the broadcasters, the Air Force, and the Department of Land and Natural Resources to relocate broadcast facilities at sufficient distance to both reduce radio interference to acceptable levels and meet present and anticipated future commercial and civil broadcast coverage requirements.

Although modern day astronomy is an important activity on Haleakalā, Haleakalā is also a locus of cultural and natural resources. Its human cultural history dates back more than a thousand years and is an integral part of the Hawaiian culture, both past and present. It was a place of ancient prayer and balance, spiritual manifestations, the art of healing, and it was used for navigation. It was a Wahi-Pana, a very special religious place that was used as a training site in the arts. Kolekole has archaeological features, sites of historic value and spiritual vistas. The area around Kolekole is also home for many burrows of the ‘Ua‘u, or Dark-rumped Petrel, a seabird that is federally listed as an endangered species, and it hosts a diversity of botanical and invertebrate species.

In broad terms, this Long Range Development Plan (LRDP) describes the general environmental, cultural, and historic conditions and the site characteristics that will guide future development. It also describes the principles that define the scientific programs that UH strive to maintain and develop at HO, and the potential new facility developments that will keep UH in the forefront of astronomy into the next decade. In order to describe and to protect this resource while accommodating the growing need for public scrutiny and partnering in our astronomical planning, the IfA planning process for long-range development takes into consideration the environmental, cultural, and historic importance of Haleakalā.

Therefore, one intent for this document is to provide a vehicle for consultation with the greater Maui community, Upcountry organizations and individuals concerned about development as well as Native Hawaiian interests, our Haleakalā neighbors such as the National Park Service, the United States Air Force, the Department of Land and Natural Resources, and any other interested agencies and individuals.
2.0 INTRODUCTION
The State of Hawai‘i is fortunate to have two astronomical sites that are among the best in the world. Advantageously, the University of Hawai‘i has developed the Institute for Astronomy (IfA) into one of the leading national and international astronomical institutions. The resulting research capability, prestige, and growth in funding has been of great benefit to the State. The main factor contributing to this recent rapid growth of astronomy has been the operation of high-altitude astronomical facilities on Haleakalā, Maui, and Mauna Kea, Hawai‘i under the direction of the IfA.

Haleakalā Observatories plays a significant role in the astronomy program of UH. Haleakalā's relatively isolated location, high elevation, relatively flat terrain near the summit, dry climate, and clear skies combine to make it highly attractive for many types of astronomical observations. Additionally, the local availability of skilled technical support personnel contributes to Haleakalā's favorable attributes. Haleakalā is also a principal site for optical and infrared surveillance and active laser illumination of objects launched into Earth orbit - activities that are crucial to our nation's space program.

Astronomy and related activities on Haleakalā now stand at the threshold of a period of marked change that offers great opportunities, including closer interactions between the scientific and space surveillance communities, which are already underway. For example, astronomical work is being undertaken with the Air Force 3.7-meter Advanced Electro-Optical System (AEOS) Telescope. The characterization, improvement, and preservation of the astronomical optical/infrared observing qualities of the site are actively being pursued. Thus, with proper planning, HO will continue to be a major resource for UH and State of Hawai‘i.

2.1 HISTORICAL OVERVIEW
The summit of Haleakalā has hosted astronomical research for almost half a century. In the early 1950s, Grote Reber, one of the pioneers of radio astronomy, experimented with radio interferometry using a large steel and wood truss antenna. Site testing for a solar observatory began in 1955. In preparation for the International Geophysical Year (1957-58), the Smithsonian Astrophysical Observatory, assisted by Dr. C. E. Kenneth Mees, a retired vice president of Eastman Kodak, approached UH to locate a Baker-Nunn satellite-tracking telescope on the mountain - a facility that remained operational until 1976. Another early astronomy program on Haleakalā was night-sky photometry, including measurements of the airglow and zodiacal light.

In 1961, Executive Order 1987 from Hawai‘i’s Governor Quinn to UH, set aside 18+ acres of land on the summit of Haleakalā to establish the Haleakalā Observatories site (Figure 2-1). Other agencies established adjacent facilities through Executive Order during the same period.
The University of Hawai‘i Institute for Astronomy is responsible for managing and developing the land.

Planning for a much-anticipated solar observatory began in earnest in 1961 with the founding of the Hawai‘i Institute for Geophysics at UH. Funding for the observatory was obtained from the National Science Foundation and ground was broken for the facility in February 1962. The facility was dedicated in January 1964 and was named the C. E. Kenneth Mees Solar Observatory to honor the man who did so much to help UH begin its astronomical programs on Haleakalā.

Haleakalā has also been the home of the Air Force Maui Space Surveillance System (MSSS) for more than four decades. Ground was broken for construction of the Advanced Research Projects Agency (ARPA, later DARPA) telescope facility in 1963, and first light was achieved in 1965. In 1967, ARPA designated the site for Western Test Range midcourse observations under the auspices of the University of Michigan, Ann Arbor. The ARPA Midcourse Optical Station, as it was known back then, began routine missile tracking operations in 1969 under contractors AVCO Everett Research Laboratory and Lockheed Missiles and Space Company. In 1975, the site became the ARPA Maui Optical Station, and ultimately the MSSS. Daily routine satellite tracking operations were inaugurated in 1977 as the Maui Optical Tracking and Identification Facility (MOTIF). In addition to MSSS, the Air Force has located three smaller telescopes for deep space surveillance as well as support facilities on Haleakalā. The entire Air Force site, known as the Maui Space Surveillance Complex (MSSC), comprises the largest single user area on the mountain.
Figure 2-1. University of Hawai‘i Haleakalā Observatories and Adjacent Properties
2.2 LOCATION AND PRESENT FACILITIES

The land designated and assigned to the University of Hawai‘i in 1961 for scientific purposes by Governor Quinn's Executive Order 1987 is located at Tax Map Key 2-2-7:08 (Figure 2-2) on State of Hawai‘i land within the Conservation District, on Pu‘u Kolekole, near the summit of Haleakalā, about 0.3 miles from the highest point, Pu‘u Ula‘ula, or Red Hill Overlook, which is in Haleakalā National Park. At an elevation of 10,023 feet, Haleakalā is one of the prime sites in the world for astronomical and space surveillance activities. The Kolekole cinder cone lies near the apex of the Southwest rift zone of the mountain. The rift zone forms a spine separating the Kula Forest Reserve from the Kahikinui Forest Reserve, both of which are pristine lands along the rift zone.

Presently, facilities located within HO (Figure 2-3) observe the Sun, provide a world-class telescope for education and research outreach to students all over the world, use lasers to measure the distance to satellites, track and catalogue man-made objects, track asteroids and other natural potential space threats to Earth, and obtain detailed images of spacecraft. It is a principal site for optical and infrared surveillance, inventory and tracking of space debris, and active laser illumination of objects launched into earth orbit, activities that are all crucial to the nation's space program.

Over the past 45 years, HO has experienced steady growth of scientific research within its boundaries. The major UH facilities at HO are the C. E. Kenneth Mees Solar Observatory (MSO) and the Lunar and Satellite Ranging Observatory (LURE). UH IfA has operated the Mees Solar Observatory since 1964 and the Lunar and Satellite Ranging Facility from 1972 until 1993. The scientific programs at MSO emphasize studies of the solar corona and chromosphere. LURE, which has been operated by UH IfA under contract to the NASA Goddard Space Flight Center, has supported the NASA Space Geodesy and Altimetry Projects, has provided NASA with highly accurate measurements of the distance between LURE and satellites in orbit about the earth, and which was involved in the NASA Crustal Dynamics Project.
Figure 2.2. Tax Map Key Setting of Haleakalā Observatories Land
Figure 2-3. Aerial of Haleakalā Observatories Looking North
The University of Tokyo, the National Observatory of Japan, and the Australian National University have installed a 2-meter telescope in the 9-meter North dome of the LURE complex to support the Multi-color Active Galactic Nuclei Monitor (MAGNUM) Project. The MAGNUM telescope is used for long-term monitoring of many active galactic nuclei (AGNs) and quasars at wavelengths ranging from infrared to ultraviolet. The MAGNUM telescope is used for measuring the distances of AGNs and quasars from those nearby out to a redshift of \( z = 1 \). The ultimate goal is to determine the destiny of the universe and decide whether it will continue to expand forever or begin to contract at some time in the future.

The Faulkes Telescope Facility houses the largest educational outreach optical telescope in the world and will shortly be operational in support of astronomy research and education for grades K-college in Hawai‘i and the United Kingdom. This new 2-meter telescope was financed largely by private funds from the United Kingdom (UK) through the Faulkes Educational Trust. The Faulkes Telescope Corporation, a nonprofit Hawai‘i corporation, built, owns, and will operate the telescope. The Faulkes Telescope will be operated remotely over the Internet, without need for permanent on-site operational staff. Control centers in the UK and at Maui Community College will provide for remote operations. As of the spring of 2004, the Faulkes Telescope was in its operational testing phase and is expected to be available to students for the fall semester.

Other facilities within HO include a Cosmic Ray Neutron Monitor Station operated in association with the University of Chicago Enrico Fermi Institute and the Faulkes Telescope Facility. The Haleakalā Cosmic Ray Neutron Monitor is the only such station in the world.

UH IfA has a support staff that serves both the LURE and Mees Solar Observatory's. Services include administration, personnel and purchasing support, as well as vehicle and building maintenance functions. The support staff serves a total of 17 technical, scientific, and engineering staff on Maui. A support facility located at HO consists of an office building, electronics lab, and vehicle maintenance shop. UH also operates a modest dormitory facility at HO, primarily for use by observers at the Mees Solar Observatory.

IfA also allocates sites on Haleakalā for optical and infrared experiments and observations carried out by the Air Force Research Laboratory (AFRL), which is the command with responsibility for the Maui Space Surveillance Complex (MSSC). One part of the MSSC is the Maui Space Surveillance System (MSSS), a state-of-the-art electro-optical facility combining operational satellite tracking facilities with a research and development facility. The MSSS houses the Department of Defense's (DoD) largest telescope, the 3.67-meter Advanced Electro Optical System (AEOS), as well as several other telescopes ranging from 0.4 to 1.6 meters.
Another major part of the MSSS is the Ground-Based Electro-Optical Deep Space Surveillance System (GEODSS), which is one of three operational sites in the world performing ground-based optical tracking of space objects. The main telescope has a 102 cm aperture and a 2 deg field-of-view and is used primarily to search the deep sky for faint (+16 magnitude), slow-moving objects. The auxiliary telescope has a 38 cm aperture and 6 deg field-of-view, and does wide area searches of lower altitudes where objects travel at higher relative speeds. The telescopes are able to "see" objects 10,000 times dimmer than the human eye can detect.

3.0 GOALS AND OBJECTIVES
This Long Range Development Plan for HO reflects multiple UH responsibilities. Haleakalā Observatories is a preeminent state, national, and international resource for astronomical and related studies. In order to continue in the forefront of astronomy, UH must provide high-quality research and training facilities, and place special emphasis on programs that have distinctive attributes, while maximizing both the educational and scientific benefits for UH and State of Hawai‘i. It is just as important that these goals be achieved while preserving, protecting, integrating, and balancing cultural, natural, and education/research values on Haleakalā. In recognition that it is a Hawaiian place with significant and unique cultural resources, this Long Range Development Plan is intended to:

1. Provide to the larger community a guiding document for communicating physical and management plans for the Haleakalā Observatories in view of the above objectives.
2. Provide guiding principles for future planning and selection of projects within HO, in light of our detailed knowledge of the environmental, cultural, and historic resources, so that Haleakalā can continue to be a unique facility for astronomical research while maximizing the scientific, educational, and socio-economic benefits to the people of Hawai‘i; and,
3. Provide a guiding document that may be useful for seeking the funding (government, private, national, and international) needed to realize the potential of HO.
4.0 METHODOLOGY

Beginning about 1980, numerous studies of environmental, cultural, historic, and economic resources, as well as potential impacts to those resources, have been undertaken at Haleakalā Observatories for various purposes. Construction of the Air Force Ground-Based, Electro-Optical Deep Space Surveillance system (GEODSS) was preceded by an Environmental Assessment (EA) in 1980, an EA was completed for the AEOS telescope in 1994, and another filed with the State of Hawai‘i prior to recent construction of the Faulkes Telescope Facility in 2001. Other assessments have been completed for environmental compliance management. While the resource descriptions in these assessments frequently encompassed the whole 18+ acres, many studies were focused on the specific project areas within HO. Some of the assessments addressed cumulative impacts on the site that may have been incurred by new construction of those three facilities since 1980.

