**Center for Astrophysics**
60 Garden Street
Cambridge, MA 02138
Tel(617) 495 7353 FAX (617) 495 7040

Harvard College Observatory
Smithsonian Astrophysical Observatory

# MEMORANDUM

To: File

MEMO #36

From: B. Bruckman

Date: 5 Oct, 1990

Subject: Mauna Kea

Attached are exerpts from the Mauna Kea Complex Development Plan for your information.

Distributions B and E

## Area C - Saddle Between Puu Wekiu, Puu Hau Oki, and Puu Poliahu

### Description

Area C, elevation 13,300 feet to 13,400 feet, is a relatively flat area approximately 450 feet lower than the summit cinder cone (Puu Wekiu). Because this area is shielded from the wind by surrounding cinder cones, it is an ideal location for millimeter-wave telescopes. The California Institute of Technology 10-meter telescope for millimeter and submillimeter astronomy (Caltech) and the United Kingdom/Netherlands 15-meter millimeter-wave telescope (UK/NL MT) are programmed for development there. There is sufficient area to allow construction of one or two additonal telescopes of this type in the future.

### Development Considerations

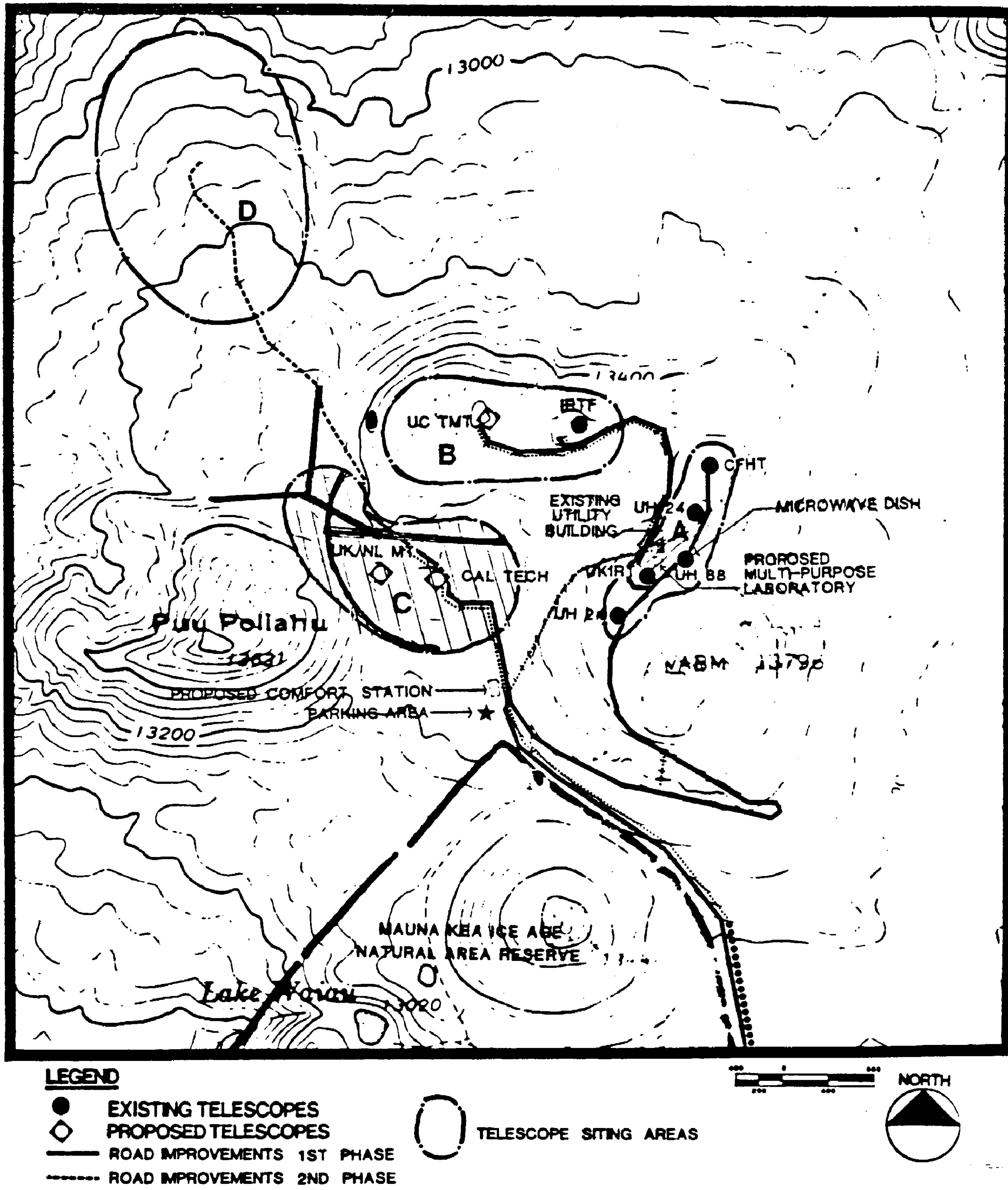
The area is situated on lava flows which consist of massive andestite, generally of the variety called Hawaiite. The flows are of the aa type and tend to be on much flatter gradients than the cinder cones. Glaciation has both removed the uppermost clinker material from the lava flows and deposited glacial debris on top of the flows, therefore, assorted rocky soil cover, up to several feet thick, exists in places. The lava flows are not affected by surface runoff. They may, however, concentrate runoff because of density and general impermeability of the rock. The lava flows will provide excellent foundation support; the rock will be able to support any loads likely to be imposed by telescopes.

Area C is not sensitive botanically. Although there is a general homogeniety of the lichen communities over most of the Science Reserve, there is a distinct paucity of species in this area, due possibly to the rainshadow effect of the surrounding cinder cones.[27]

The area is the habitat of the moth Archanarta, the spider Lycosa species and the centipede Lithobius; they are common in this location. Except for dust and pollution problems, this habitat is less vulnerable to human impacts than are the tephra cinder cones (Area B).[28] Construction in the area will not require specific biological mitigating measures other than minimizing dust.

There are two archaeological sites located approximately 450 feet south-southwest of the Caltech site. These features are classified as "shrines", as a convenient term to designate a simple altar without a prepared court.[29] Telescopes should not be located on or in close proximity to these features.

Access to sites within Area C will be via a spur road which branches off from the main summit access road at approximately the 13,000-foot elevation. This road should be improved and paved to the northern boundary of the UK/NL MT site. If a future telescope should locate north of this boundary, the road improvements and paving should be extended to service the new site.




**PROPOSED PHYSICAL PLAN FOR THE SUMMIT TO YEAR 2000**

# MAUNA KEA SCIENCE RESERVE CDP - FIG. 18

Power will be distributed to sites in Area C via a buried conduit, extending from a connection with the HELCO system, at approximately the 13,040-foot elevation, to the entrance of UK/NL MT site. If additional telescopes locate in the area, the utility trench must be extended to the boundary of northernmost site. Construction of this system and on-site electrical distribution systems is the responsibility of the individual telescopes.

