

THIRTY METER TELESCOPE MANAGEMENT PLAN

Executive Summary

On behalf of the TMT Observatory Corporation, the University of Hawai'i is seeking a Conservation District Use Permit (CDUP) from the State of Hawai'i Board of Land and Natural Resources (BLNR) that will allow the construction, operation, and eventual decommissioning of the Thirty Meter Telescope (TMT) Observatory within an area below the summit of Mauna Kea that is known as "Area E". The proposed TMT Project consists of an observatory to be located in a roughly 5-acre site within Area E, near the end of an existing 4-wheel drive road. An Access Way would provide road access and utilities to the site. The existing 4-wheel drive road would be improved from the point where it diverges from the existing Mauna Kea Loop Road that serves the summit of Mauna Kea and, to the extent possible, utilities would be placed beneath the improved road. The Batch Plant Staging Area, which has been used in the construction of other observatory facilities, will be used for storing bulk materials and operation of a concrete batch plant.

This TMT Management Plan is in accordance with Hawai'i Administrative Rules (HAR) Chapter 13-5, specifically Exhibit 3. Pursuant to HAR Chapter 13-5, this document is intended to manage TMT land use in the Conservation District for the purpose of: (1) conserving, protecting, and preserving the important natural and cultural resources of the State of Hawai'i through appropriate management and use to promote their long-term sustainability; and (2) the public health, safety, and welfare.

This TMT Management Plan was also developed to work in conjunction with the BLNR-approved Comprehensive Management Plan (CMP) and the four CMP subplans: (1) Cultural Resources Management Plan; (2) Natural Resources Management Plan; (3) Decommissioning Plan for the Mauna Kea Observatories; and (4) Public Access Plan for the UH Management Areas on Mauna Kea. The CMP and subplans are the primary management documents governing activities and uses in the UH Management Areas on Mauna Kea. These documents have and will continue to guide TMT Project development.

The TMT Management Plan is intended to guide various activities and uses within the TMT Project area. Together, the CMP, the CMP subplans, and this TMT Management Plan are intended to fulfill the purpose of the Conservation District with regards to the TMT Project.

Section 1 of this plan provides a general description of the TMT Project and this Management Plan. Section 2 describes the existing conditions on or in the vicinity of the TMT Project site. Section 3 provides a detailed description of the TMT Project. Section 4 describes the TMT management measures and controls that would ensure the protection of Mauna Kea's cultural, historic, and natural resources through various policies, practices, and procedures. Section 4 also details the comprehensive measures TMT developers would implement to mitigate the impacts of the TMT Project. Section 5 presents TMT Project monitoring and reporting strategies.

The effective time duration for this Management Plan shall be for the life of the TMT Observatory.

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APPENDIX E: ARTHROPOD ACCESS WAY MONITORING PLAN

1.0 General Description

1.1 Background & Purpose

1.1.1 Mauna Kea Comprehensive Management Plan

Mauna Kea is one of the most significant cultural sites in Hawaiʻi and significant astronomical observing sites in the world. The Mauna Kea Comprehensive Management Plan (CMP), which is an integrated planning tool for resource management, was developed to ensure the ongoing protection of the varied resources located in the UH Management Areas on Mauna Kea and to effectively manage and guide existing and future activities and uses on Mauna Kea. The Board of Land and Natural Resources (BLNR) approved the CMP on April 9, 2009.

On March 25, 2010, BLNR-approved four subplans to the CMP, the: (1) Cultural Resources Management Plan (CRMP); (2) Natural Resources Management Plan (NRMP); (3) Decommissioning Plan for the Mauna Kea Observatories (Decommissioning Plan); and (4) Public Access Plan for the UH Management Areas on Mauna Kea (PAP). These subplans provide more detail on specific Mauna Kea management issues. Together, the four subplans and the CMP provide for the comprehensive management of resources, activities, and land uses found in the UH Management Areas on Mauna Kea. The UH Management Areas on Mauna Kea include the Mauna Kea Science Reserve (MKSR) (TMK 4-4-15:9), Hale Pōhaku (TMK 4-4-15:12), and the Mauna Kea Access Road between these two properties including 400 yards on either side of the road, except for the western side of the road where that width would extend into the Mauna Kea Ice Age Natural Area Reserve (Ice Age NAR).