For this Long Range Development Plan, comprehensive, site-wide environmental, cultural/historic, and conceptual planning studies, surveys and inventories were completed during 2002-2003. The survey work was coordinated with the appropriate State agencies where required, and although much prior work was already available as reference resources, all the qualified experts involved conducted their own field and laboratory work at the HO site to collect samples, examine in-situ materials, take measurements, etc. The surveys and studies established current conditions in support of the guidelines for the future physical and management planning described in Sections 8 and 9 of this document.

Surveys and studies for this Plan include geological history, structure, and geochemistry, distribution and inventory of botanical resources, avifaunal distribution and population analysis, description and inventory of invertebrate species, identification and significance of historic and cultural resources, inventory and analysis of archaeological resources, survey of traditional practices, calculations for current and potential visual lines-of-sight, and current traffic volume. Information concerning current and potential economic benefits to UH and the State of Hawai‘i has also been incorporated. The surveys and studies are summarized in Section 5.
The University of Hawai‘i intends for this document to have broad community input. The results of such input will be integrated into a final version of the Long Range Development Plan. It is not intended that any future potential construction or significant new project be undertaken without such input. It also noted that projects discussed in Sections 8 and 9 constitute all potential expansion of facilities and optical assets in the next decade, so far as is known at the time of publication of this document.

5.0 CURRENT ENVIRONMENTAL CONDITIONS AT HALEAKALĀ
This section contains summary descriptions of the current environmental and physical conditions on and immediately adjacent to the 18+ acres designated by Executive Order 1987 for the University of Hawai‘i to use for the purposes of scientific research. Detailed descriptions are contained in the extensive surveys, studies, and inventories that were conducted during the period 2002-2003, and which are appended to this Long Range Development Plan.

5.1 GEOLOGICAL HISTORY AND THE SIGNIFICANCE OF PU‘U KOLEKOLE
Haleakalā Observatories is wholly contained within Pu‘u Kolekole. The Kolekole volcanic center is located in East Maui on the southwest rift of Haleakalā, adjacent to the deeply eroded and spectacular summit depression. Alkalic lava flows in this area belong to both the post-shield stage Kula series as well as to the initial phase of the rejuvenated stage Hana series. The observatories are largely built on ankaramitic picro-basalts and some basanites (Appendix A). The recent geological field studies completed for this Long Range Development Plan describe the Haleakalā Observatories property as an asymmetric volcanic cone whose slopes are steeper at the western and northwestern sides, while the eastern and southern slopes are gentler. Much of the northern slope (most of which is occupied by the Air Force Maui Space Surveillance Complex) is flattened and had been disturbed. The central crater of Kolekole is described as a flattened bowl of ponded ankaramite lava, spatter and pyroclastic ejecta. More than one eruptive vent was present on Kolekole. The primary vent was likely in the approximate position of the present day LURE observatory, and one prominent likely secondary event is within the wide depression near the western border of the property (Appendix A: Figure 5).
The significance of Pu‘u Kolekole appears to be a result of its geographical position near the apex of the southwest rift zone of Haleakalā, which resulted in a somewhat unusual volcanic history. Kolekole exhibits both post-shield (Kula) volcanism and the initial stage of rejuvenated (Hana) alkaline volcanism in proximity to each other on or near the surface. Samples from different eruptive centers on the site that were collected and analyzed demonstrate that the transition between eruptive cycles was taking place at Pu‘u Kolekole. Age dating of lavas from the site and micro-chemical barometry confirm this unusual confluence of what are two distinct volcanic regimes elsewhere on Maui.

5.2 BOTANICAL RESOURCES
The vegetation type at Haleakalā Observatories is an *Argyroxyphium/Dubatia* alpine dry shrubland. Dry alpine shrublands are typically open communities, occurring at 3,000 to 3,400 m (9,842 to 11,155 ft) elevation, predominantly on barren cinders, with very sparse vegetation cover (Wagner et al. 1999). The substrate is a mixture of ash, cinders, pumice, and lava (MSSC 2002). The vegetation is sparse, from a near barren <1% cover to about 10% cover. The vegetation is also low, no more than one meter (3 ft) tall anywhere on the site. During the most recent survey (Appendix B), a total of 32 plant species were observed. Of these, 11 (34%) were native and 21 (66%) were non-native.

Within the site there are two general types of land area: undisturbed and those where construction has occurred. Undisturbed areas are comprised of predominantly native plants including shrubs, such as na‘ena‘e (*Dubautia menziesii*), pukiawe (*Styphelia tameiameiae*) and ‘ohelo (*Vaccinium reticulatum*), herbs, such as tetramolopium (*Tetramolopium humile*), and grasses, including bentgrass (*Agrostis sandwicensis*), hairgrass (*Deschampsia nubigena*), and mountain pili (*Trisetum glomeratum*). Three species of native ferns, ‘iwa ‘iwa (*Asplenium adiantum-nigrum*), ‘oali‘i (*Asplenium trichomanes* subsp. *densum*), and kalamoho (*Pellaea ternifolia*) are found tucked into rock crevices and overhangs around the LURE Observatory and on the steep slopes on the southeast part of the property near the Mees Solar Observatory.
Areas of UH property where construction has occurred generally support fewer native species and contain more weeds. One notable exception is the endemic silversword or 'ahinahina (Argyroxyphium sandwicense subsp. macrocephalum) which is found exclusively on areas where construction has occurred. Weeds found in these disturbed areas include non-native herbs, such as thyme-leaved sandwort (Arenaria serpyllifolia), storksbill (Erodium cicutarium), hairy cat's ear (Hypochoeris radicata), sweet allysum (Lobularia maritima), common mallow (Malva neglecta), black medick (Medicago lupulina), evening primrose (Oenothera stricta subsp. stricta), common plantain (Plantago lanceolata), polycarpon (Polycarpone tetraphyllum), sheep sorrel (Rumex acetosella), wood groundsel (Senecio sylvaticus), sow thistle (Sonchus sp.), and common dandelion (Taraxicum officinale). These areas also harbor a selection of non-native grasses, including sweet vernalgrass (Anthoxanthum odoratum), rescue grass (Bromus willdenowii), Bermuda grass (Cynodon dactylon), Yorkshire fog (Holcus lanatus), annual bluegrass (Poa annua), Kentucky bluegrass (Poa pratensis), and brome fescue (Vulpia bromoides).

The only "trees" found on the property were two unidentified pines (Pinus sp.) located between a weather station tower and the MSO. The pines were about 20 cm tall and looked more like a small multi-branched shrub than a tree. This was the first record of pines on the summit of Haleakalā. It was not known if the trees were planted, arrived as contaminants in soil, or blew in on the wind. Though small, they appeared to be many years old. At the recommendation of the Friends of Haleakalā National Park, the trees were removed.

**5.2.1 ENDANGERED, THREATENED, LISTED, OR PROPOSED PLANT SPECIES**

Haleakalā silverswords (Argyroxyphium sandwicense subsp. macrocephalum) are federally listed as a "threatened" species, meaning they may become endangered throughout all or a significant portion of their range if no protective measures are taken. Nine live silverswords and three dead silversword flower stalks were located on UH property. All of the live plants are on the MSSC site. Despite being quite large, up to 50 cm (20 in) in diameter, these nine live silverswords apparently are all less than five years old and have grown since construction of the Advanced Electro-Optical System (AEOS) facility (Appendix B). They are located in landscaped areas, alongside retaining walls, on a steep slope just below the parking area, and in the MSSC septic leach field. There are also three dead silversword flower stalks on UH property. National Park Service personnel placed two of the stalks near the MSSC septic leach field. The other dead silversword flower stalk is located near the LURE observatory and was alive in 1991 (Air Force 1991).
5.3 FAUNAL RESOURCES
Faunal resources at Haleakalā Observatories consist of avifaunal species, invertebrates, and mammals. Each of these populations is described below.

5.3.1 AVIFAUNAL RESOURCES
5.3.1.1 ‘Ua‘u (Hawaiian Dark-rumped Petrel)
The ‘Ua‘u, or Hawaiian Dark-rumped Petrel (*Pterodroma phaeopygia sandwichensis*), is the only seabird that is federally listed. About 85% of the world's known population nests on Haleakalā, Maui, near the summit. Most of the population is within National Park boundaries (Figure 5-1). About 55 burrows are within 1/4 mile (400 meters) of the Haleakalā Observatories, but outside National Park boundaries (Appendix C). These are considered part of the “Haleakalā population.” Haleakalā National Park biologists have been conducting regular monitoring and searches of ‘Ua‘u nests since 1988.

‘Ua‘u are at the Haleakalā colony from February through November each year. The birds make their nests in burrows and use the same burrow year after year. Not all burrows are occupied. Regular monitoring include monthly checks of whether or not burrows are occupied and which nests successfully fledge young birds. ‘Ua‘u fly at night; and they fly from the ocean to the Haleakalā colony just before sunset and leave the colony for the ocean just before sunrise. These birds fly up the slopes of Haleakalā, some passing near the Haleakalā Observatories. The 13 burrows immediately surrounding HO are shown in Figure 5-2, which was derived from data obtained during the 2003 survey (Appendix C).
5.3.1.2 Nene (Hawaiian Goose)
The Hawaiian Nene (Branta sandvicensis or Nesochen sandvicensis), currently on the Federal List of Endangered Species, are found only in the Hawaiian Islands and are the only extant species of goose not occurring naturally in continental areas. The Hawaiian goose formerly bred on most of the Hawaiian Islands, but currently is restricted to the islands of Hawai‘i, Kaua‘i, and Maui. Preferred nest sites include sparsely to densely vegetated beach strands, shrublands, grasslands, and woodlands on well-drained soil, volcanic ash, cinder, and lava rock substrates.

Hawaiian Nene are considered sedentary, but historically seasonal movements were made in response to changes in food availability, as a result of rainfall patterns. Females typically nest on the ground and lay an average of three eggs. The Hawaiian Nene are among the most isolated and threatened of all waterfowl. Worldwide, it is the sixth most endangered waterfowl species. Hunting, egg collecting, and predation by introduced mongoose, cats, pigs, dogs, and rats, contributed to the historic decline of this species. Current threats include scarcity of native food plants, predation by introduced mammals, and habitat loss. In certain areas, collisions with vehicles are a major source of mortality. Recovery efforts have included captive rearing and release, predator removal, provision of supplemental food, and restoration of native habitats. In 1997, the wild or free-ranging population in the Hawaiian Islands was estimated at 885 birds. Nene typically feed on both native and introduced plants in the grasslands and slopes where it lives, but has been known to fly over Haleakalā Observatories, although the entire summit area is outside the known range of the bird.

5.3.1.3 ‘Ope‘ape‘a (Hawaiian Hoary Bat)
The Hawaiian Hoary Bat (Lasiurus cinereus semotus), known locally as the ‘ope‘ape‘a, was listed as an endangered species on October 13, 1970, under the Federal Endangered Species Act. A recovery plan was assigned to the Hawaiian Hoary Bat, which indicates it is a subspecies with moderate degree of threat and a high potential for recovery.

The nocturnal Hawaiian Hoary bat is the only existing native terrestrial mammal known to occur in the Hawaiian archipelago, although other bat species have been found in sub-fossil remains. According to the U. S. Fish and Wildlife Service, relatively little research has been conducted on this endemic Hawaiian bat and data regarding its habitat and population status are very limited. Most of the available documentation suggests that this elusive bat roosts among trees in areas near forests.

Today, the largest populations are thought to occur on Kaua‘i and Hawai‘i. Population estimates for all islands have ranged from hundreds to a few thousand, however, these estimates are based on limited and incomplete data. The magnitude of any population decline is
unknown. Observation and specimen records do suggest, however, that these bats are now absent from historically occupied ranges. It is listed as endangered due to apparent population declines, and a lack of knowledge concerning its distribution, abundance, and habitat needs. It is suspected that the number of bats has decreased in the past 100 years or so due to habitat loss, although population numbers are not known. Other threats which affect the bats are the availability of roosting sites, pesticides (directly and indirectly), predation, changes in the composition and availability of food, and roost disturbance. Hawaiian Hoary Bats are non-migratory, although seasonal elevation movements and island-wide migrations may occur. The activity of Hawaiian bats apparently varies seasonally, although the exact nature of these movements is unclear.

On Maui, the bat resides in the lowlands of the Haleakalā slopes. Even though several sightings have been reported near the Haleakalā Observatories, it is considered unlikely that the bat is a resident of the area, due to the relatively cold summit temperatures and the very low abundance of flying insects, the primary prey of the bat. The largest concentrations of bats are considered to occur on Hawai‘i and Kaua‘i.

5.3.1.4 Other Introduced Fauna
Other introduced fauna that could be observed within the summit area include the chukar (Alectoris chukar), the feral goat (Capra hircus), the Polynesian rat (Rattus exulans), and the roof rat (Rattus rattus). The Indian mongoose (Herpestes auropunctatus) is occasionally observed on the summit. These species are not included on Federal or State threatened or endangered lists.