Telephone communication and data transmission should be accomplished by extending a line from the microwave system, located at the UH 88-inch telescope, to each telescope site. This line should be installed in the existing utility trench which runs approximately 1,600 feet along the slopes of Puu Wekiu to the 13,040 foot handhole. From this handhole to each telescope site, the conduit should be buried in the same trench as the power conduits. Handholes for allowing access to the communications conduits are required at intervals of 400 feet. Those along the existing utility trench can be installed adjacent to those already in place.

Each individual telescope facility that locates in Area C must provide for water storage and distribution and wastewater disposal on its respective site. Cesspools or septic tanks with leaching fields must be sited so as to insure that there is no possibility of effluent reaching Lake Waiau. If possible, these septic tanks should be located on the north side of the summit where effluent will tend to flow northward, away from Lake Waiau.

Two telescope facilities have selected sites in Area C, they are:

California Institute of Technology 10.4-Meter Telescope for Millimeter and Submillimeter Astronomy

United Kingdom/Netherlands 15-Meter Millimeter Wave Telescope

## Area D - North Shield Area

### Description

Area D is an oval-shaped area whose south/southeast boundary (elevation 13,285 feet) is approximately 2,000 feet north/northwest of the UK/NL MT site. Approximately 2,800 feet long and 1,800 feet wide at its longest and widest point respectively, it extends to the 13,000-foot contour at its north/northwest boundary.

A temporary data collection station is presently located in the central portion of the area. Area D is highly suitable for future major optical/infrared telescopes. It can accommodate three to four telescopes, on the flatter portions, with some flexibility in choice of sites based on technical site selection criteria such as laminar wind flow and obscuration.

The area is characterized by a rich variety of lichens including Pseudephebe pubescens, a newly discovered species found only on Mauna Kea. Construction in this habitat must be carefully planned to minimize disturbance to this rare species of flora.

The arthropods Lycosa, Archanarta, and Lithobius are common in this area. As with Area C, the lava flow habitat is less vulnerable to human impacts than are tephra cinder cones. Construction in the area will not require specific measures to mitigate impacts on these arthropods, other than to minimize dust.

There are two archaeological sites in the northern portion of Area D, one is located between the 13,000-and 13,150-foot elevation and the other at the 13,140-foot elevation, near the terminus of the existing spur road. Both of these features are classified as "shrines" as a convenient term to designate a simple altar without a prepared court.[30] If future telescopes are proposed to be sited on or in close proximity to either one of these features, archaeological mitigation, as specified by the State Historic Preservation Officer, will be required.

Access to sites within Area D will be via the spur road which services the telescopes located in Area C. When future telescopes are planned for this area the road must be improved and paved. A new road will have to be constructed from the terminus of the existing spur road, at the 13,140-foot elevation, if future telescopes are sited north of this point. Power and communications conduits must also be extended from the nearest handhole to each future telescope site. These conduits must be buried; this will require new trenches which should be excavated alongside the access road. Handholes for allowing access to the conduits will be required at intervals of 400 feet. Access roads, power, and communications extensions should be phased in conjunction with the construction of each new telescope. Proration of costs of infrastructure extension is subject to negotiation between the UH and the proposing institution.

Each individual telescope facility that locates in Area D must provide for water storage and distribution and wastewater disposal on its respective site. Because this area is located in the northern portion of the summit, sewage effluent will flow to the north, away from Lake Waiau. No specific siting criteria for cesspools or septic tanks is required.

There are no astronomy facilities planned for development in Area D during the 1980s.

# DESCRIPTION OF THE PHYSICAL CHARACTERISTICS

## Geology

### Mauna Kea Science Reserve

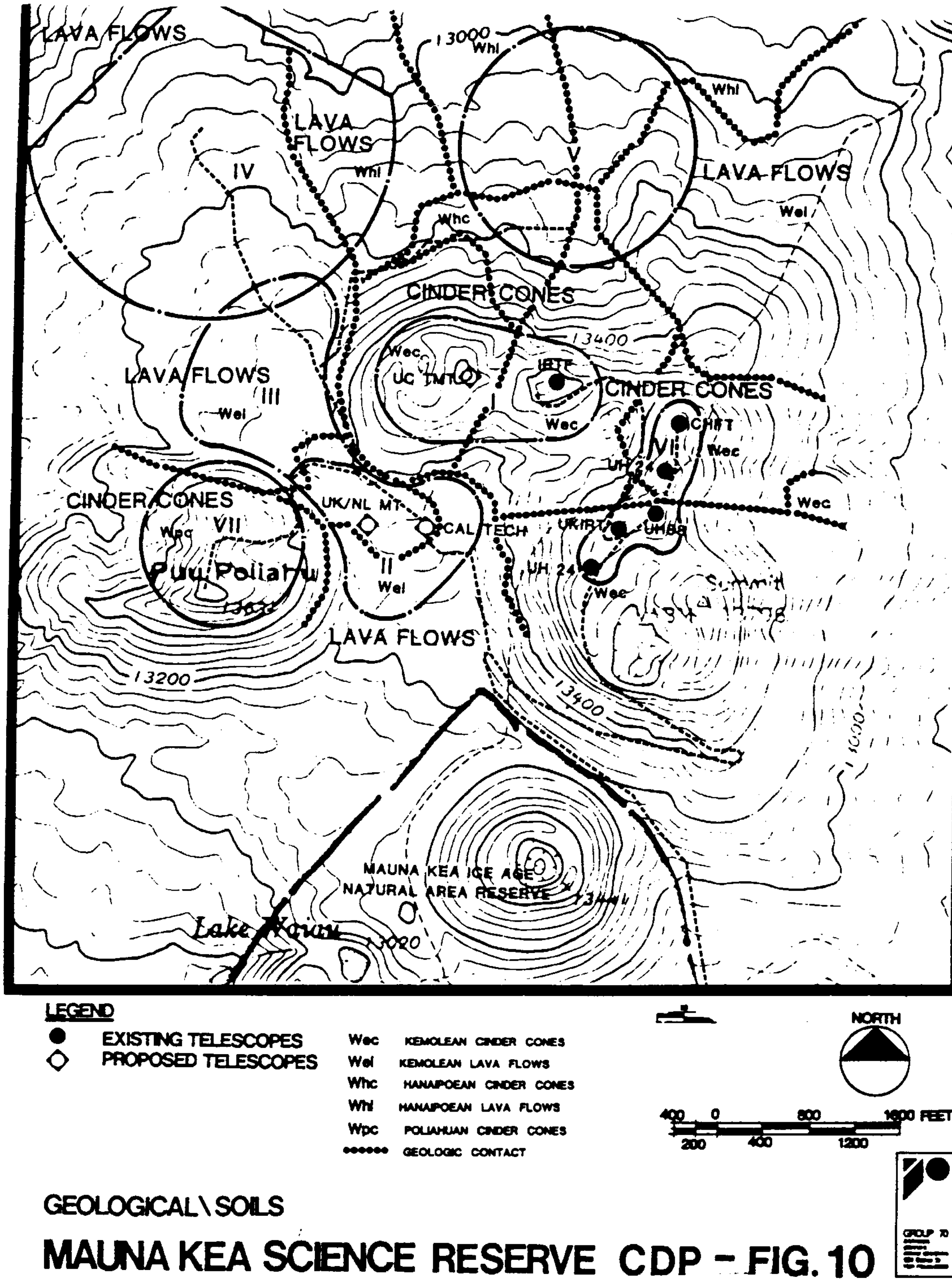
The rocks of Mauna Kea have evolved to a relatively mature stage. The most recently erupted rocks possess higher alkali and silica contents than the basalts which comprise the main mass of the volcano. Mauna Kea has been dormant for at least 3,500 years, although occasional weak seismicity and the general evolutionary characteristics do not preclude future eruptions. The subaerial portion of Mauna Kea has been dated as at least 315,000 years old ($\pm$ 50,000 years).