These management documents fulfill the requirement for a "Management Plan" for the entire parcel being considered for the siting of the Thirty Meter Telescope (TMT) Observatory under the existing rules and regulations of the State Land Use Conservation District, and also satisfy the requirement for a "Comprehensive Management Plan" under the proposed amendments to the above rules and regulations.¹ These documents will be referred to as the "CMP and subplans" in this TMT Management Plan. It should be noted that the CMP and subplans only apply to UH's managed lands on Mauna Kea and do not apply to all of Mauna Kea.

1.1.2 TMT Management Plan Objectives & Purpose

The CMP and subplans are the primary management documents governing activities and uses within the UH Management Areas on Mauna Kea. These documents have and will continue to guide TMT Project development. The TMT Project was designed to comply with all of the requirements of the CMP and subplans. To that end, the TMT Management Plan has been developed to ensure the preservation and protection of Mauna Kea resources through the implementation of the strategies and management actions called for in the CMP and subplans.

¹ The Department of Land and Natural Resources ("DLNR") recently promulgated draft amendments to Hawaii Administrative Rules ("HAR") 13-5 relating to the Conservation District. DLNR hopes to have the amendments approved by the BLNR by December 2010.

The TMT Management Plan adopts the approach, goals, objectives, and management strategies and actions of the CMP and subplans in their entirety. The TMT Management Plan is intended to guide various activities and uses within the TMT Project area. Together, the CMP, subplans, and this TMT Management Plan are intended to fulfill the purpose of the Conservation District with regards to the TMT Project and the UH Management Areas:

The legislature finds that lands within the state land use conservation district contain important natural resources essential to the preservation of the State's fragile natural ecosystem and the sustainability of the State's water supply. It is therefore, the intent of the legislature to conserve, protect and preserve the important natural resources of the State through **appropriate management and use** to promote their long-term sustainability and the public health, safety and welfare.

HRS § 183C-1 (2009) (emphasis added). The TMT Management Plan was developed with the following objectives in mind. Many of these objectives come directly from the CMP:

1. To ensure consistency in the management of Mauna Kea resources, uses, and activities by adopting and implementing the management strategies and actions of the CMP and subplans.
2. Mitigate the impact of telescope facilities on Mauna Kea by implementing the CMP and subplans.
3. Increase understanding and appreciation of Native Hawaiian history and cultural practices related to Mauna Kea to ensure that these practices are protected and respected.
4. Increase understanding of the status of Mauna Kea natural resources and address particular threats to these resources to better protect these resources.
5. Minimize adverse impacts to resources during all phases of construction, through use of innovative best management practices.
6. Conduct effective observatory operations in support of the management of Mauna Kea resources in the UH Management Areas.
7. Mitigate the impact of the TMT Project and astronomy related development on Mauna Kea by doing the following:
 - Developing and implementing various mitigation measures as described in the Final Environmental Impact Statement (Final EIS) for the Project (UH, 2010) and Draft Historic Preservation Mitigation Plan attached to this TMT Management Plan; and
 - Planning for the eventual decommissioning and demolition of the TMT Observatory and restoration of the TMT Project areas.

The TMT Management Plan was also developed to comply with the Conservation District rules, particularly HAR § 13-5-24 and 13-5-39 regarding management plans. The TMT Management Plan closely follows the management plan requirements provided in Exhibit 3 to the Conservation District rules, Management Plan Requirements: September 6, 1994 and also would comply with the requirement for a "Comprehensive Management Plan" under the proposed amendments to the Conservation District Rules.

1.2 General Description of Proposed Use

On behalf of the TMT Observatory Corporation, the University of Hawai'i (the "University") is seeking a Conservation District Use Permit (CDUP) from the BLNR that will allow the construction, operation, and eventual decommissioning of the TMT Observatory² within an area below the summit of Mauna Kea that is known as "Area E". The TMT Observatory Corporation³ is a private non-profit corporation that was formed to manage the design, construction, operation, and eventual decommissioning of the TMT Project. Area E is located approximately 1/2-mile northwest of the nine existing optical/infrared observatories located near the summit.

The TMT Observatory is proposed for a roughly 5-acre site within Area E, near the end of an existing 4-wheel drive road; the site is known as 13N in reference to its elevation (roughly 13,000 feet) and location (north of the summit). An Access Way would provide road access and utilities to the site. The existing 4-wheel drive road would be improved from the point where it diverges from the existing Mauna Kea Loop Road and, to the extent possible, utilities would be placed beneath the improved road. One segment of the Access Way would cross the base of Pu'u Hau'oki and another segment would extend through the existing Submillimeter Array (SMA)⁴ complex and Area E. Leasehold title and ongoing maintenance of the roadway will remain the responsibility of the University as part of the common areas under its jurisdiction.