5.3.2 INVERTEBRATE RESOURCES
Due to the harsh environment, fewer insects are present at upper elevations on Haleakalā than are found in the warm, moist lowlands. However, an exceptional assemblage of insects and spiders make their home on the mountain’s upper slopes. A survey and inventory of arthropod fauna was conducted for the 18+ acres of HO in 2003 (Appendices D and E). The arthropod species that were collected during this study were typical of what has been found during previous studies. No species were found that are locally unique to the site, nor were there any species found whose habitat is threatened by normal observatory operations. Several species were added to the previous inventory site records.

The diversity of the arthropod fauna at HO is somewhat less than what has been reported in adjacent, undisturbed habitat. This is expected, in that buildings, roads, parking areas, and walkways occupy 40% of the site. However, the undisturbed habitat on the site that was sampled has an arthropod fauna generally similar to what could be expected from other sites on the volcano with similar undisturbed habitat. Most of the arthropods collected during the most
recent study are largely associated with vegetation at the site. Observatory construction and operations have increased the suitability of some habitats for plants (Appendix D) and increased vegetation has probably caused an increase in the populations of some native arthropod species, specifically Heteroptera. Only a few exclusively ground dwelling species were found. Several types of spiders were found, including the endemic wolf spider, *Lycosa hawaiensis* and spiders of the family Linyphiidae. Eleven species of ground beetles were recorded. Six species of moth were reported, eleven species of Hymenoptera (wasps), nine species of Homoptera (lice and aphids), eight species of Heteroptera, or true bugs, nine species of flies, two species of Collembola, eleven species of beetles, and one species of millipede. A full inventory listing of arthropods found at the site is in Appendix E.

### 6.0 HISTORIC AND CULTURAL RESOURCES

For the ancient kanaka maoli (Aboriginal Hawaiian), Haleakalā — which includes the Kolekole area on which HO resides — is considered a piko (the navel, or center of Maui Nui a Kama (Greater Maui). It is a sacred refuge, or place of peace (Pu'ú Honua), which Hawaiian ancestors believed was a Waoakua, or place where gods and spirits walk. Planning for scientific development at HO must be done with an understanding of, and a respect for, the connection and delicate balance between the kanaka maoli, the āina (land), and the ocean from which it was born.

A Cultural Resource Survey, a Traditional Practices Assessment, and an Archaeological Inventory, were completed in 2003 to address historic and cultural issues for long-range development planning at HO. This section briefly describes the results of those surveys and the numerous previous studies with respect to resources of cultural value and their significance, ancient traditional practices, and archaeological sites in and around what is now Haleakalā Observatories. We will address the IfA management plans for long-term preservation of these resources in Section 9.
6.1 CULTURAL RESOURCES
The cultural resources of Kolekole date back more than a thousand years (Appendix F) and are an integral part of the Hawaiian culture, both past and present (Figure 6-1). In ancient times, commoners could not even walk on the summit because it belonged to the gods. The sacred class of na poäo kähuna (priest) used the summit area as a learning center. It was a place where the kähuna could absorb the tones of ancient prayer and balance within the vortex of energy, for spiritual manifestations, the art of healing, and for navigation. Kolekole itself was a Wahi-Pana, a very special religious place. It was used by the kähuna poʻo as a training site in the arts. There were numerous gods and goddesses said to reside on the summit, in the crater, and all around the mountain. Pele, goddess of fire, Poliʻahu, the goddess of snow, Māui, the demigod, and others inhabited the area. In Hawaiian lore, it is said that Māui stood with one foot on Kolekole and the other on Hanakauhi Peak when he lassoed the Sun.
Haleakalā
The Sacred House of the Sun

Kumulipo
The Creation Chant
Ka Wā 'Akahi
The First Era
O ke au i kahului wea ka honua
At the time that turned the light of the earth
O ke au i kahului lele ka lani
At the time when the heavens turned and changed.
O ke au i kuka 'aka ka la
At the time when the light of the sun was subdued
E ho'omalamaiana i ka malama
To cause the moon to break forth.
O ke au Makali i ka po
At the time of the night of Makali (Midnight)

Ka Mo‘olelo o Ala Hea ka Lā
The Story of Haleakalā
When Pele, the goddess of fire, first visited Haleakalā, she dug a deep pit and made sixteen pua' (hills, cinder cones). These pua form a sacred alignment from the summit of Haleakalā, to the tip of Hāna (a land section near Hāna, Maui), and continues for about 30 miles into the ocean. Along this path, on the eastern side of Haleakalā, there are over 300 hale'ulan (temples of worship), the highest concentration in the Hawaiian archipelago.

Ka Lā
The Sun
The sun’s energy is the source of all life, and governs its most basic rhythm, day and night. Ancient cultures have venerated it being and respect its power. The native Hawaiian culture praises its existence from sacred points on Haleakalā’s rim to honor this ancient path. The kanaka Hawai‘i (Hawaiian people) have a cherished saying, “Mai ka lihi ke a ka lā ka‘au,” from the rising of the sun to setting of the sun - with the coming of the sun, comes life, wealth, blessings, and benefits.

Māui
The Demigod
At Haleakalā, Māui, the demigod known as the trickster, leapt from his hiding place in the roots of an old willow (erythrina sandwicensis) tree and lassoed the sun with a strong rope. Using a sacred kōl (adze) given to him by his grandmother, Mahui, Māui beat the sun for racing across each day and not providing the people enough light. Māui broke some of the sun’s strongest legs leaving only his weakest ones with which to claw across the sky. This provided the people of Hawai‘i more daylight to dry their kapu (cloth made from the inner bark of the wana - paper mulberry tree), and seed necessary plants.

Ke Ala Lo‘a’a
The Long Path
Using the hōkū pānānā (sideral compass) system, the Polynesian voyagers, or “wayfinders,” were the first to travel Oceania with great confidence. When approaching the Hawaiian islands at night, these wayfinders would use the stars Hōkūle‘a’s (Hawai‘i’s zenith star, Archerg) and Hōkūpua’s (Polaris, the North Star) and the peaks of Haleakalā and Mauna Kea to navigate their way safely into the ‘Aenulahā ‘a Alakekeiki channel.

Ka Makahiki
The Season of Peace
The Kahuna Kilo (a priest who would watch the skies for omens) studied the sky from the summit of Haleakalā. Around November, when they observed the rising of the constellation Makalii (Pleiades) in the east as the new moon and sun sat in the west. They would declare the beginning of the great Makahiki festival which was dedicated to Lono, the god of the land and of peace, the rain, thunder, and winds.

Ka Mana‘olana
The Hopes and Expectations
The ancient spiritual use of Haleakalā was for meditation and receiving spiritual wisdom by nā Kahuna Pō‘o (the lead priests). It is said to be a place where the tones of ancient prayer are balanced within the vortex of energy for spiritual manifestations. In ancient times, only the Kahuna (priests) and their haumāna (students) lived at Haleakalā for initiation rites and practices.

All who visit Haleakalā ought to strive to become sensitized to the subtleties of nature and the culture of this place. Considering the aggregated eons of history at Haleakalā, this summit demands respect. It is a place of prayer, it is A la hea ka lā: the path to calling the sun.

Hawaiian Protocol for Sacred Places:
E Uī No Ka ‘Ac
Ask Permission.
E Mahalo Aku
Give Thanks.
E Komo Me Ka Hōano
Enter With Reverence.
I ka hele aku, e ho‘oma’amau i ka wahi!
When you leave, return it as you found it!

Figure 6-1. Cultural Summary, Institute for Astronomy Website by Kahu Charles Kauluwehi Maxwell, Sr.
Haleakalā Crater was used as a trans-Maui thoroughfare and source for basalt stones. There are specific teachings related by the kūpuna (Elders) that guided commoners who were permitted access for gathering stones and to bury the dead. Numerous archaeological sites have been recorded on the crest and in the crater, including, in order of frequency, temporary shelters, cairns, platforms with presumed religious purposes, adze quarries and workshops, caves, and trails (Rosendahl, 1978). These are all remnants of the very elaborate spiritual and cultural life that the kanaka maoli focused around the summit area.

Within Kolekole, cultural resources of importance are: temporary habitation or wind shelters, two petroglyph images, one site interpreted as a possible burial, and two ceremonial sites (Appendix F). The sites are important in that they have yielded information on prehistory. Native Hawaiians know that this area provides significant cultural value as a remnant of a Native Hawaiian landscape because of its ceremonial and traditional importance.

6.2 TRADITIONAL PRACTICES
During preparation of the Traditional Practices Assessment (Appendix G), it was understood that due to the construction of former and existing buildings over the past 70+ years, much of the physical evidence of ancient Hawaiian traditional and cultural practices in the area was destroyed. However, as shown in oli (chants) and the mo‘olelo (stories) about the summit of Haleakalā, the area around Kolekole was used for a training ground in the arts of reading the stars and being one with the celestial entities above, by the kahuna po‘o (High Priest). This site was sacred to them because of its height and closeness to the heavens.

Evidence of sacred use found within HO includes ko‘a (ceremonial rock formations) and temporary habitation shelters. These may have been used for ceremonies by the priesthood during Makahiki festivals. In ancient times, the mo‘olelo tells of kāhuna and their haumāna (students) living at Haleakalā for conducting initiation rites and practices. Traditional accounts also exist of the use of Haleakalā in rites of passage such as birth and death. Haleakalā's connection to a symbolic rebirth is reflected in the traditional Hawaiian practice of piko storing. A pit at Haleakalā named Na Piko Haua was still being used by Kaupo residents in the 1920s to store their offspring's umbilical cords (Krauss, 1988).

Haleakalā has long been recognized as a traditional traveling route thru East Maui. In the sixteenth century, Kihapiʻilani, aliʻi nui (high chief) of a united Maui constructed a trail around the island and over Haleakalā, uniting the politically important districts of Hana and Kaupo with West Maui. Peoples of Honuaʻlua buried their dead in Haleakalā Crater (Handy and Handy, 1972). Several references specify burials of both chiefs and commoners in Haleakalā Crater (Kaʻaiʻe, Kamakau; in Sterling, 1998:264-265), and one possible burial is recorded on the northwest boundary of HO property (Appendix H).
Early post-contact travel to Haleakalā by haole (foreigner) was mostly limited to expeditions and sightseeing until the late 1800s. There is evidence that the Hawaiians continued to ascend Haleakalā throughout the 1800s not only for its popularity as a traveling route, but also for its ceremonial significance. Cattle ranching occurred on the slopes in the late 1800s, and in 1916 the U.S. Congress allotted 21,000 acres at the summit of Haleakalā as part of the Hawai‘i National Park. The park opened in 1921 and operated peacefully for 20 years until the U.S. Army began seeking sites for “unspecified defense installations” (Jackson, 1972:130). By 1945, the Army had installations on both Red Hill and Kolekole Peak, just outside National Park boundaries. These installations were utilized until the end of World War II and intermittently thereafter, including during the Korean War. Grote Reber built a radio telescope on Kolekole in 1952, and between 1955 and 1958, the University of Hawai‘i and the U.S. Air Force shared use of the Red Hill facilities. By 1960 to 1961, the University of Hawai‘i was operating its observatory at the Kolekole location (Jackson, 1972:131).

Today, spiritual practices continue in and around Kolekole. Flora and fauna are still collected for hula adornment by Kumu Hula, and native Hawaiians frequent the site for sunrise or sunset practices. The mana (spirit) of the area is wholly dependent on the vistas that can be viewed and the connection with earth and sky. For example, Native Hawaiians know that the spiritual essence is not something tangible at the summit area, but that one can feel the presence of the gods (Appendix G, oral history).

6.3 ARCHAEOLOGICAL INVENTORY
Discussion about the prehistoric settlement pattern for the rim and crater of Haleakalā has been occurring since 1919, when Kenneth Emory of the Bishop Museum conducted the first archaeological work in the crater. Most archaeologists agree that the structures found within the crater seem to be constructed as markers (ahu or cairns), or small walls constructed as windbreaks for travelers or hunters within the crater. The platforms found elsewhere in the crater are generally construed as altars or special places for hunting and gathering within the crater (i.e., adze material, birds, plants). In historic times, goat hunters have also built blinds and windbreaks in the crater and visitors are known to have built small cairns as mementos of their trip.

A comprehensive archaeological inventory survey of HO was completed in fall of 2002. Whereas surveys had previously been conducted for specific construction projects within HO, and a number of archaeological features had been identified (Bushnell & Hammatt, 2000, J. C. Chatters, 1991), the most recent survey of the entire 18+ acres was exhaustive and included location and description of six previously unidentified sites on the property. These sites were assigned State designations and, in addition, further documentation was obtained for four previously identified sites that were listed with the State Historic Preservation Division Maui
Office (Appendix H and Figure 6-2). In total, twenty-nine new features were identified and five excavation units were utilized to sample selected features that were located in some of the previously undocumented sites.