"The lava flows on top of Mauna Kea consist of massive andesite, generally of the variety called Hawaiite. Basically these flows are of the aa type, but the lavas were more viscous than similar flows composed of the basaltic materials that are common throughout the Hawaiian Islands. The flows tend to be on much flatter gradients than the cinder cones and the surface of the flows is typically very uneven. Aa flows are characterized by a core of dense rock overlain and underlain by volcanic clinker. Clinker fragments typically are on the order of 3 inches and are very rough textured. The core is also greatly variable in thickness so that lateral contacts between rock and clinker are frequent."

"The cinder cones are composed of volcanic ash and cinder which have locally been weakly cemented to varying degrees and may be interbedded with other volcanic materials such as splatter, volcanic bombs and other ejecta. Competent rock may exist at depths shallow enough to provide support for deep foundations. The ash and cinder frequently are loosely packed and have low densities. They exhibit low crushing strength and high permeability. Natural angles of repose tend to vary between about 34 and 45 degrees, depending upon the grain size distribution and apparent cementation. The slopes of the cinder cones tend to be somewhat flatter that these inclinations. Permafrost layers may exist within the cinder cones, but if present, are not expected to be encountered by any construction." (Dames & Moore)[14]

## Geology/Soils (Figure 10)

The summit area is composed primarily of two ground types, tephra cinders and lava flows; each has different characteristics which may affect the construction and the operation of telescopes. For example, the density of volcanic ash material present on the cinder cones is frequently rather low, thus foundation loads on this material should not exceed 2,000 pounds per square foot on shallow foundations. Lava flows, on the other hand, provide excellent foundation support, as the rock is able to support any loads likely to be imposed by telescopes.




GEOLOGICAL\SOILS

## MAUNA KEA SCIENCE RESERVE CDP - FIG. 10

Geology/Soils (Figure 10)

The summit area is composed primarily of two ground types, tephra cinders and lava flows; each has different characteristics which may affect the construction and the operation of telescopes. For example, the density of volcanic ash material present on the cinder cones is frequently rather low, thus foundation loads on this material should not exceed 2,000 pounds per square foot on shallow foundations. Lava flows, on the other hand, provide excellent foundation support, as the rock is able to support any loads likely to be imposed by telescopes.

Analysis areas I, IV, VI and VII, and the southern portion of Area V, lie within areas of cinder cones. The cones are composed of volcanic ash and cinder; the ash and cinder frequently are loosely packed and have low densities, they exhibit low crushing strength and high permeability.

Cinder cone material is readily excavatable by standard earth moving equipment. Because cinder cone material is highly erodible, any construction in areas of volcanic ash will require drainage improvements to avoid concentrating runoff.

Analysis areas II, III, IV, and the northern portion of Area V are primarily on lava flows. These lava flows consist of massive andesite, generally of the variety called Hawaiite; they are generally of the aa type.

Analysis areas I, IV, VI and VII, and the southern portion of Area V, lie within areas of cinder cones. The cones are composed of volcanic ash and cinder; the ash and cinder frequently are loosely packed and have low densities, they exhibit low crushing strength and high permeability.

Cinder cone material is readily excavatable by standard earth moving equipment. Because cinder cone material is highly erodible, any construction in areas of volcanic ash will require drainage improvements to avoid concentrating runoff.

Analysis areas II, III, IV, and the northern portion of Area V are primarily on lava flows. These lava flows consist of massive andesite, generally of the variety called Hawaiite; they are generally of the aa type.

## Hazards

Mauna Kea has progressed to a later stage in its volcanic life cycle, a stage characterized by short and stubby flows, larger and more numerous cinder cones and less frequent eruptions. Based on the infrequency of its eruptions in the recent past, the probability of Mauna Kea erupting in the next several decades is very low. If Mauna Kea does erupt again some time in the future, its eruptions will likely be of the explosive type that produces abundant blocks and ash that covers areas near the eruptive site with large and small fragments.[16]

Mauna Kea, and the entire Island of Hawaii, is located in Earthquake Zone 3 (on a scale of 0 - 3, this is in the zone of highest seismic occurrence and danger). All construction work is subject to provisions of the "Uniform Building Code" which requires that all structures be designed and constructed to meet Zone 3 requirements.

In 1966, Dames & Moore performed a geological/soils investigation of the summit in order to determine whether observatory operations would be feasible there. They concluded that an observatory could operate successfully with a foundation system designed to minimize the magnitude of ground vibrations transmitted to the telescope.[17]

## Topography

### Mauna Kea Science Reserve

The Mauna Kea Science Reserve includes a number of cinder cones of varying sizes and shapes along the rift zones that descend from the summit. Slopes in the area vary from flat plateaus to close to vertical slopes on the cinder cones. Puu Wekiu, the summit cinder cone, rises several hundred feet above the surrounding lava plateau. Both the inner and outer slopes of this cone average about 28 degrees.

## Hydrology and Permafrost

### Surface Water

The only perennial surface water present on the summit, except that trapped within the crater of Puu Pohaku, is Lake Waiau, a small body of water in the crater of Waiau cone, located at approximately the 13,020-foot elevation. The lake is approximately 240 feet in diameter and 8 feet deep at overflow stage.[18]

### Groundwater

Because of the very limited precipitation and high permeability of the soils at the summit. . . "the only groundwater known to exist consists of perched water in the center of some of the cones, including the area immediately east of Lake Waiau "(Woodcock, 1974, 1980). Borings for existing telescopes did not encouter groundwater.[19] No water table is known to exist anywhere in the vicinity of Hale Pohaku, nor are any groundwater supplies developed in the vicinity.[20]

### Permafrost

Permafrost is known to have been identified in only two locations at the summit, Puu Wekiu and Puu Goodrich, both sheltered portions of cinder cone craters. . ."Woodcock and Friedman (1979) speculate that permafrost might exist 60 meters below the top of the summit cone, and Woodcock (1981) speculates that permafrost may underlie the groundwater body east of Lake Waiau, (but not under Lake Waiau). In general, the climate on Mauna Kea is considered to be slightly too warm for permafrost. . . No borings for existing facilities are known to have encountered permafrost." (Dames & Moore)[21]

## Air Quality

The summit area is well above the 7,000-foot temperature inversion layer which limits the vertical convection transport of aerosols (particulates, including dust, salt particles, water droplets and man-made pollutants); the aerosols do not cause any particular problem as long as they are generated below the inversion level. Atmospheric pollutants at the summit are locally generated by combustible engines such as in automobiles, trucks and the existing diesel generator, and by travel over unpaved roads.