1.3 Consistency with Conservation District & Subzone

1.3.1 Conservation District Purpose

As discussed above, the State Land Use Law (Chapter 183C, Hawai'i Revised Statutes) provides that the purpose of the Conservation District is ". . . to conserve, protect and preserve the important natural resources of the State through appropriate management and use to promote their long-term sustainability and the public health, safety and welfare."

The University and the TMT Observatory Corporation are both committed to implementing management strategies and mitigation measures that will achieve these purposes. As previously discussed, BLNR has adopted the CMP and subplans as the approved management documents for land use and activities within the UH Management Areas on Mauna Kea. The CMP and subplans provide management strategies designed to preserve and protect Mauna Kea's resources, and the University is committed to their implementation using the resources that are available to it. This TMT Management Plan adopts the approach, goals, objectives, and

² An observatory includes the telescope, the dome that contain the telescope, and the instrumentation and support facilities for the telescope that fall under a common ownership.

³ The TMT Observatory Corporation is currently a partnership of the University of California (UC), the California Institute of Technology (Caltech), and the Association of Canadian Universities for Research in Astronomy (ACURA). The National Astronomical Observatory of Japan (NAOJ) is a collaborator and potential partner, and the National Astronomical Observatories of the Chinese Academy of Sciences (NAOC) and India's Department of Science and Technology (DST) are observers and potential partners.

⁴ The Submillimeter Array (SMA) is a radio interferometer that operates at frequencies from 180 GHz to 700 GHz using multiple 20-foot diameter dishes that can be arranged in a variety of configurations with baselines as long as 509m. Submillimeter Array is a joint project between the Smithsonian Astrophysical Observatory and the Academia Sinica Institute of Astronomy and Astrophysics and is funded by the Smithsonian Institution and the Academia Sinica.

management strategies and actions of the CMP and subplans in their entirety and is intended to be an extension of the CMP and subplans. In addition, as detailed in Sections 4.2 and 4.3 and the attached Draft Historic Preservation Mitigation Plan (Appendix A), TMT is also committed to implementing various mitigation measures intended to address the impacts of the TMT Project and, in some cases, astronomy related development on Mauna Kea.

The design of the TMT Project is consistent with the CMP and subplans, and the financial and other resources that it would make available would enable the University to implement the various management actions called for in the CMP and subplans to a greater extent than would be possible without them. In short, the TMT Project would improve the University's ability to implement the measures in the CMP (and therefore, to preserve, protect, and manage all of Mauna Kea's resources) by:

- implementing the various mitigation measures outlined in the Final EIS and this plan;
- helping fund OMKM's implementation of the CMP by making future sublease rent payments that it anticipates will be required by BLNR⁵; and
- adhering to this proposed TMT Management Plan (which is consistent with and implements the CMP and CMP subplans in the TMT Project area).

1.3.2 Objective of Subzone

The Conservation District Rules, HAR § 13-5, which regulates land use in the Conservation District, establishes five subzones. They are the Protective subzone, the Limited subzone, the Resource subzone, the General subzone, and the Special subzone. For each subzone, the Conservation District Rules describes the objective of the level of protection and management and identifies permitted uses. All of the new uses that are proposed in this permit application are within the Conservation District Resource subzone. The objective of the Resource subzone is to allow development of identified uses when they are accompanied by proper management that ensures sustained use of natural resources in these areas.

Astronomy facilities are an identified land use in the Resource subzone (see HAR § 13-5-24(c) [R3/D1]) under an approved management plan. This means that development of astronomy facilities implementing appropriate management has been deemed to be consistent with proper management of the natural resources in the Resource subzone. In addition to being an identified use, both the University and the TMT Observatory Corporation are committed to managing the natural and cultural resources throughout the UH Management Areas in a manner that fulfills the objective of the Resource subzone of the Conservation District. The TMT Project would help meet the objectives of the Resource subzone by using the excellent astronomical resources that Mauna Kea possesses to maintain Mauna Kea at the forefront of astronomical research while implementing and supporting overall management activities that will promote the sustained use of the natural resources in the subzone.