Most of the newly identified features are temporary habitation areas or wind shelters. Two features at one site are petroglyph images and, as indicated above, one new site is interpreted as a possible burial. Two small platforms thought to have ceremonial functions were also identified, as was a possible trail segment. All of the newly identified sites and previously designated ones retain their significance rating under at least Criterion “d” for their information content under Federal and State historic preservation guidelines. The general lack of material culture remains suggests that the area comprising HO was utilized for short-term shelter purposes, rather than extended periods of temporary habitation use. While there was no charcoal located during testing in the project area, the newly identified sites are nevertheless tentatively interpreted as indigenous cultural resources, some of which may have been modified and/or used in modern times.
Figure 6-2. Archaeological Sites at Haleakalā Observatories
(Data based on 2003 survey by Xameneck Researches, Inc.)
7.0 EDUCATION AND RESEARCH
Haleakalā is one of the world's most important astronomical sites. It has a fundamental role to play in long-term astronomical research and education using moderate aperture nighttime and solar telescopes. The emphasis on specialized facilities also makes the Haleakalā site particularly well suited for educational telescope use.

7.1 CURRENT AND FUTURE EDUCATIONAL PROGRAMS
The Faulkes Telescope (North), a partnership between UH and the Faulkes Telescope Corporation, is the world's largest telescope dedicated to education and outreach. The telescope itself is a modern 2-meter design on an alt-azimuth mount. The enclosure for this facility is a "clam shell" design that folds down the sides, leaving the telescope sitting in the open air when in operation. These designs are very similar to those being used in the Liverpool Telescope that is operational in La Palma, Canary Islands, and to the Faulkes Telescope (South) in Australia that is under construction.

Both remote and robotic operation of the Faulkes Telescope will permit observations for students in the UK and Hawai‘i. These data will be used by students in secondary schools and undergraduate institutions for research projects mentored by professional astronomers. During periods when the primary clients of the telescope are unavailable (e.g., school vacation periods, summers), observing time will be made available to other serious amateur astronomers and educational users such as the Bishop Museum.

While teaching the basics of research is the primary goal of this project, it is fully expected that as part of this process the research undertaken by the students will be published in scientific literature. Data from the Faulkes Telescope will be archived and available to the public for research and educational purposes. A collection of the spectacular images that help make astronomy a subject that has wide appeal will be made available to schools and publishers. Current plans for the Faulkes Telescope include participation in the project by students from Maui Community College (MCC), which range from control of the telescope to assisting with telescope maintenance to the analysis of observations. The UH Space Grant program has previously sponsored students at MCC in astronomy-related projects (through the USAF facilities in Kihei, HI), and we are exploring future projects for Space Grant students associated with HO. The IfA and MCC are also pursuing opportunities to develop training internships at the HO.

In addition, HO was a key participant in the Towards Other Planetary Systems (TOPS) program, a 5-year NSF-sponsored Teacher Enhancement program. The objective of this program was to initiate systemic reform in science education in Hawai‘i by enabling science and math teachers to implement astronomy in the classrooms. Teachers participated in an
intensive 3-week summer workshop held in part on Oahu and in part on the Big Island at the Hawai‘i Preparatory Academy. Teachers learned basic astronomy content, participated in hands-on activities using exemplary materials, and then begin to integrate state and national science/astronomy standards into their classrooms. In addition, a privately funded student component of the program was available to local high school students with interests in astronomy. The program give students an opportunity to learn astronomy, engage in hands-on activities and get an idea of what careers in astronomy and related sciences have to offer. The participants were exposed to the cutting edge astronomy that is being conducted on Haleakalā and Mauna Kea.

7.2 CURRENT AND POTENTIAL RESEARCH PROGRAMS
While predicting future needs is always difficult, we have a clear idea of what the scientific needs are at HO for about the next decade. The growing demand for the use of Haleakalā can be managed and planned over this period to ensure unobtrusive scientific access, increased high-level skilled jobs, and local educational benefits for both the Maui and international scientific communities that will contribute to the local educational and economic environment in a truly meaningful way. The following descriptions of current and potential astronomical programs on Haleakalā illustrate the depth and breadth of the scientific focus at HO over the next 10-year period:

1. The world's largest infrared corona graphic telescope (SOLAR-C) will be used to observe the solar corona and as a stepping-stone for developing tools to observe distant extra-solar planets.
2. The world's most sensitive solar magnetic field studies will continue to be obtained at visible and near-infrared wavelengths using the Mees Solar Observatory.
3. New state-of-the-art infrared detector systems will continue to be deployed at all of the telescope facilities as they are developed at the Haleakalā mid-level facility (ATRC).
4. The world's largest telescope devoted to global astrophysical education will be accessed electronically from around the world and partly controlled from Maui using the Faulkes Telescope (North).
5. The Japanese Multi-color Active Galactic Nuclei Monitor (MAGNUM) telescope will routinely obtain long-term remote scientific studies of supernovae and gamma-ray burst sources.
6. Visiting scientists will routinely conduct experiments with the USAF 3.7-meter AEOS telescope and UH instrumentation operating at the AEOS facility.
7. A new mirror recoating facility will be constructed within the current AEOS parking area to provide vital recoating of all optical assets at the site.
8. The long-term instrument development program for the MSSC telescope suite will be fully underway. It will be globally competitive because of the marriage of academic and
defense-related technology solutions.

9. The Pan-STARRS test bed (PS-1) will be constructed within the current LURE footprint. The testing of extremely high resolution camera imagery will lead to development and deployment of a small, economical, four-telescope system for observing the entire available sky several times each month to discover and characterize Earth-approaching objects, both asteroids and comets, that might pose a danger to our planet. At this time, site studies are being conducted on Haleakalā and Mauna Kea to determine the best site to construct the full four-telescope Pan-STARRS system. Studies are expected to be completed and the decision made as to which site would be the most appropriate, by the end of 2004.

10. The atmospheric characterization program will continue to provide advance warning of detrimental atmospheric conditions for all telescopes at HO.

11. IfA will continue as a key participant in Deep Impact, a long-term collaborative project to find clues to the formation of the solar system using analysis of a man-made impact with Comet Tempel 1. After pre-impact observations, the Deep Impact team will then observe how the crater forms, measure the crater's depth and diameter, measure the composition of the interior of the crater and its ejecta, and determine the changes in natural outgassing produced by the impact. Using UH and Air Force optical assets at Haleakalā, IfA will help determine the rotation period of the nucleus and the size of the nucleus.

12. SLR-2000 is a Satellite Laser Ranging (SLR) system, which will be operated by UH IfA under contract to the NASA Goddard Space Flight Center, in support of measurements to determine distance between HO and satellites in orbit about the earth. SLR-2000 will be a totally automated sub-centimeter SLR system designed at Goddard Geophysical and Astronomical Observatory (GCAO). SLR-2000 will replace the LURE SLR capability, without the need for on-site operators.

13. Should Haleakalā Observatory be selected, the national Advanced Technology Solar Telescope (ATST) will be constructed at the site.

14. In the Baker-Nunn site, UH will continue to support numerous, small, temporary experiments utilizing existing platforms, pads and support structures.

HO will command an increasingly vital role in the development of ground- and space-based experiments. HO is unique in that there is a symbiotic combination of defense-related astronomical researchers and purely academic astronomers. We expect this local constellation of expertise to generate important benefits for the traditionally separate Air Force and academic communities.
<table>
<thead>
<tr>
<th>Facility (Optics)</th>
<th>Proposed LRDP Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>UH Mees Solar Observatory (3.6-meter Spar)</td>
<td>Remain As-Is or Be Replace by ATST</td>
</tr>
<tr>
<td>UH LURE Observatory (MAGNUM 2-meter and Pan-STARRS (PS-1) 1.8-meter)</td>
<td>Remain As-Is (Renovated in 2004)</td>
</tr>
<tr>
<td>UH Atmospheric Airglow (instrument platform)</td>
<td>Remain As-Is or Be Replaced by ATST or Pan-STARRS</td>
</tr>
<tr>
<td>UH Zodiacal Light (.5-meter)</td>
<td>Remain As-Is</td>
</tr>
<tr>
<td>Cosmic Ray Neutron Monitor Station (NA)</td>
<td>Remain As-Is</td>
</tr>
<tr>
<td>UH Baker-Nunn Site (Numerous, Small, Temporary Experiments)</td>
<td>Continue to Serve as a Platform for Small Temporary Experiments</td>
</tr>
<tr>
<td>Faulkes Telescope North (2-meter)</td>
<td>Remain As-Is</td>
</tr>
<tr>
<td>Air Force Maui Space Surveillance Complex (4-meter, 1.6-meter, 2X1.2-meter and various instrument platforms)</td>
<td>Add Mirror Coating Facility</td>
</tr>
<tr>
<td>Possible New: UH Pan-STARRS System (4X1.8-meter)</td>
<td>New Sites/Recycle Sites</td>
</tr>
<tr>
<td>Possible New: Advance Technology Solar Telescope (4-meter)</td>
<td>New Site/Recycle Site (Should the ATST not be funded, another similar, but likely smaller, solar facility will be proposed.)</td>
</tr>
</tbody>
</table>

Note: All new and redeveloped facilities require individual project review and approval.

Figure 7-1. Table of Existing and Proposed Facilities at the Haleakalā High Altitude Observatory Site
7.3  APPROACH TO ASTRONOMY DEVELOPMENT ON HALEAKALĀ

Our approach will be to focus on projects that benefit UH directly by enhancing research and educational opportunities. These programs should be of high caliber—sufficiently large to attract a staff that can aggressively lead the scientific development of Haleakalā, and make sustainable contributions to education at all levels. Programs that satisfy this requirement on Haleakalā will:

1. Be identified with scientific areas which depend on dedicated facilities that can make the best use of the exceptional qualities of Haleakalā and that offer major scientific benefits to UH program;
2. Capitalize on the opportunity to develop facilities that will attract faculty internationally recognized as excellent;
3. Pursue major new initiatives in areas consistent with the goals and objectives of the University and the State; and,
4. Be dedicated projects that use single-purpose facilities to measure fundamental properties of nature with extraordinary efficiency and depth. Researchers typically use all of a dedicated telescope's time on a specific project. Examples of such facilities include searches for supernovae, Massive Compact Halo Objects (MACHOs), planetary systems, and near-Earth asteroids; surveys of galaxy redshifts or stellar oscillations; monitoring of activity of the Sun, stars, and exotic objects; coordinated observations with spacecraft missions; and the initial mapping of the sky at new energies/wavelengths. Such work is often groundbreaking, especially when combined with new detector technology or novel instrumentation. This type of work complements the research at Mauna Kea, which emphasizes work done with large telescopes or interferometers in which each program has very limited observing time.
8.0 PHYSICAL PLANNING
This section is divided into two parts. The first part describes the physical inventory of current facilities at HO. It also describes the associated infrastructure and services for those facilities. The second part describes potential new facilities needed at HO during the next decade, including conceptual designs, visual appearance as it would be from various locations outside the property, needed infrastructure, and projected traffic and economic impacts for these new facilities. Implementation of any or all of these new facilities would be in keeping with our approach to astronomy development on Haleakalā, although we recognize that building new assets at the site would be contingent on many factors, including funding, site selection criteria, and community input.

8.1 CURRENT FACILITIES
This section describes the major facilities at HO. The current facilities are shown in Figure 2-3, which is an aerial view looking eastward. Smaller storage, maintenance, equipment, and temporary structures have not been labeled.

8.1.1 Mees Solar Observatory (MSO)
The C. E. Kenneth Mees Solar Observatory (MSO) resides on the southern side of the property. The scientific programs at the Mees Solar Observatory emphasize studies of the solar corona and chromosphere, primarily as related to manifestations of energetic solar activity, such as solar flares. The Mees Solar Observatory building is the principal UH facility at HO. It was completed in 1966 and it contains a 3.6-meter equatorial spar for tracking the Sun, and numerous specialized instruments designed for study of solar phenomena. The main building includes small electronic and mechanical workshops, an optical engineering laboratory, and a maintenance stock area. The MSO with its enclosure is about 30 feet high. Its position within HO and low height reduce the profile of the facility such that it is not visible from outside the HO complex.

8.1.2 LURE Observatory
The Lunar Laser Ranging Experiment (LURE) Observatory lies to the east of the MSO. LURE was built in 1971 to support NASA's Lunar Laser Ranging program and was operated by the IfA under contract to NASA Goddard Space Flight Center until the late 1980s.