## Climate

### Precipitation

Precipitation at the summit averages approximately 15 inches annually, most of which is in the form of freezing fog or snow. Snowfalls are more common during the cooler half-year (October to April); between April and December weather causes only minor interruptions in working schedules. From December through March, snow in the summit area can block the road and cause schedule disruptions. Major snowfalls which have caused blockage of the summit road have occurred in at least seven of the past ten years.

Records of rainfall show that Hale Pohaku averages approximately 25 inches annually, the wettest months falling between November through March. Measurements of rainfall at Pohakuloa, near the Saddle Road, show the mean monthly rainfall for the area ranges from one to five inches.

### Temperature

The temperature at the summit of Mauna Kea is relatively mild for its elevation. During most of the year, the mean temperature is a few degrees above freezing. The extremes in monthly average temperature range from 11°C maximum to -4°C minimum.

Existing data indicate that temperatures at Hale Pohaku range from the 30s (Fahrenheit) to the mid-70s (Fahrenheit).

### Wind Direction and Atmospheric Turbulence:

Optical/infrared telescopes are sensitive to atmospheric turbulence. Turbulence has the effect of producing rapid motion and/or enlargement of the image of a star or other astronomical object being observed. Turbulence and shaking due to wind compromise these telescopes by causing the light or radiation to be spread out in constantly changing patterns instead of focused on a steady point. Optical/infrared telescopes must be sited where the laminar air flow is not disturbed by turbulence generated by nearby cinder cones or other telescopes. On the other hand, millimeter-wave telescopes should be located where natural topography provides a shield against the wind.

Tests were conducted at several areas on the summit during 1965 and 1966. (Wind roses derived from frequency distributions of nightime wind direction are presented for two test locations in Figure 8.) These tests indicate that night-time wind direction at the summit of Mauna Kea is predominately from the east-southeast. Analyses of wind direction in relation to existing and proposed telescopes and summit area cinder cones indicates that Area I (Puu Hau Oki), Area IV (the north shield area), and Area VI (the summit ridge), are the areas most likely to be free of turbulence and thus most suitable for optical/infrared telescopes. Most of Area V would probably not be affected by wind deflection off of natural topography, however, nearby cinder cones (Puu Mahoe and Puu Poepoe) could create turbulence in some portions of the area. Areas II and III are less suitable for optical/infrared telescopes as they are located in a plateau between the summit cinder cone and Puu Poliahu. Because the natural topography provides a shield against the wind, these areas are suitable locations for millimeter-wave telescopes.

Winds at the summit follow a diurnal pattern of prevailing west/northwest daytime and east/southeast nighttime wind direction. Wind velocity usually ranges from 10 to 30 miles per hour. During severe winter storms, winds occasionally exceed 100 miles per hour on exposed summit areas, such as the top of cinder cones.

The following table shows the average daily temperature and nighttime wind velocities at the Mauna Kea summit:

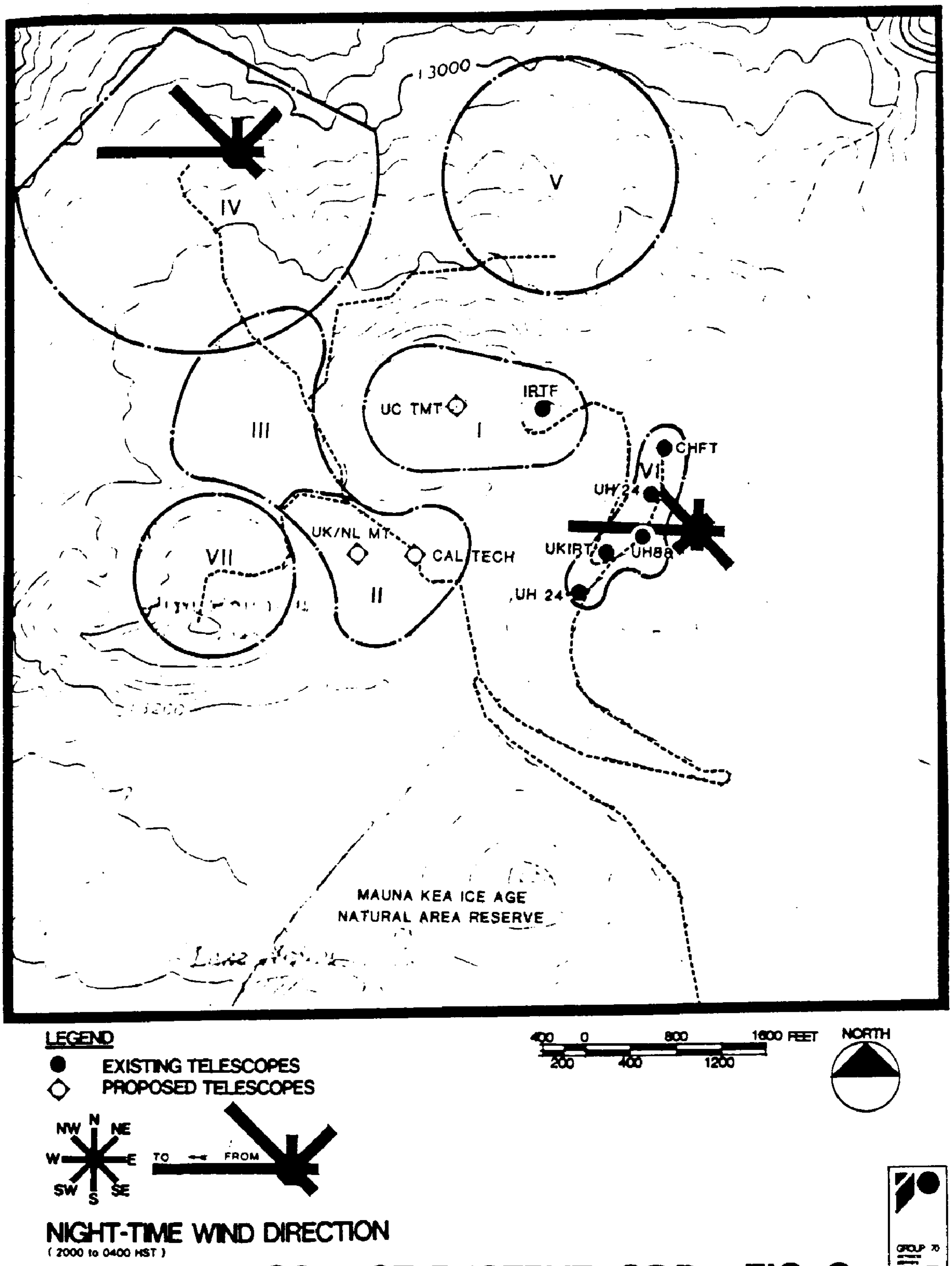
TABLE 1

Average Daily Temperature and Nighttime Wind Velocities

| Month | $T_{max}$(°C) (1965-69) | $T_{min}$(°C) (1965-69) | Nighttime Wind Speed (mph) (1965-69) |
|---|---|---|---|
| Jan | 3 | -4 | 11 |
| Feb | 3 | -4 | 20 |
| Mar | 5 | -1 | 17 |
| Apr | 5 | -3 | 24 |
| May | 5 | -1 | 17 |
| Jun | 10 | 0 | 15 |
| Jul | 10 | 0 | 15 |
| Aug | 11 | -1 | 13 |
| Sep | 11 | +1 | 13 |
| Oct | 10 | 0 | 15 |
| Nov | 6 | -3 | 13 |
| Dec | 3 | -4 | 19 |

Source: D. Morrison, R.E. Murphy, D.P. Cruikshank, W.M. Sinton, and T.Z. Martin, "Evaluation of Mauna Kea, Hawaii, as an Observatory Site", Publications of the Astronomical Society of the Pacific, Vol. 85, No. 505, (June 1973): 255 - 67.

Prevailing winds at Hale Pohaku and at the Saddle Road are from the northeast and are characterized by occasional strong to heavy gusts.




NIGHT-TIME WIND DIRECTION
( 2000 to 0400 HST )

MAUNA KEA SCIENCE RESERVE CDP - FIG. 8



Tests were conducted at several areas on the summit during 1965 and 1966. (Wind roses derived from frequency distributions of nightime wind direction are presented for two test locations in Figure 8.) These tests indicate that night-time wind direction at the summit of Mauna Kea is predominately from the east-southeast. Analyses of wind direction in relation to existing and proposed telescopes and summit area cinder cones indicates that Area I (Puu Hau Oki), Area IV (the north shield area), and Area VI (the summit ridge), are the areas most likely to be free of

Table 2

ANALYSIS OF TELESCOPE SITING AREAS

| SCREEN & VARIABLES | AREA I | AREA II | AREA III | AREA IV | AREA V | AREA VI | AREA VII |
|---|---|---|---|---|---|---|---|
| Screen One - Technical | | | | | | | |
| Wind Direction, Turbulence | Laminar | Unknown - wind deflection from surrounding cinder cones expected | Same as Area II | Laminar | Wind deflection from nearby cinder cones could create turbulence in some portions | Laminar | Unknown |
| Obscuration | No obscuration from natural topography if telescopes are located on peaks of cinder cones | Puu Poliahu will partially obscure view of southern horizon for telescopes sited in south-southwest corner of area | Horizon from western portion of area obscured by Puu Poliahu | Puu Hau Oki obscures view of southern horizon from eastern portion of area | Southern horizon obscured by cinder cones except for area between 13,000 and 13,080 feet elevation | Horizon, as viewed from peaks, is not obscured by natural topography | None |
| Screen Two - Physical /Environmental | | | | | | | |
| Geological/Soils | Tephra cinders<br>Max. foundation load 2,000 lbs. /ft. for shallow foundations<br>High erosion potential<br>High dust potential | Lava flows<br>Excellent foundation support<br>Rigid base for telescope mechanisms<br>Low erosion potential<br>Low dust potential | Same as Area II | Same as Area II<br>Avoid locating within 100 feet of geologic contact | Most of the area lava flows<br>Southwest portion is cinder deposits<br>Flatter portions similar to II & III | Same as Area I | Same as Area I |
| Slope | Tops of cinder cones relatively flat<br>Sides of cinder cones have slopes > 20% | Entire area relatively flat | Same as Area II | Eastern portion at geologic contact has slopes ≥ 20%<br>Remaining area has slopes < 20% | Same as Area IV | Same as Area I | Only small portion at peak has slope > 20% |

Table 2 (Continued)