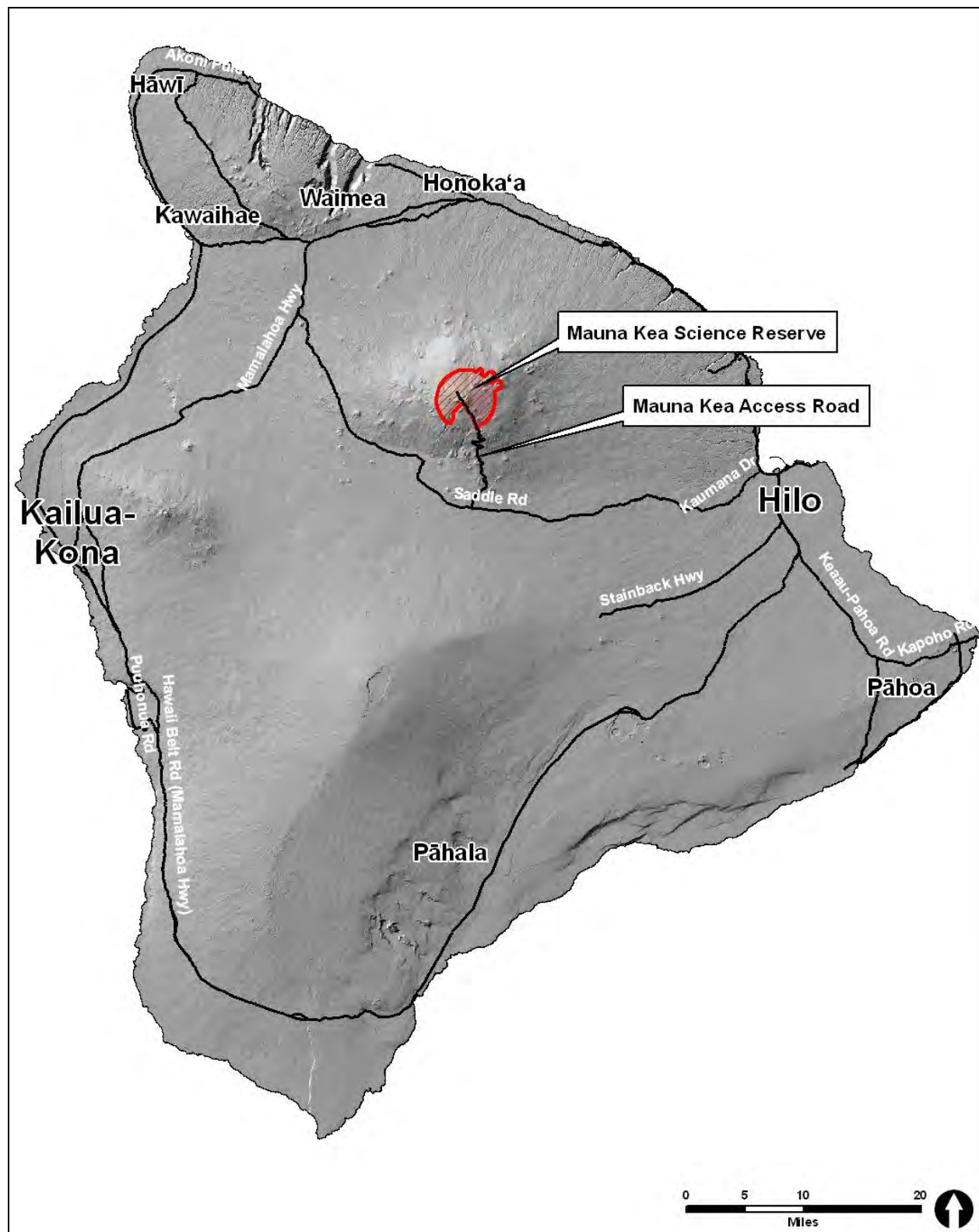
The proposed project would be developed and operated in compliance with the Conservation District rules and with all conditions that may be attached to the Conservation District Use

⁵ Although the amount of sublease rent has not been negotiated, it is anticipated that the sublease rent will amount to a large portion of the OMKM operating budget.

Permit. The proposed use is consistent with the provisions of the applicable mountain-wide and site-specific management plans (CMP, subplans, and this TMT Management Plan). TMT intends to implement and fund the TMT Management Plan, thus implementing the management actions and strategies called for in the CMP and subplans and helping to ensure the sustained use of the natural and cultural resources in the Resource subzone. This is further evidence of the proposed use's consistency with the objectives of the Resource subzone.