8.1.2.1 Satellite Laser Ranging (SLR)
Since 1972 the IfA under contract to NASA Goddard Space Flight Center has operated the LURE SLR. By utilizing the optical system located in LURE's 7-meter south dome and a neodymium YAG laser, satellites in Earth Orbit can be illuminated to obtain accurate distance measurements. UH has participated in NASA's Crustal Dynamics Project and has supported NASA's Space Geodesy and Altimetry Projects which provides data to the International Laser Ranging Service. This program is scheduled to conclude in June of 2004. The facility will
undergo renovation for a Pan-STARRS test bed (Section 8.2.1). It is anticipated that the satellite ranging capability for IfA will be replaced by a new, small, autonomously operated facility in development. This new facility, SLR-2000, is described in Section 8.2.3.

8.1.2.2 MAGNUM Telescope
The MAGNUM Telescope resides in the slightly larger 9-meter North Dome of the LURE Observatory. The University of Tokyo, the National Observatory of Japan, and the Australian National University have an agreement with UH to operate the 2-meter telescope to support the Multi-color Active Galactic Nuclei Monitor (MAGNUM) Project. The telescope optics are housed in an alt-azimuth mount with a tertiary mirror mounted on the Cassegrain instrument rotator. The LURE facility and associated MAGNUM dome are visible from the Red Hill Overlook in Haleakalā National Park. This is due largely to its position on higher ground formed by a lava plateau on the eastern side of HO (Figure 8-1).

8.1.3 Atmospheric Airglow, Zodiacal Light, Cosmic Ray Neutron Monitor Station
Three smaller UH facilities reside between LURE and the MSO. A small building just west of the LURE complex that was used during the 1970s to observe atmospheric Airglow now serves as a platform for various instruments and for weather/aircraft watch during laser experiments. About 150 feet further to the west is the UH Zodiacal Observatory facility housing the test bed SOLAR-C Telescope Facility. Haleakalā is the premier international location for studies of the solar corona and NASA has funded the development of the SOLAR-C for this research. The National Science Foundation has also adopted this instrument as a working prototype for its development of the next generation national solar telescope facility, called the Advanced Technology Solar Telescope (ATST), which will be discussed in Section 8.2.2. The third facility is a complex of small one-story buildings currently being used in association with the University of Chicago Enrico Fermi Institute for the Haleakalā Cosmic Ray Neutron Monitor Station. It is the only such station in the world. Except for the very topmost part of the Zodiacal Observatory, none of these three smaller facilities are visible from outside HO.
8.1.4 Faulkes Telescope North (FTN)
The newest facility at HO is the Faulkes Telescope (North). A second Faulkes Telescope (South) resides in Australia, in order to gain access to the southern sky. The FTN consists of a 3,300 square foot building approximately 60 ft\(^2\). It is positioned on a concrete pad across the road from the Neutron Monitor Station. The FTN incorporates a collapsible hemispherical dome that is approximately 30 feet above ground level when closed. The facility houses a 2-meter f/10 Ritchey-Cretien telescope design that represents a new generation of astronomical telescopes. By the end of 2004, it will be operated remotely from a control center in the United Kingdom and later from a control center at Maui Community College. By directing the telescope's operation remotely over the Internet, students in Hawai‘i and the UK will be able to access observation data in real-time from their classrooms. FTN is the largest educational outreach telescope in the world. Because of both its position within HO and low height, the FTN facility is not visible from outside the HO complex in the direction of the National Park or populated areas.

Due to the proximity of the FTN to two State archaeological sites, an Historic Preservation Plan was prepared prior to construction. It was approved by the State Historic Preservation Division and implemented in May 2001. The long-term treatment of those sites will remain in effect permanently. The plan calls for preservation by “avoidance”. The sites are protected by not exhibiting, describing, or providing access to them, and they are subject to routine inspection by a cultural specialist as discussed in Section 9.3.2.

8.1.5 Maui Space Surveillance Complex (MSSC)
The Air Force Maui Space Surveillance Complex resides on the northern side of HO. It consists of three separate facilities within a 4.5-acre leasehold property—the Advanced Electro-Optical System facility (AEOS), the Maui Space Surveillance System (MSSS), and the Ground Based Electro-Optical Deep Space Surveillance System (GEODSS).

The AEOS facility is the largest and most prominent of the three Air Force facilities. It consists of a 19,300 square foot building housing a 3.67-meter telescope. The building has three essential elements: the telescope pier, which supports the telescope, the metal telescope enclosure, and an equipment building containing laboratories and offices. The main building is approximately 150 ft x 175 ft and the top of the enclosure is approximately 120 feet above ground level. The enclosure is covered with a reflective material to control daytime heating of the interior space and telescope, which negatively impacts telescope “seeing” as these structures cool during nighttime hours. Because of its height, position within HO, and reflective enclosure surface, the AEOS facility is visible from the central valley of Maui as far away as 25 miles during early morning and late afternoon hours. During midday, the reflective surface is less visible than the other white dome structures at MSSS.
The MSSS consists of two main telescope enclosures and an adjoining facility. The telescope enclosures are 48 ft in diameter and approximately 60 ft above ground level. The easternmost enclosure contains a 1.6-meter Cassegrain telescope with rear and side instrument mounting surfaces that is used for research and development purposes. The westernmost enclosure at MSSS houses a twin telescope mount with 1.2-meter optics for routine space surveillance. In addition to the two larger enclosures, three smaller dome structures are visible on the roof of the facility. Two of these contain laser beam directors—a Beam Director/Tracker (BD/T) and Laser Beam Director (LBD)—for laser ranging experiments. The third houses one of the Raven systems, which is a 40 cm (16 in) f/3.75 prime focus telescope with an open framed truss and German equatorial mount for deep space surveillance. The Raven system now conducts all autonomous metric tracking at the site and is a certified sensor of the Space Surveillance Network. Because of its position at the northernmost edge of HO and the 60 ft height of the two larger telescope enclosures, both the 1.6-meter and 1.2-meter white domes are visible from the uppermost areas of Haleakalā National Park and various locations in the Central Valley of Maui.

Co-located with MSSS is the GEODSS facility, which appears as the southern extension of the MSSS facility and which has three aluminized telescope enclosures. GEODSS was added to MSSS in 1981 and has been operational since then providing data from space objects in geosynchronous orbits (about 22,000 miles) and beyond. The two main telescopes have a 40-inch aperture and a 2 deg field-of-view. The other, a 38 cm telescope, does wide searches of lower altitudes where objects travel at higher relative speeds. The system only operates at night. The three GEODSS enclosures are somewhat lower in height than the adjacent MSSS enclosures, are shadowed by them, and are much smaller in diameter. While the GEODSS domes are visible from various locations within the upper areas of Haleakalā National Park, they are not visible from the greater distances to populated areas within Central or South Maui.

8.2 POTENTIAL NEW FACILITIES AT HO

This section describes conceptual plans for new facilities that meet UH criteria discussed in Section 7.3, where the focus will be on projects that benefit UH directly by enhancing research and educational opportunities. We will also discuss any known environmental, natural, or historic/cultural implications, and the economic potential of each facility.

From prior sections of this document, two conclusions are inescapable: Haleakalā is one of the most important astronomical sites in the world, with Haleakalā Observatories (HO) as the embodiment of a unique science resource; and secondly, the most utilized and most important UH facilities at the site were designed and built more than three decades ago. For example, the MSO physical plant that houses solar research is 38 years old, the LURE complex that houses
satellite laser ranging and the MAGNUM program is 34 years old, the Zodiacal Observatory that hosts the SOLAR-C telescope is 33 years old, the complex housing the Neutron Monitor Station is more than 40 years old, and the Airglow facility is more than 30 years old. Because they are subject to the high altitude Haleakalā environment and because technology has advanced significantly since they were built, these facilities are all very old in terms of infrastructure, mechanical plants, enclosure technology, rain proofing, mount controls, etc. With the exception of the recently completed Faulkes Telescope (North), the University of Hawai‘i has been managing the unenviable task of maintaining its position of international leadership in astronomy on Haleakalā with physical assets that are at least three generations removed from state-of-the-art.

It is also clear that there are only a limited number of viable sites for eventual construction of new facilities. Those consist of the areas where current older facilities reside (i.e., MSO, LURE, Airglow, Zodiacal Observatory—replacement, renovation, upgrades) and three other undeveloped sites that the surveys and studies suggest would not contribute significant impact. As shown in Figure 2-3, these are:

1. Reber Circle, which is suitable for 4- to 8-meter class telescopes like the ATST. It is listed in the archaeology inventory as a former radio telescope site that qualifies by its age (1952) for recovery of data, but need not be preserved;
2. The approximately 1.5-acre area just to the northeast of the Mees Solar Observatory, which is suitable for 2- to 4-meter class telescopes such as the Pan-STARRS system, or part of the ATST facility not within the MSO footprint; and,
3. The paved staging area behind AEOS, which is suitable for a building addition to house the Mirror Coating Facility.

These areas were all graded at least once (during the 1950-60 era), they contain no endangered faunal or botanical species or archaeological, historic, or cultural resources, and they are positioned within HO to provide favorable telescope fields-of-view and atmospheric “seeing”.

There is additional undeveloped acreage at HO, but it is not suitable for development for various reasons. Some locations would infringe on the line-of-sight for other observatories, or be disadvantageously positioned with respect to horizon obstruction or wind regime. Importantly, survey maps identifying archaeological resources and endangered species indicate that some locations may be unsuitably close to endangered species, archaeological or cultural remains (Figures 5-2 and 6-2). These sites will not be considered further below.
8.2.1 The Panoramic-Survey Telescope and Rapid Response System (Pan-STARRS)

Pan-STARRS is designed to be the next level of advancement in discovering asteroids and comets whose orbits bring them into the inner solar system, and therefore present collision risk to the Earth. These objects are collectively known as Near Earth Objects (NEOs). Pan-STARRS will have 3 to 16 times the collecting power of the current NEO survey telescopes and a massive array of state-of-the-art focal plane CCD detectors. This will enable the Pan-STARRS survey to reach about 5 magnitudes (a factor of 100) fainter objects than are currently observed by the NEO surveys. This translates to smaller or more distant NEOs.

Further, the Pan-STARRS large field-of-view (7 deg$^2$ per exposure) is larger than that of any of the current NEO survey programs. This will permit IfA to observe the available sky faster and more frequently than any of the current programs. Finally, Pan-STARRS will have higher spatial resolution than the existing survey systems, allowing IfA to work in the parts of the sky where the ecliptic plane overlaps with the Milky Way, often too crowded with stars for the current surveys to observe effectively.

Site selection for the four-telescope system is still in progress and will not be finalized before the end of 2004. Both Haleakalā and Mauna Kea are under consideration, and each has technical and logistical merits. However, the IfA plans to build at least one Pan-STARRS telescope as a test bed to provide operational evaluation of the state-of-the-art CCD focal plane array, which is currently in development. However, the construction of one element of the final four-telescope system on Maui will not be the deciding factor as to where the whole system ultimately resides. Should Mauna Kea prove to be preferable, the test bed on Haleakalā could eventually be employed for other astronomical programs requiring ultra-high resolution observations.

The test bed will be built in the LURE Complex. The current facility will be renovated such that a new telescope enclosure will be built to replace the LURE South Dome, while simultaneously the 38-year-old facility containing control rooms, offices, and work areas will be rebuilt within the same footprint as the present building. Figure 8-1 is a view of the present LURE complex from Haleakalā National Park's Red Hill Overlook. Figure 8-2 shows a conceptual rendering of the Pan-STARRS renovation as it will appear from Red Hill.
Considering that the test bed construction is actually the renovation of a current facility (i.e., the footprint and appearance of the renovated facility will be substantially the same as the present LURE complex) no significant impact is anticipated to the environment or to cultural and natural resources. The only potential impacts will be from short duration construction activities. The IfA developed effective means of mitigating these impacts that were utilized for the earlier construction of Faulkes Telescope (North), and these will be applied to the Pan-STARRS renovation at the LURE complex. Noise, dust, traffic, etc., will be mitigated by providing construction specifications and independent monitoring as described in Section 9. On-site monitoring for cultural/historic preservation, protection of nearby archaeological resources, and monitoring for impact to endangered species will also be employed, which is also described in Section 9.