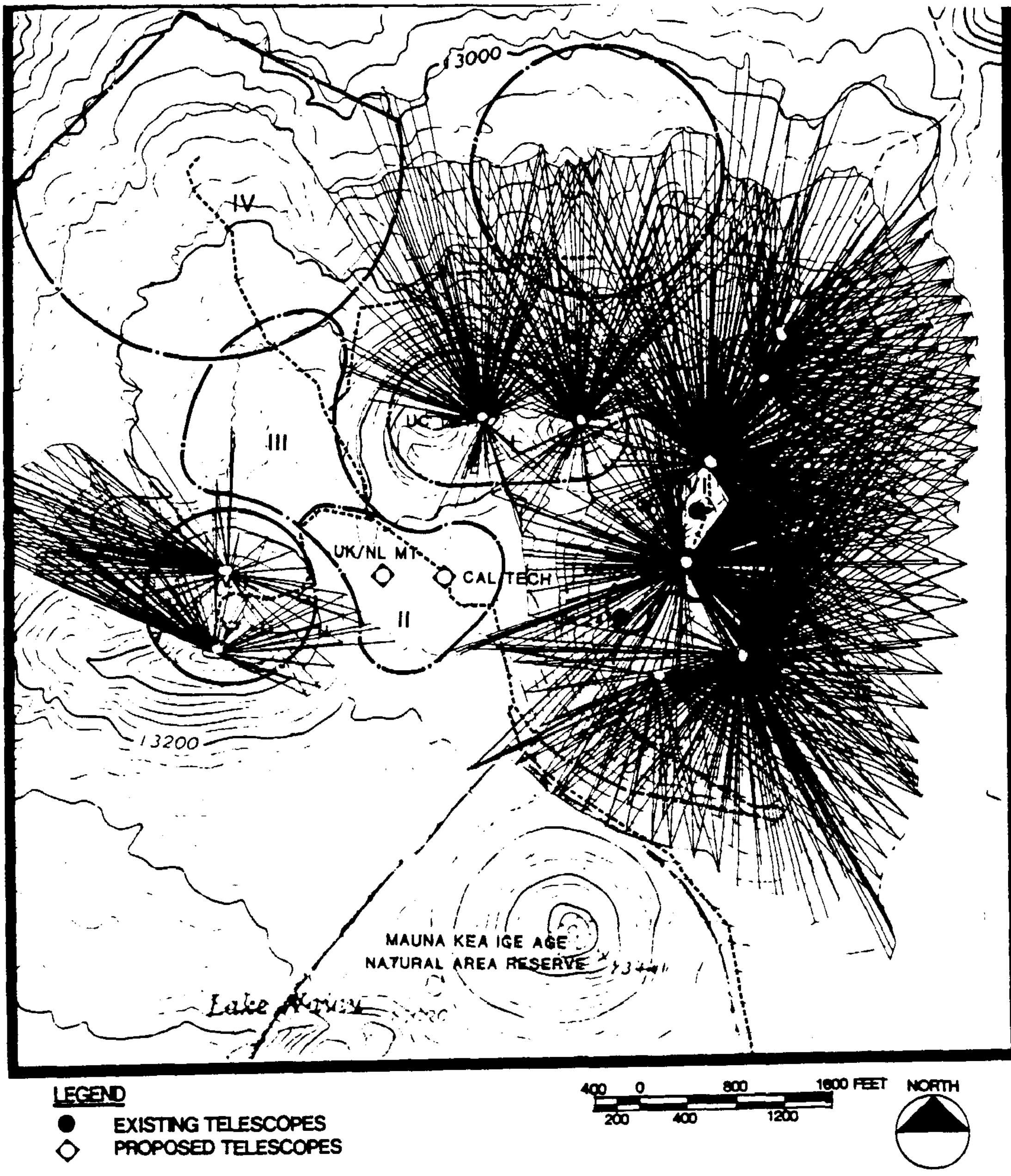
| SCREEN & VARIABLES | AREA I | AREA II | AREA III | AREA IV | AREA V | AREA VI | AREA VII |
|---|---|---|---|---|---|---|---|
| Biological/ Botanical | Prime habitat of Nysius<br>Unsuitable for flora | Lycosa common<br>Southwest portion moderate density Nysius<br>Low density and diversity of lichen | Lycosa common<br>Northern portions sensitive for rare lichens | Lycosa common<br>Most of area sensitive for rare lichens | Moderate density Nysius<br>Not sensitive for lichens | Adjacent area (but not within area) prime habitat Nysius<br>Unsuitable for flora | Moderate Nysius<br>Unknown botanical |
| Archaeological Sites | None present | Two sites southern portion | One site north-east corner | Three sites | Four sites | None | Unknown |
| Visibility | Visible from Waimea, South Kohala, Hawaii Volcanoes National Park | Not visible outside of immediate area | Telescopes sited in northern portion may be visible from Waimea, South Kohala | Visible from Waimea, South Kohala some portions of North Kona | Same as Area IV | Visible from Hilo, Waimea, Hawaii Volcanoes National Park | Unknown |
| Screen Three<br>Recreational Uses | | | | | | | |
| Skiing | No effect | Some effect - Menehune run | Some effect - Maidens run | No effect | Some effect - Warriors Run | No effect | Heavy ski use |
| Hiking | No effect | No effect | No effect | No effect | No effect | No effect | No effect |
| Hunting | No effect | No effect | No effect | No effect | No effect | No effect | No effect |
| Screen Four<br>Infrastructure | | | | | | | |
| Costs | Road-IRTF to UC IMI: $106,000<br>UC IMI to east of area: $100,000<br>Power-IRTF to UC IMI: $116,000<br>UC IMI East: $109,000 | Cost of road to UK/NL MT: $200,000<br>Power extension: $272,000 | Road-UK/NL MT to to N. Boundary: $300,000<br>Power extension: $326,000 | Road-UK/NL MT to 13,000 foot: $650,000<br>Power extension: $707,000 | Road-UK/NL MT to N. Boundary: $700,000<br>Power extension: $762,000 | Infrastructure in place | Road: $600,000<br>Power: $605,000 |

Obscuration:

Telescopes must be able to view all parts of the southern and northern sky down to 12° above the horizon. The southern horizon is more critical for research being conducted in Hawaii; if this horizon is obscured, some objects could not be observed at all. The most obvious sources of obscuration are the natural and man-made features within the summit, the cinder cones and other telescopes.

Computer analysis was utilized to identify sites that met the 12° obscuration criterion. The top of the mountain was digitized and a program was written that allowed testing of obscuring features against potential locations. The program scanned a range of minimum viewing angles above the horizon and analyzed 6,000 positions against 11 major obscuring features. This process resulted in a plot showing pinwheels of lines. The pinwheel centers are obstructions and the ends of the lines are points where the view is obscured. This plot is reproduced on Figure 9.

Areas I, VI, and VII, which are located on the tops of cinder cones, Area IV, the north shield area, and Areas II and III, the saddle between the major cinder cones, experience minimal obscuration. In Area V, only the area between the 13,000-and 13,080-foot elevations is not affected by obscuring features.




AREAS OF OBSCURATION

# MAUNA KEA SCIENCE RESERVE CDP - FIG. 9

Computer analysis was utilized to identify sites that met the 12° obscuration criterion. The top of the mountain was digitized and a program was written that allowed testing of obscuring features against potential locations. The program scanned a range of minimum viewing angles above the horizon and analyzed 6,000 positions against 11 major obscuring features. This process resulted in a plot showing pinwheels of lines. The pinwheel centers are obstructions and the ends of the lines are points where the view is obscured. This plot is reproduced on Figure 9.

Areas I, VI, and VII, which are located on the tops of cinder cones, Area IV, the north shield area, and Areas II and III, the saddle between the major cinder cones, experience minimal obscuration. In Area V, only the area between the 13,000-and 13,080-foot elevations is not affected by obscuring features.