Ultimately, the Pan-STARRS system will contain four 1.8-meter telescopes to provide the field-of-view and rapid sky coverage necessary to identify NEOs, and therefore the remaining three telescopes could join the original test bed at HO. Two-meter class telescopes are somewhat “off-the-shelf” and therefore, it will be cheaper and faster to design, fabricate, and deploy a multi-telescope configuration than to design and build a single large aperture system. The Pan-STARRS approach will permit detection of NEOs as small as about 300 meters in diameter when they are at aphelion (i.e., out near the main asteroid belt and moving slowly) in addition to the ones close to Earth that are bright. The small, multi-telescope concept requires that each be located within the same acquisition and tracking environment that is close enough to observe the same region of the sky simultaneously. The telescopes would be operated remotely and would not require operator staffing. Figure 8-3 shows a conceptual rendering of how a full complement of four telescopes might appear if the other three were constructed at the undeveloped Reber Circle site, which is close enough to the LURE complex to meet the criteria for close proximity of all four component telescopes in the system. Construction of three new telescopes on the original site of Grote Reber's 1952 radio telescope would require excavation, concrete pours, fabrication of building and enclosure sections, transportation of materials to the site, and other activities. Surveys conducted in 1994 and 2003 (Appendix H) identified archaeological resources close to what would be a construction zone for the three additional telescopes. In addition, three closely spaced structures would require the appropriate study for impact to over-flights of ‘Ua’u. Mitigation measures would be developed in the Environmental Impact Statement for the project, and a Conservation District Use Permit would be prepared in the event that Haleakalā is selected as the location for the additional three telescopes for the Pan-STARRS system.
Figure 8-3. Conceptual Rendering Showing Pan-STARRS Test Bed and Three Additional Pan-STARRS Telescopes in Reber Circle
A geometric survey of height vs. visibility was completed for the sites under consideration in this document (Appendix I). From that data, three new Pan-STARRS facilities under 40 feet in height would not be visible from anywhere outside of Haleakalā National Park, either due to terrain or blocking by current facilities. Also, remote operation would not require additional vehicles or personnel at the site.

The Pan-STARRS system will ultimately cost approximately $60M to build, of which about $25M will be needed for construction of the four telescopes, the majority of which will be spent within the State of Hawai‘i. The test bed will cost approximately $2M, including renovation to the LURE complex. Of the initial cost, about half will be spent on Maui. The telescopes are anticipated to cost about $5M to operate annually, with about $4M for local salaries, services, and materiel support.

8.2.2 Advanced Technology Solar Telescope (ATST)
With its unprecedented 4-meter aperture, integrated adaptive optics, low scattered light, infrared coverage, and state-of-the-art post-focus instrumentation, the ATST will be the largest and most capable solar telescope in the world. It will be an indispensable tool for exploring and understanding physical processes on the Sun that ultimately affect Earth. The ATST will uniquely resolve fundamental length and time scales of the basic physical processes governing solar variability. The ATST represents a collaboration of 22 institutions, reflecting a broad segment of the solar physics community. The design phase of the project to build the next generation ground-based solar telescope is underway and the two-year site selection process was concluded near the end of 2004. Haleakalā Observatories was the candidate site selected out of the original 72 considered, therefore the ATST must be considered in this plan as a future facility at HO.

As the national solar telescope, ATST would not just replace the science being accomplished at Mees Solar Observatory; it will have broad impacts on astronomy, plasma physics, and solar-terrestrial relations by resolving fundamental astrophysical processes in space and time on the Sun. The ATST will attack critical details of the non-linear dynamical processes that govern the highly conducting, turbulent solar plasma. The large aperture, wide field-of-view, broad wavelength range, high spatial resolution and other recent technological developments that ATST will employ are an absolute necessity because the field of solar physics has developed rapidly over the last decade to a point where sophisticated theories and models await critical observational tests. However, existing instrumental capabilities at facilities such as the Mees Solar Observatory no longer are sufficient to meet this challenge. The recent demonstration of a practical adaptive optics system, coupled with other advances in innovative and powerful instrumental techniques, now promises a major advance in solar observing capabilities.
The design of the ATST facility is still in a preliminary stage, however, a basic conceptual facility design is available for planning purposes. The ATST will be a large observatory with attendant control and computer rooms, mirror handling facilities, instrument shops, and mechanical equipment areas.

If the ATST is to be sited at Haleakalā, there are only two potential sites that could accommodate the facility. Figure 8-4 shows a footprint rendering within HO of the two proposed alternate ATST sites. The one site that has been tested for ATST is adjacent to the existing Mees Solar Observatory (Figure 8-5). This 1.5-acre site to the east and north of Mees is large enough to accommodate ATST and its attached support building as they are currently envisioned (Figure 8-6). If a larger site becomes necessary as the design evolves, or if an alternate more southwesterly location proves advantageous for environmental or seeing-quality reasons, removal of the existing Mees facility to make room for ATST may be considered. The second site that could accommodate ATST is Reber Circle, which is currently undeveloped. Figure 8-7 shows the ATST as it would appear in Reber Circle, as seen from the Red Hill Overlook in the National Park.

These two siting combinations of ATST would work with a full Pan-STARRS system on Haleakalā. Should ATST be sited at Reber Circle and all four Pan-STARRS telescopes be sited at Haleakalā as well, the three later Pan-STARRS telescopes would be constructed on the south side of the HO access road. Figure 8-8 shows the ATST and four Pan STARRS telescopes in that configuration. One final combination of ATST and four Pan-STARRS telescopes could be accommodated with ATST sited at the current Mees Solar Observatory location and the three later Pan-STARRS telescopes at Reber Circle.

Construction of ATST is estimated to cost about $200M in 2003 dollars. The construction would occur over a period of about seven years, and during that time, approximately $50M would be spent in Hawai‘i for labor, planning and engineering services, construction materials, and infrastructure upgrades. Operating budget for the forty or more scientists, technicians, and engineers will be between $5-8M per year to be spent on Maui (only a few personnel will work at the facility—the remainder will be located at the new 20,000 square foot facility under construction in the Kulamalu subdivision in Kula.)
Figure 8.4: Proposed Alternate Sites for ATST
Figure 8-6. Conceptual Rendering of Advanced Technology Solar Telescope (ATST) at MSO Location
Figure 8.7. Conceptual Rendering of ATST in Reber Circle, Viewed From Red Hill.
Figure 8-8. Conceptual Rendering of ATST at Reber Circle and Four Pan-STARRS Telescopes
The results of the various surveys, studies, and inventories conducted for this Long Range Development Plan and the accompanying recommendations by the experts who prepared them suggests that the ATST can be constructed without significant impact to the environment or to the cultural resources at the site. As discussed earlier, both the Reber Circle and current Mees Solar Observatory sites are already disturbed and have been graded several times. They do not contain botanical or faunal endangered species, or archaeological resources, and the two prospective sites are acceptable for field-of-view and other technical considerations.

The ATST will be a large facility compared to the current Mees Solar Observatory. The top of the telescope enclosure may be as much as 142 feet or more above ground level. If sited at either the present MSO location (Figure 8-9) or Reber Circle (Figure 8-7), the white telescope enclosure would be quite visible from the Red Hill Overlook and on cloud-free days it could be visible from South Maui and the Central Valley, although it would be blocked in some directions by the AEOS facility (Appendix I).

A construction project to build ATST would require excavation, concrete pours, vehicle access; contractor personnel, material transport to and storage at the site, and it would produce some noise during heavy construction. While there are no natural, historic, cultural, or faunal resources at the potential construction sites, such resources have been identified nearby. Therefore, specific evaluation of those sites for any significant impacts to those nearby resources from construction and/or operation of the ATST would be required and mitigation measures developed, if necessary. An Environmental Impact Statement and Conservation District Use Permit Application would be initiated for this project.
8.2.3 SLR-2000

SLR-2000 is an autonomous and eye-safe photon-counting Satellite Laser Ranging (SLR) station with an expected single-shot range precision of about 1 cm. The system will provide 24-hour tracking coverage of artificial satellites at altitudes up to 20,000 km for the NASA Goddard ranging program in which IfA has been participating. Costs are expected to be up to 75% less to operate and maintain than the current manned system at HO. A photograph of the prototype SLR-2000 system is shown in Figure 8-10.

The facility will be a pre-fabricated, insulated building with dimensions approximately 12 ft x 12 ft x 8.7 ft high on a steel-reinforced, concrete slab. Support for telescope mount will be a steel-reinforced concrete pier, which is vibration-isolated from the shelter foundation. When the autonomous system becomes available, it will be placed on an existing concrete pad just to the southwest of the current MSO (Figure 2-3). Because the construction will be minimal, modular, involve no excavation, noise, heavy equipment, etc., and it can be completed in only a few days, no impact is anticipated to the environment, cultural, archaeological, historic, or natural resources. The fully complete system will cost about $2M, about $100K of which will be spent in Hawai‘i for construction and engineering services. It is anticipated that SLR-2000 will cost about $150K a year to operate.
8.2.4 Advanced Electro-Optical System (AEOS) Mirror Coating Facility

The AEOS telescope is the largest and most sensitive telescope within the Department of Defense. Its sensors produce simultaneous images in the visible and infrared, it has the capability to track both satellites and missiles, and it has full hemispherical viewing at a highly favorable location. To maintain this capability, the telescope mirror needs to be recoated approximately every six years.

To maintain the capability of AEOS, an on-site Mirror Coating Facility will be constructed. This project was part of the original AEOS design, but was not constructed with the AEOS facility due to funding shortfalls during that period. The facility will be a two-story addition to AEOS that will provide for the mirror coating function, and the facility will also provide mirror-coating services for other telescopes on Haleakalā. Support facilities will include utilities, electrical services, security lighting, lightning protection, potable water lines, storm drainage and other site improvements. The project will also provide physical security measures to the primary and supporting facilities, including security system measures, minimum building and parking standoff distances, and installation perimeter standoff distances. An elevation and rendering of the proposed facility are shown in Figure 8-11.

Construction will involve removal of the concrete paving behind the AEOS staging area, excavation and grading, site improvements, drainage, water connections, sewage connection to the current system for AEOS, and parking lot reconstruction. The low height of the proposed facility and its position behind AEOS will minimize visibility. The facility will not be visible from the Red Hill Overlook (Figure 8-12) or from anywhere else outside of HO. It is anticipated that the physical construction of the facility will cost about $7.5M and the interior equipment will cost an additional $2.5M. Of the construction costs, approximately half will be expended in Hawai‘i.

The experts whose studies, surveys, and inventories are appended to this document surveyed the proposed Mirror Coating Facility construction site during preparation of this Long Range Development Plan. There were no natural, historic, or cultural resources within the proposed footprint of construction. However, as is true elsewhere at HO, there are nearby archaeological resources of cultural significance (Appendix H), and these would need to be monitored and protected during construction. The mirror recoating facility will require an Environmental Assessment to evaluate potential impacts before final planning can be accomplished for this project.

A Conservation District Use Permit for the mirror recoating facility already exists. In August of 1994, DLNR approved AEOS CDUP MA-2705 with a seven-year period to complete construction of AEOS. In June of 2001, the IfA requested and was granted a two-year
extension for completion of the construction to allow for the construction of the AEOS Mirror Coating Facility, which was part of the original plan. In June of 2003, the IfA requested another two-year extension of the construction phase. On October 24, 2003, in a public meeting, the Board of Land and Natural Resources (BLNR) approved another extension, but expressed their concern that construction could not realistically be completed in two years and therefore granted the IfA an unprecedented three-year extension to complete construction of the AEOS Mirror Coating Facility.
Figure 8-11. Elevation and Conceptual Rendering of AEOS Mirror Coating Facility
Figure 8-12. AEOS Mirror Coating Facility, From Red Hill Overlook
9.0 MANAGEMENT PLANNING

We presented programmatic information pertinent to actual development of the area in Section 7. Section 8 presented a general plan that describes the considerations leading to the site locations, organization, and general physical characteristics of future facilities. This section specifies the design and environmental criteria that should be followed when implementing development, and we present strategies for managing, monitoring and protecting the various natural and cultural resources and uses of UH-controlled areas. Ultimately, these planning considerations will include more input from Maui community groups, the Department of Land and Natural Resources, the Office of Hawaiian Affairs (OHA), the National Park Service, the Maui County Planning Department, the United States Air Force, and other interested agencies and individuals.

The management planning discussed below will address:
1. specific requirements and guidelines for future astronomical facilities;
2. guidelines for Air Force facilities and other scientific activities at the site;
3. issues regarding neighboring broadcasters;
4. terms and conditions that will be applied to leases; and,
5. future planning for IfA in support of HO.

In preparing the general plans for managing HO, we have taken into account the data and recommendations from the experts who provided surveys and studies of archaeological and cultural resources, traditional practices of the summit area, botanical and faunal resources, traffic, and others. We will also discuss general maintenance and operations considerations. We have already conducted preliminary consultations with our Haleakalā neighbors about various aspects of future planning, and we have conducted initial consultations with the Native Hawaiian community and individuals in the Upcountry and broader Maui communities. The intent of the IfA is to provide opportunities for the public to participate with comments and recommendations on these plans from all who wish to provide input.

9.1 MANAGEMENT FOR ASTRONOMICAL FACILITIES

The objective for management of astronomical facilities is to create a structure for sustainable, focused management of the resources and operations of the Haleakalā Observatories, in order to protect historic/cultural resources: e.g. archaeology sites, traditional cultural practices, to protect natural resources, protect and enhance education and research, and to provide a base for future expansion of the scope of activities at HO.
9.2 FACILITY DESIGN CRITERIA

The architects and engineers who design astronomical facilities must consider numerous technical considerations to determine what is actually feasible. Those design features or elements that would be too costly, not yet proven to be reliable, or are unsuitable for the specific site, are not incorporated into the final specifications. For example, observatory designers typically incorporate methods for reducing atmospheric influences on optical imaging—depending on feasibility, observatories may have active temperature control systems that require mechanical plants, elaborate Heating Ventilation and Air Conditioning systems (HVAC), high tech insulation, and structural elements designed to dissipate heat. Not all of these methods are feasible for a given observatory and design compromises are inevitable.

While these kinds of technical issues are addressed for facilities built everywhere in the world, there are no practical design techniques to render astronomical facilities completely invisible within an area, or to not occupy a particular footprint on what was previously an undeveloped site. However, the IfA has learned from observatories constructed elsewhere and from its own long experience at HO how to incorporate design elements that minimize the impact of new facilities on others on or off the site, as well as how to minimize any environmental and cultural impacts. The intention is also to have the small number of new facilities likely to be built at HO be as appropriate as possible on a mountain summit that has rich natural, cultural, and spiritual resources.

The design criteria that will be used for new facilities at HO are in keeping with that intention:

1. Existing observatories require a clear line-of-sight in so far as is possible given the terrain. New facilities will not be permitted to obscure the observation function of existing facilities;
2. New facilities will not be permitted to impact the ‘Ua’u habitat. They will not be fenced in order to protect ‘Ua’u flyways, and they will not have lights or other attractants. During the nesting season (February to November) when birds are present on Haleakalā, care must be exercised to ensure that the birds will not be disturbed. Vibration and noise from heavy construction equipment or activities must not impact the normal life cycle of resident birds. If heavy construction equipment will be necessary at the site, consultation with IfA and avifaunal experts will be required to determine feasibility;
3. New facilities will not impact known archaeological resources. The resources at HO have been mapped and those sites nearest to facilities have been delineated with single post and railing buffers. No construction will be permitted within 50 feet of any archaeological site or feature;
4. Presently, all HO facilities are painted with a formula that was computer-matched to the most common color of the cinders and lava within HO boundaries. Whenever possible,
new buildings will be painted to blend with their surroundings; however, solar observatories that operate during daylight hours will be allowed to be painted white, as it would otherwise be virtually impossible to keep the enclosure and building surfaces cool enough to prevent degradation of seeing conditions;

5. Construction design will consider sight planes to population centers of Maui. Where buildings can be oriented to limit visibility or be built partly underground, they will be. Where they cannot, every effort will be made not to use materials that draw attention from a distance, i.e., reflective surfaces, unusual shapes, incompatible colors;

6. Wherever possible, natural materials from the construction site will be used for building facings, walls, walkways, entryways, etc.; and,

7. IfA will seek early and broad public comments and input concerning any new proposed construction at HO.

9.3 ENVIRONMENTAL PROTECTION OF SITE RESOURCES

During the course of more than 40 years of IfA management of the 18+ acres of HO land near the summit, there has been a significant increase in awareness of the importance of effective, long-term stewardship of the land by the public and government of the United States. Here on Maui, the Native Hawaiians who lived and cared for the land and its resources did so for many hundreds of years before anyone on the U.S. Mainland brought attention to conservation, preservation, and restoration during the last century. Centuries before inception of any National or State environmental regulations or policies, the Native Hawaiian ali‘i imposed strict constraints on use and preservation of resources. We have listened to the recommendations by kanaka maoli and experts working with IfA at the site, and in the spirit of the ancient Hawaiians who closely protected the summit and in compliance with the regulatory requirements of the State of Hawai‘i, we developed principles and practices to which everyone must adhere when working at HO. These principles and practices were developed in cooperation with the DLNR, Haleakalā National Park, the U.S. Air Force, Boeing LTS, Department of Energy, and other neighbors and summit users.

9.3.1 Construction Practices

All contractor personnel working at the HO or the Air Force leased site must receive environmental training from IfA or from the Air Force, respectively, prior to beginning work. Both organizations offer training programs, which explain and amplify the specifications that are required of all construction projects within HO boundaries. For environmental protection, the specifications to protect vital environmental resources are as follows:

1. Haleakalā National Park has experienced the introduction of destructive non-native species that compete with and have in some cases displaced native plants and insects. These introductions threaten the ecological balance at the site, and in cooperation with Haleakalā National Park, IfA requires any contractor to take the following measures at HO to prevent
construction or repair activities from introducing new species:

a) Any equipment, supplies, and containers with construction materials that originate from elsewhere, i.e., the other islands or the mainland, must be checked for infestation by unwanted species by a qualified biologist or agricultural inspector prior to being transported from Kahului. Specimens of non-native species found in these inspections are to be offered to the state for curation, and those not wanted are to be destroyed. All construction vehicles must be steam cleaned before they are transported through the National Park. The contractor shall provide certification attesting to compliance with this paragraph for inspection and steam cleaning. Contractors shall also notify IfA a week prior to their initial entry into Haleakalā National Park, so that arrangements can be made with the Park Service or other provider of inspection services. After the initial entry, coordination shall be directly between the inspectors and the contractor.

b) Importation of fill material to the site is prohibited, unless such fill (e.g., sand) is sterilized to remove seeds, larvae, insects, and other biota that could survive at the site and propagate. All material obtained from excavation is to remain on Haleakalā. Surplus excavated cinders, soil, etc., is to be offered to other agencies located at the summit or the NPS.

c) Contractors are required to participate in IfA pre-construction briefings to inform workers of the damage that can be done by unwanted introductions. Satisfactory fulfillment of this requirement would be evidenced by a signed declaration from each worker who drives a construction vehicle into the site.

d) Parking of heavy equipment and storage of construction materials outside the immediate confines of HO property is prohibited.

e) Contractors are required to remove construction trash frequently, particularly materials that could serve as a food source that would increase the population of mice and rats that prey on native species.

f) The endangered ‘Ua’u, or Dark-rumped Petrel, occupies burrows on the upper slopes of Haleakalā from February to October. The burrows are located in cinder and are active year after year, since the birds return to the site of their birth. Petrels are night flying birds, leaving their burrows to search for food during nesting and fledgling seasons. The nearest burrows are located on the south slopes below Mees Solar Observatory and on the north slopes below the Maui Space Surveillance Complex. The following seven requirements are in place to ensure that the ‘Ua’u habitat will be protected during any construction activities:

1. During the months when birds are present on Haleakalā, care must be exercised to ensure that the birds will not be disturbed. Therefore, vibration and noise from heavy construction equipment or activities must not impact the normal life cycle of resident birds. If heavy construction equipment will be necessary at the site, consultation with IfA and avifaunal experts will be required to determine
feasibility.

2. Haleakalā Observatories personnel will notify HNP of any ‘Ua’u mortalities. Contractor personnel will report mortalities to IfA immediately.

3. Contractors will be given current maps of locations of ‘Ua’u burrows to assist with ‘Ua’u conservation. HNP biologists are continuously finding and mapping new ‘Ua’u burrows, and these maps will made available to the Haleakalā Observatories for planning purposes.

4. Construction of fences will be avoided, if possible, to avoid ‘Ua’u mortality from collisions.

5. To avoid attracting ‘Ua’u, contractors will make every effort not to use lighting the same color as stars. Other colors, such as red, blue, or orange or similar colors, should be considered.

6. Lighting for construction hazards or night work must be approved by IfA prior to installation. All lighting must be shielded from above, so that night flying birds will not be disoriented by upward projecting lights that are mistaken for natural sources of navigable lighting.

7. Workers at the site must be informed of vibration, noise, and lighting hazards to endangered species, and must be informed that their activities are to be confined to the construction site to minimize risk to birds in adjacent areas.

2. HO is located in a cinder cone in a State Conservation District. Construction at the site requires special care to maintain the unpolluted environment.
   a) No hazardous waste is to be released at the site. Surplus or used paint, oil, solvents, cleaning chemical, etc., must be removed from the area and disposed of by an EPA-approved Transport Storage Disposal Facility.
   b) Accidental spills of any hazardous material during the execution of a contractor's project at the site must be reported immediately to the on-site IfA supervisor. Spill containment will be supervised by UH personnel at the site.
   c) Spill remediation methods must be approved by the University of Hawai‘i’s Environmental Health and Safety Office (EHSO) prior to clean up, and all costs incurred for clean-up will be assigned to the contractor. In the event of a reportable release, the construction contractor will be liable for any federal or state imposed non-compliance penalties.
d) Washing and curing water used for aggregate processing, concrete curing, clean up, etc., cannot be released into the soil at the site. A recovery process is required by the contractor to capture wastewaters.

3. It is of particular importance to maintain a dust free environment at HO. Telescope mirrors, lenses, and sensors can be quickly damaged by wind born dust. HO is located at 10,000 feet, and is often exposed to winds in excess of 30 mph. Before, during, and after winter storms, winds can exceed 50 mph. The natural substrate at the site is a mixture of fine volcanic sand and cinders. Fugitive dust from the finer material can be released when the substrate is disturbed.
   a) Contractors will adhere strictly to the requirement that dust be controlled at all times, including non-working hours, weekends, and holidays. Sprinkling or similar methods will be required to keep disturbed finer material from becoming airborne.
   b) Dust control must be accomplished by equipment that the Contractor keeps on site, and sprinkling or similar activities must result in less than 10 pounds of fugitive dust released into the atmosphere per 24-hour period, as measured by standard collection methods.
   c) No oil or chemical treating shall ever be used at the site for dust control.
   d) Dust resulting from surface preparation of surfaces to be painted by sanding, power tools, or scraping and brushing shall be controlled by the Contractor by use of catchments and filtering systems/devices to prevent damage to the telescope mirrors, lenses and sensors.

4. Construction or refurbishing of existing facilities will result in quantities of solid waste, and remnants of food and packaging that construction crews may bring for consumption at the site.
   a) Only materials that are not EPA “Listed” or “Characteristic” wastes can be managed as solid waste at the site.
   b) Solid waste cannot be stockpiled or dumped at the site or on the slope below the HO facilities.
   c) Solid waste and debris must be secured such that strong winds cannot disperse materials. This is particularly important during weekends, holidays, and other non-working hours.
   d) No food is to be left on the ground or in HO solid waste storage areas to prevent attraction of rats and other pests.

9.3.2 Protection of Historic and Cultural Resources
For the kanaka maoli, the lava, cinders, dust, rocks and boulders are all sacred to Pele, the goddess of the volcano. In fact, Pele means lava in Hawaiian. Workers at HO need to be culturally sensitive to the fact that they are in a place still considered sacred by Native Hawaiians. As the
responsible agency, UH IfA is committed to preserving the cultural resources at the site and has sought advice from the native Hawaiian community on Maui concerning the best methods to use to achieve that objective. One outcome of those consultations and the cultural resource evaluations of HO is that the IfA has adopted rules for the long-term preservation of archaeological and cultural resources for all facilities, past, present, and future, based on recommendations in the Cultural Resources Assessment (Appendix F). The preservation of cultural resources is defined as an IfA policy as follows:

1. Any construction within HO requiring a permit from the Department of Land and Natural Resources shall require the consultation and monitoring of a Cultural Specialist. The Cultural Specialist will be engaged at the earliest stages of the planning process, monitor the construction process, and consult with and advise the on-site Project Manager with regard to any cultural or spiritual correction. For the purposes of this section, a Cultural Specialist must be a kanaka maoli, preferably a kupuna (elder), and a kahu (clergyman) as well, and one who has personal knowledge of the spiritual and cultural significance and protocol of Haleakalä.

2. All cultural and archaeological sites and features identified in the HO Archaeological Inventory Survey shall be protected and preserved per Hawai‘i Administrative Rules, Title 13, Sub-Title 13, Chapter 277 “Rules Governing Requirements for Archaeological Site Preservation Development”. Protection shall include the establishment of clearly marked buffer zones and periodic monitoring by both the project Archaeologist and Cultural Specialist throughout any future construction process.

3. All construction crewmembers shall attend UH-approved “Sense of Place” training prior to working at projects within HO.

4. A Cultural Specialist shall conduct a cultural inspection of HO two times a year, to ascertain that HAR Title 13 Chapter 277 rules are being followed.

5. All permanent employees working at HO shall attend UH-approved “Sense of Place” training prior to working at facilities within HO.