# DESCRIPTION OF THE EXISTING BIOLOGICAL CHARACTERISTICS

## Vegetation

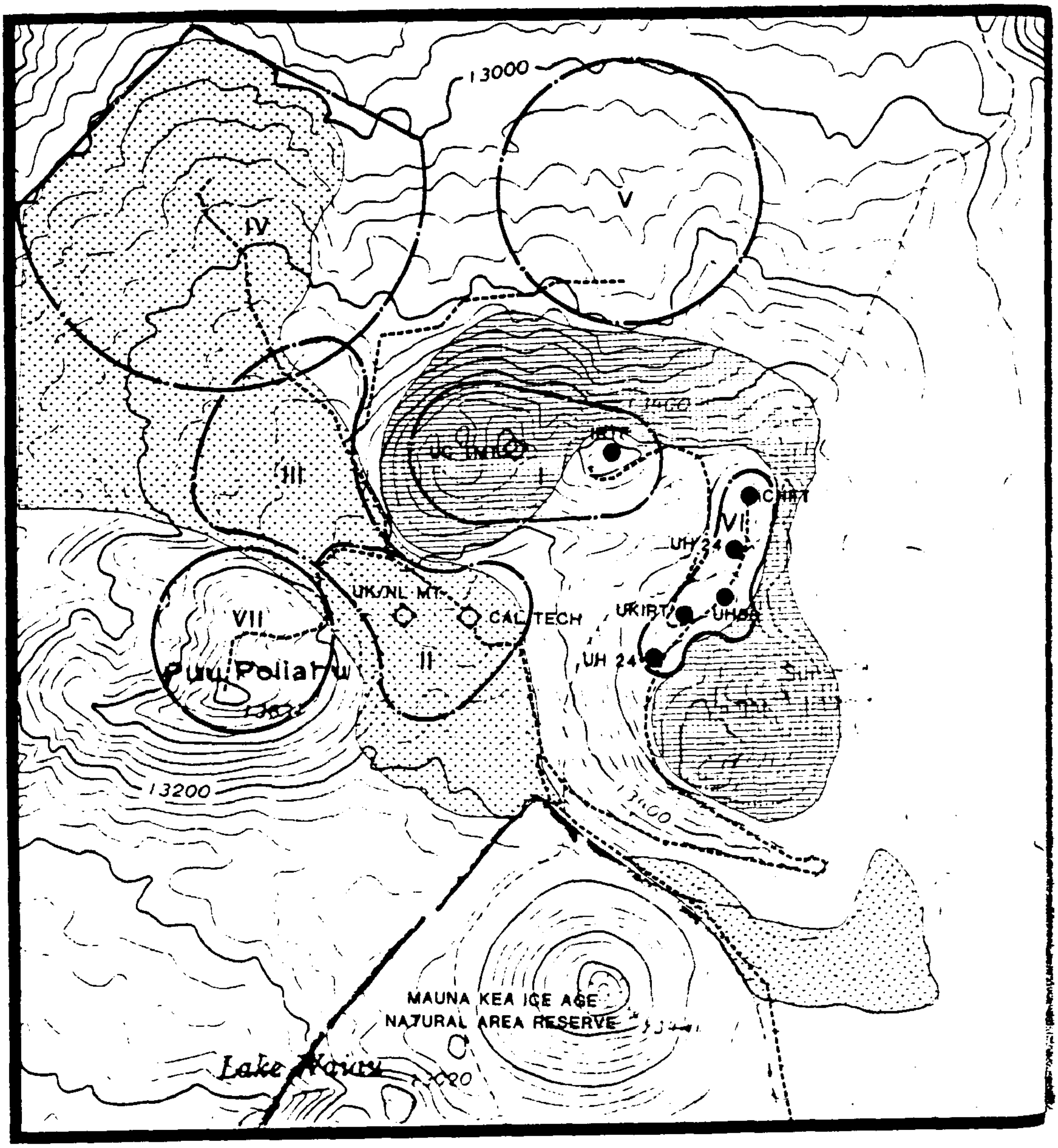
### Summit

Lichens and bryophytes are the principal components of the flora at the summit of Mauna Kea. The climatic conditions at that altitude tend to be so severe as to exclude most higher plants. The Bishop Museum, Department of Botany, has conducted a botanical survey of the summit area of Mauna Kea, (Volume 2, draft EIS, Appendix G). Two areas of interest were identified: the slope of Puu Wekiu below the switchback; and, an area north of Puu Poliahu to the 13,000-foot elevation. The first area contains numerous large rocks which support a substantial colony of lichens. The second area is characterized by a rich variety of lichens including the Pseudephebe pubescens, a lichen which was first discovered during the course of this survey. The latter species is primarily found in high altitude alpine regions and has never been collected before in Hawaii or anywhere in the tropics.

## Fauna

### Summit

The major faunal components of the summit ecosystem are arthropods such as spiders, moths, mites, springtails, centipedes, booklice, barklice, and true bugs. One true bug, a highly aberrant new species of the world wide genus Nysius, was recently discovered at the summit. The habitat of this new bug is most commonly found under large boulders and among cinders. There are no officially designated endangered species of arthropod fauna present at the summit.




LEGEND
● EXISTING TELESCOPES
◇ PROPOSED TELESCOPES

LYCOSA COMMON

NYSIUS HIGH DENSITY

400 0 200 400 800 1200 1600 FEET NORTH

ARTHROPOD FAUNA

## MAUNA KEA SCIENCE RESERVE CDP - FIG.12

Biological/Botanical

Recent biological investigations of the summit area have resulted in the identification of a neogeoaeolian ecosystem on Mauna Kea. The major component of the fauna of the summit ecosystem is arthropods. One true bug, a highly aberrant new species of the world wide genus Nysius, was recently discovered at the summit. Figure 12 identifies the major summit habitats of two species, the Nysius and the Lycosa, a spider.

Tephra cinder cones are a prime habitat for the Nysius. These habitats are particularly vulnerable to degradation by human activities because the tephra are easily crushed during construction activities. Area I, Puu Hau Oki, is located within this habitat.

## NATURAL AND ARCHEOLOGICAL FEATURES

### National Natural Landmark

Mauna Kea has been designated as a National Natural Landmark and is listed in the National Registry of Natural Landmarks. In spite of this listing, Mauna Kea, among other landmarks also designated, is not a registered landmark, since the BLNR has not officially agreed to that designation.

### Mauna Kea Ice Age Natural Area Reserve

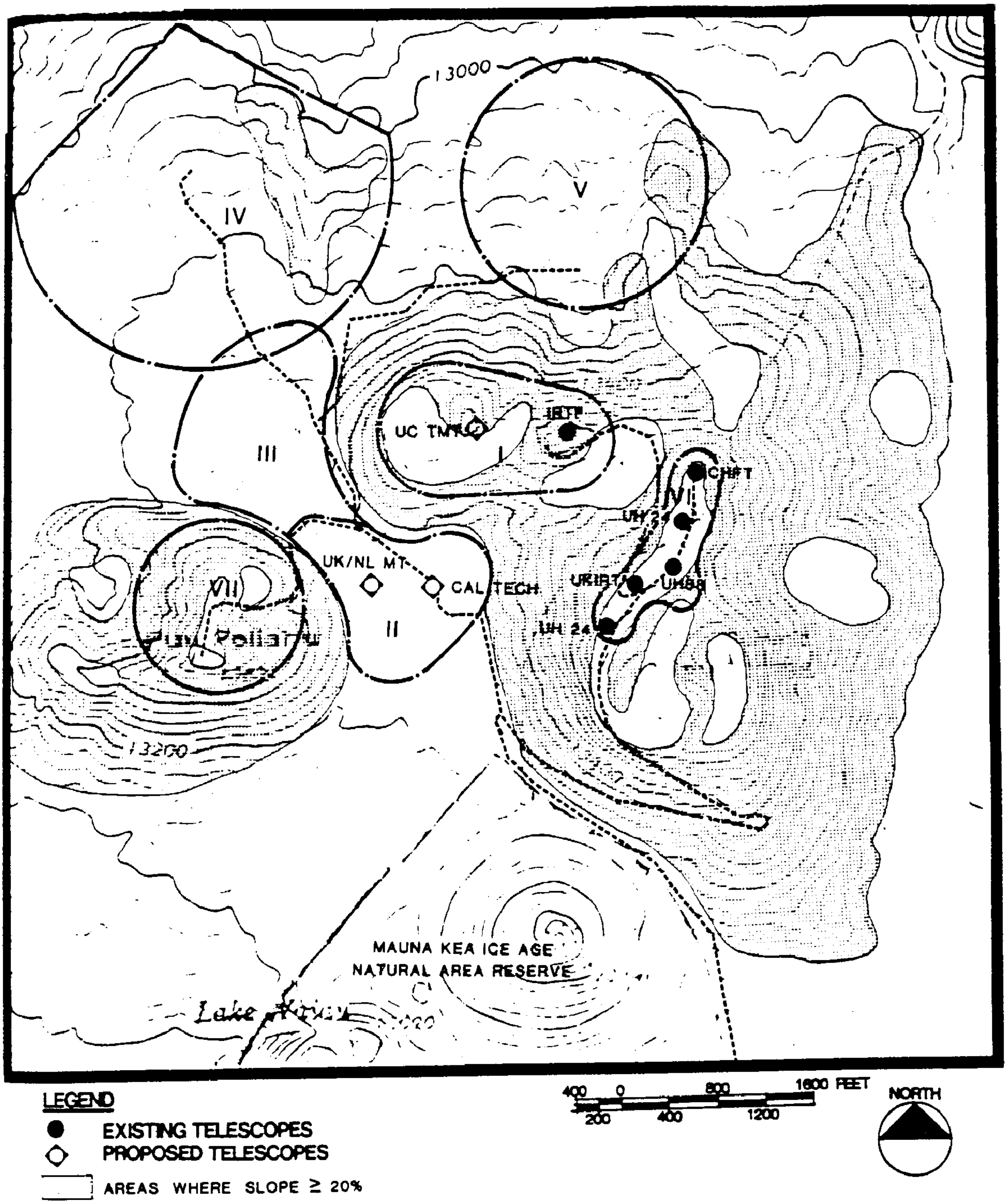
The Mauna Kea Ice Age Natural Area Reserve is located between the elevations of 10,400 and 13,200 feet. It extends into a portion of the summit area that is leased to the University of Hawaii as the Mauna Kea Science Reserve. This Natural Area Reserve (NAR) designation was approved by the BLNR on November 9, 1978. A CDUA for the area was approved by the BLNR in 1981. On November 16, 1981, the Governor signed an Executive Order establishing the Mauna Kea Ice Age Natural Area Reserve.[22]

Features within the NAR are managed by the DLNR according to their management plan for the area. Regulations for activities within NARs have also been promulgated by the the DLNR.

The main ice age features located in the NAR are Pohakuloa Gulch (formed by glacial meltwater), glacial moraine and meltwater deposits of fine sediments (present down to the 10,500-foot elevation), and the glacially sculptured features of cinder cones and lava flows. Lake Waiau, one of the highest lakes in the United States, and the Keanakakoi Adze Quarry, are other features of the Reserve.

The Keanakakoi Adze Quarry is located at the 12,400-foot elevation. The quarry site is listed on the National Register of Historic Places. There are a variety of ancient Hawaiian culture remains, dating back to about 1000 A.D., that are scattered throughout this quarry. These include religious shrines and rock shelters of different types, which were established in conjunction with a series of adze (tool) quarries and workshops.[23]

> "The Mauna Kea Adze Quarry is probably one of the nation's least known but most important National Historic Landmarks, from both a research and interpretive point of view. It is the only landmark of its kind in the United States. Moreover, it is probably one of the largest and most complex stone tool quarries in the world." (McCoy 1976)




SLOPE MAP

# MAUNA KEA SCIENCE RESERVE CDP - FIG. 11

Slope

Figure 11 identifies areas within the study area where slopes are 20 per cent or greater. Construction on steeper slopes would require massive re-grading to accommodate most structures and roads. Because these steep slopes are most often associated with cinder cones, erosion problems caused by construction could be severe.

Each analysis area was evaluated based on the extent of the area within its boundaries with slopes less than 20 per cent. The number of potential siting areas within an analysis area was constrained by the amount of area with steep slopes.

The site was a very important and extensive center of Hawaiian adze manufacturing. Scientists at the Bishop Museum have been collecting information about the process of obtaining raw materials for, and the manufacture of, this important class of stone tools. During their excavations and analysis of the Quarry, they found the first evidence of Hawaiian rock art on the upper slopes of the volcano. They also found evidence of intermittent, short-term habitation in the numerous rockshelters, including artifacts and well-preserved food remains.[24]

## Archaeology

### Summit

A total of 22 archaeological sites were recorded in a recent Bishop Museum survey. All but two of the 22 sites are located on the north slope, below the summit cones. All but one site, an open air shelter, were classified as "shrines", a convenient term to designate a simple altar without a prepared court. Shrines are characterized by the presence of one or more upright stones. In a number of instances they were simply set up on the surface of an outcrop and are braced by a few stones. The platforms and cairns are distinguished by stack-stoned construction. No offerings were found at any of the 21 sites. In contrast to the structures found at the Keanakakoi Adze Quarry, the function of the 21 shrines is unknown. (EIS, Volume II, Appendix A)

## OTHER USES OF THE SUMMIT AREA

### Skiing and Snow Plan

Many residents and visitors participate in snow activities during the winter season. The Ski Association of Hawaii works closely with the Institute for Astronomy in order to make certain that skiing is compatible with astronomical observation.

### Hiking, Sightseeing and Photography

Hiking, sightseeing and photography are among some of the recreational activities in the summit area. Joyriding has become increasingly popular and the use of "off-road" vehicles has left scars up the cinder slopes and cones.

### Other Scientific Research

Mauna Kea has a number of natural resources which are of interest to scientists from various disciplines. The Kitt Peak National Observatory (KPNO) and the UH are presently conducting a site survey of Mauna Kea. Climatological and astronomical data will be collected over a three year period. Identical surveys are being carried out simultaneously at other stations located within the United States.

Geologists are interested in Mauna Kea's unique volcanic and glacial history. The summit's altitude, climate and atmosphere are attractive for the study of meteorology. As the highest insular volcano in the world, Mauna Kea with its remnant endemic ecosystems represents a unique research environment for biologists and botanists.

### Transmitters/Receivers

Presently, there are a total of four transmitters within the Science Reserve. Two National Weather Service transmitters are located at the Planetary Patrol building. The transmitters are a part of the tsunami warning system and are used primarily for transmitting weather information on a 24-hour basis from Hilo up to Mauna Kea and then to Haleakala, Maui and Ewa Beach, Oahu. Two transmitter/receivers are located at the brick power building, one is used by the DLNR Forestry Division and the other by the Volcano Observatory. The forestry transmitter is used in case of forest fires; the Volcano Observatory transmitter/receiver translator is used in monitoring the Kilauea and Mauna Loa volcanoes. Under agreements with BLNR, these transmitters are allowed until they interfere with astronomical observations and telescope functions.