The requirements specified above apply to and must be included in all land use-related Memoranda, Facility Use Agreements, Operating and Site Development Agreements and Leases.

Additionally, an area consisting of approximately 24,000 square feet and located Southwest of the Maui Space Surveillance Complex, as further identified and more particularly described as Area A in Figure 9-1, will be set-aside in perpetuity for the sole reverent use of the kanaka maoli for religious and cultural purposes, on a noninterference basis with site activities.

Recommendations were submitted with the latest archaeological inventory survey concerning protection of the archaeological resources at the site, and they have been coordinated with the State Historic Preservation Division (Appendix H). These recommendations have been adopted
by the IfA to protect those resources. Passive in-place preservation will be continued for features that were identified and listed with State Historic Preservation Division during the J. C. Chatters 1994 survey, i.e., sites 4836, 2806, and 2805 were delineated with post and railing boundaries in 1995. Discussions during the latest survey indicate that no fencing or other demarcation should be added to the most recently described features, so as not to draw attention to them. However, site 5440 will be part of the “set-aside” for kanaka maoli in Area-A described above, and the remaining four sites on HO property will be monitored routinely by the Cultural Specialist during inspections.
Figure 9-1: Area A “Set Aside” Kanaka Māoli Cultural Practices Site


9.3.3 Light Pollution

Observatories have traditionally been located at dark mountain sites far from city lights. Indeed, the "darkness" of a good observatory site is one of its most important traits. The degradation of observatories on the mainland by light pollution—the urban sky glow that leads to a brightening of the sky overhead—has taught us many valuable lessons on what should be done to protect our valuable astronomical sites. In the lifetime of an observatory complex, it is clearly important to start addressing this problem sooner rather than later. Minimizing stray light that is detrimental to astronomical observations is virtually always in the best financial interest of users of outdoor lighting and is environmentally responsible in using energy.

Measurements taken at HO since the early 1960s clearly indicate that the Maui night sky has become significantly brighter from light pollution. In 1999, the County of Maui adopted "Street Lighting Standards." These standards include the required change to fully shielded luminaires (fixtures). Additionally, they required light standards only at intersections with a collector road. Unfortunately, these are minimum standards and developers or homeowners can install additional fixtures if they so desire. Also, against the 1997 recommendations of the Subdivision Engineering Standards Committee, the County approved the use of high-pressure sodium vapor lamps.

The first meeting of the Outdoor Lighting Standards Subcommittee of the Maui County Council Public Works Committee was held at the beginning of 2002. The Subcommittee, which has IfA representation, later proposed a draft outdoor lighting bill to curtail and reverse the degradation of the nighttime visual environment by minimizing light pollution, glare, and light trespass through regulation of the form and use of outdoor lighting, as well as to conserve energy and resources while maintaining nighttime safety, utility, security and productivity.

In guarding against light pollution, we can consider development on other islands. As experience in the U. S. Southwest has shown, city lights can affect conditions at observatory sites from large distances. Fortunately, the Big Island already has outdoor lighting standards that will minimize light pollution at HO from future development on the Kona Coast. However, enforcement is inconsistent and "Big Box" stores on all islands are still selling mercury vapor outdoor lighting fixtures to the general public for installation on private property. The IfA will continue to work with the Legislature to establish statewide standards to end the use of unshielded high-pressure sodium vapor lamps on State highways.

Controlling stray light that is harmful to the observing environment at HO should not conflict with sensible development elsewhere on Maui. The IfA will continue to work with community groups to develop appropriate outdoor lighting standards and has also provided information to the media, on-line, to community groups, etc., in order to educate the public as to why such
standards are beneficial.

9.4 GUIDELINES FOR AIR FORCE FACILITIES
The Air Force facilities at HO are operated under Air Force regulations for environmental protection, cultural and historic preservation, and pollution prevention that are specific for installations such as the Maui Space Surveillance Complex. These regulations are enforced by frequent inspections from the host command and managed through the Air Force Environmental Compliance Assessment and Management Program (ECAMP). The ECAMP Program is a comprehensive means for establishing, integrating, and maintaining environmental plans so that the MSSC can effectively protect the environmental and cultural resources within its boundaries. The plans are described in Appendix J. Boeing LTS, the prime contractor for Air Force at MSSC, is responsible for routine environmental operations at the site, and independent inspections by the host command are conducted frequently.

The surveys and inventories conducted for this Long Range Development Plan were unanimous in their praise for the care with which the Air Force is protecting their leased land at HO. For example, the Botanical Survey (Appendix B) states, “The MSSC does a good job of controlling weedy species while letting the native species flourish on their site.” IfA is appreciative of the stewardship exhibited by the host command at MSSC, and environmental protection will be emphasized as a key element in any future lease renewal negotiations with the Air Force. IfA is currently not aware of any plans by the Air Force for expansion of the MSSC or dedicated Air Force facilities outside their current boundaries at HO.

9.5 CONTROL OF RADIO FREQUENCY INTERFERENCE (RFI)
Proliferation of broadcast antennas within and adjacent to HO has seriously degraded the astronomical quality of the site. The International Astronomical Union (IAU) has determined that the acceptable level of RFI as measured outside an observatory doing optical or infrared observations is less than $2 \, \mu W/m^2$. Repeated measurements at various locations within HO were in excess of $184,000 \, \mu W/m^2$ in at least one area, and above $60,000 \, \mu W/m^2$ most everywhere else on site. This extremely high level of RFI is unacceptable. In 2003, Congress allocated funding for relocating the broadcasters from their present site adjacent to UH. The broadcasters are in the process of site selection and public scoping to select an area on Haleakalā that has the necessary broadcast coverage, reduction in RFI at HO, and minimum environmental impacts. UH IfA is encouraging relocation to a new coordinated broadcast facility and UH was asked by the Federal Government to assist with administrative support to the broadcasters to facilitate their infrastructure engineering and design.
9.6 USE OF LASERS AT HO AND THEIR IMPACT ON ASTRONOMY

Haleakalā is a unique high-altitude site that has a history of laser use dating back to the early 1960s. The most common historical uses of lasers include lunar and satellite laser ranging, target illumination, object discrimination/characterization, and Light Detection and Ranging (LIDAR). It is anticipated that both the IfA and the USAF will continue to use lasers on Haleakalā. Additional future uses may include more sophisticated discrimination techniques, laser guide star technology development, laser communications, and missile ranging techniques. Both the USAF and the IfA have extensive written guidelines for the safe use of lasers and guidelines for noninterference with the astronomical observations at the site. No weapons-grade lasers will be permitted at HO.

9.7 INFRASTRUCTURE AND SERVICES PLANNING

In the future, it is anticipated that telecommunications equipment and services will continue to be provided by Verizon. The service is distributed to various sites via underground conduits, and the principal organization responsible for a new facility would negotiate directly with the telephone company to obtain service.

The electric power available at HO for future development is dependent on the capability of Maui Electric Company (MECO) to upgrade its hardware at the site. At present, power is provided via a step-down transformer substation located within HO, near the MSSC. Power is distributed to various sites via a combination of underground conduits and overhead line conductors. Both three-phase and single-phase AC electric power is available to sites at conventional voltages of 240 volts and 480 volts (three-phase AC). Transformers and service are provided by MECO. Each of the new facilities described earlier would be required to work with MECO for purchase of any new transformers.

The roads within HO are maintained by UH with contributions from all users of roads and easements. Vehicular traffic is normally low in volume (Appendix K) and this volume would continue, even if all the potential construction actually occurs. Remote operations, autonomous systems, and more modern, reliable equipment will likely keep site traffic to only five to fifteen vehicles more transiting HO daily even in the event all four of the new facilities at HO are built during the next decade. Currently, roadways require very little maintenance and have considerable longevity. The roadways were not designed to support unusually heavy loads, e.g., large trucks and construction vehicles, and therefore contractors will be made aware of the potential for road damage.

Potable water is obtained by two methods. At various times during the year (particularly...
winter) rainwater can be collected from building roofs, etc., and stored in water-catchment systems. Rainwater collection is unpredictable and is not adequate to ensure a reliable supply of potable water throughout the year; so to supplement this source, water is trucked to each user in certified tanks where it is stored on-site. Each facility maintains its own collection system and storage tank for potable and/or non-potable water, as well as individual pumping and distribution systems. New facilities would be required to build water storage tanks and use catchment wherever possible for water.

Septic tanks are the primary means of sewage disposal within HO. There is no central waste/sewage collection or storage system. Each major user at HO provides for the collection and proper storage of wastewater and sewage generated by their facility. Future construction at HO would employ the latest techniques in septic tank separation and sewage handling.

9.7.1 Off-Site Facilities
Waikakoa Laboratory is UH IfA's 4,614 square foot support facility located in Kula. It is in an 80-year-old building that is not easily renovated or expanded. At Waikakoa, the IfA maintains an office building, electronics shop, optical assembly shop, and vehicle maintenance shop. For transport to and from HO to the Waikakoa Laboratory, UH maintains a fleet of 10 vehicles, which are parked and serviced at the Waikakoa Laboratory. Services include administration, personnel and purchasing support as well as vehicle and building maintenance functions. The current support staff consists 15 to 20 technical, administrative, and engineering persons on Maui

In July of 2003, the University of Hawai‘i Board of Regents approved an agreement with the Kulamalu LLC to develop a new $8.6M Maui facility for the Institute for Astronomy. The Advanced Technology Research Center (ATRC) will include needed offices for scientific and engineering/technical personnel; optics and detector/instrument laboratories; electronic shop; a clean room; vacuum and cryogenic support areas; instrumentation fabrication, staging and testing facilities; computer support and remote observing rooms. The ATRC will augment the support provided by the ancient Kula facility and would become an integral part of the laboratory and office support provided to the Advanced Technology Solar Telescope. The new center will be important to the higher level of research occurring on the Haleakalā summit.

9.8 MANAGEMENT PLANNING SUMMARY
The Maui community generally recognizes the economic, scientific and research benefits of astronomy on Haleakalā. Local Maui residents, including part Hawaiians, fill numerous jobs at the site, which include engineering, technical, and administrative positions. Astronomy is part of the non-polluting, diversified, and robust high-technology growth industry on Maui, including more and more lucrative opportunities for local residents each year.
The Office of Economic Development of the County of Maui website states, “Enormous potential exists for the high-technology industry in Maui due to the intellectually stimulating atmosphere created by Maui’s beauty and lifestyle, Hawai‘i’s vast and growing high-technology support infrastructure, and the state's geographic position, making it a natural portal between the U.S. and Asian high-technology markets.” This is certainly true for astronomy research at Haleakalā Observatories and its international partners.

This Long Range Development Plan offers a physical plan and management structure that seeks to preserve a balance within Haleakalā Observatories, in which astronomy can continue its evolution at a premier ground-based viewing location with the associated economic benefits, while protecting cultural and environmental resources and values. Additionally, this Long Range Development Plan provides resource protection and guidelines for future development that will not lead to desecration or over-development of the small HO property, as the IfA continues to lead the international scientific community toward a deeper understanding of the universe in which we live.
LIST OF APPENDICES

Appendix A: Bhattacharji, S., PhD, Geological Survey of the University of Hawai‘i Haleakalā Observatories at Haleakalā Summit Region, East Maui, Hawai‘i

Appendix B: Starr, Forest and Kim, November 2002, Botanical Survey, University of Hawai‘i “Haleakalā Observatories”, Island of Maui, Hawai‘i


Appendix D: Pacific Analytics, L.L.C., July 2003, Arthropod Inventory and Assessment, Haleakalā High Altitude Observatory Site, Maui, Hawai‘i

Appendix E: Pacific Analytics, L.L.C., October 2003, Arthropod Inventory and Assessment, Haleakalā High Altitude Observatory Site, Maui, Hawai‘i, Species List

Appendix F: CMKculturalresources, March 2003, Cultural Resources Evaluation for the Summit of Haleakalā

Appendix G: CMKculturalresources, December 2002, Traditional Practices Assessment for the Summit of Haleakalā

Appendix H: Fredericksen, Erik M. and Demaris L., April 30, 2003, Archaeological Inventory Survey of 18.1-acre parcel at Science City, Haleakalā Crater, Papa‘anui Ahupua‘a, Makawao District, Maui Island (TMK: 2-2-07: por. of 8)

Appendix I: KC Environmental, Inc., 2003, Clear Line-of-Sight (CLS) From Locations Within Haleakalā Observatories

Appendix J: Air Force Environmental Management Plans for the Maui Space Surveillance Complex

LIST OF REFERENCES


Handy, E.S. Craighill and E. G. Handy.1972. Native Planters in Old Hawai‘i: Their Life, Lore, and Environment, Bishop Museum Press, Honolulu, Hawai‘i.