1.4 Location Map

Figure 1-1: Location Map



2.0 Existing Conditions

2.1 Ownership

The TMT Observatory and Access Way would be located on Mauna Kea in the MKSR on Hawai'i Island in the State of Hawai'i. The Batch Plant Staging Area is also within the MKSR. The entire 1,288-acre MKSR is owned by the State of Hawai'i and is designated as part of the State of Hawai'i Conservation District Resource subzone and is leased to the University under General Lease S-4191. The building and operation of the TMT Observatory on Mauna Kea will require a sublease of the area from the University. The sublease will be subject to approval first by the TMT Board and University of Hawai'i Board of Regents (UH BOR) followed by approval by BLNR.

2.2 Resources in Project Area

2.2.1 Cultural Resources

Cultural resources is a term that encompasses both physical features, typically referred to as historic properties, as well as cultural practices and beliefs. Each of these resource types are described separately here.

Cultural Practices and Beliefs

The CMP, including the CRMP subplan, as well as the Cultural Impact Assessment (CIA) conducted during the preparation of the EIS for the TMT Project, the CIA prepared for the 2000 Master Plan, and other cultural studies performed on behalf of OMKM provide detailed descriptions of the cultural practices and beliefs surrounding Mauna Kea. Those descriptions are briefly summarized here.

Native Hawaiian traditions state that ancestral *akua* (gods, goddesses, deities) reside within the mountain summit area. These personages are embodied within the Mauna Kea landscape and they are believed to be physically manifested in earthly form as various *pu'u* (hills) and as the waters of Lake Waiau. Because these *akua* are connected to the Mauna Kea landscape in Hawaiian genealogies, and because elders and *akua* are revered and looked to for spiritual guidance in Hawaiian culture, Mauna Kea is considered a sacred place.

Mauna Kea is still a focus of many traditional and customary Native Hawaiian cultural practices and beliefs. It is a source of inspiration and object of reverence for many Hawaiians. Ongoing cultural practices involving Mauna Kea include:

- Performance of prayer and ritual observances important for the reinforcement of an individual's Hawaiian spirituality, including the erection of ahu or shrines.
- Collection of water from Lake Waiau and snow from the summit in general for a variety of healing and other ritual uses.
- Deposition of piko (umbilical cords) at Lake Waiau and the summit peaks of Mauna Kea.

- Use of the summit region as a repository for human burial remains, by means of interment, particularly on various pu'u, during early times, and more recently by means of releasing ashes from cremations.
- Burial blessings to honor ancestors.
- Belief that the upper mountain region of Mauna Kea, from the Saddle area up to the summit, is a sacred landscape – as a personification of the spiritual and physical connection between one's ancestors, history, and the heavens.
- Association of unspecified traditional navigation practices and customs with the summit area.
- Annual calendrical rites (i.e. solstice and equinox observations) that take place at the summit of Kūkahau'ula.

Historic Properties

In accordance with CMP Management Action CR-11, the University has completed a comprehensive Archaeological Inventory Survey (AIS) that identifies and describes all known historic properties within the UH Management Areas on Mauna Kea, including within the TMT Project area. The survey identified 263 historic properties within the MKSR. These historic properties consist of individual sites, as well as larger areas of land with an associated cultural significance. The AIS for the MKSR provides detailed descriptions of the historic properties in the TMT Project area. Those descriptions are briefly summarized here.

The TMT Observatory site, the Access Way, and the Batch Plant Staging Area are all within the Mauna Kea Summit Region Historic District – Statewide Inventory of Historic Places (SIHP) No. 50-10-23-26869 – as defined in the *Mauna Kea Historic Preservation Plan Management Components* (DLNR Historic Preservation Division, 2000). The District includes a concentration of significant historic properties that are linked through their setting, historic use, traditional associations, and ongoing cultural practices. The properties include shrines, adze quarry complexes and workshops, burials, stone markers/memorials, temporary shelters, historic campsites, traditional cultural properties (TCPs), a historic trail, and sites of unknown function. All of these types of historic sites are contributing properties to the Historic District. The Historic District has been determined by the State Historic Preservation Division (SHPD) to be significant under all five criteria (A, B, C, D and E), as defined in HAR § 13-275 -6.

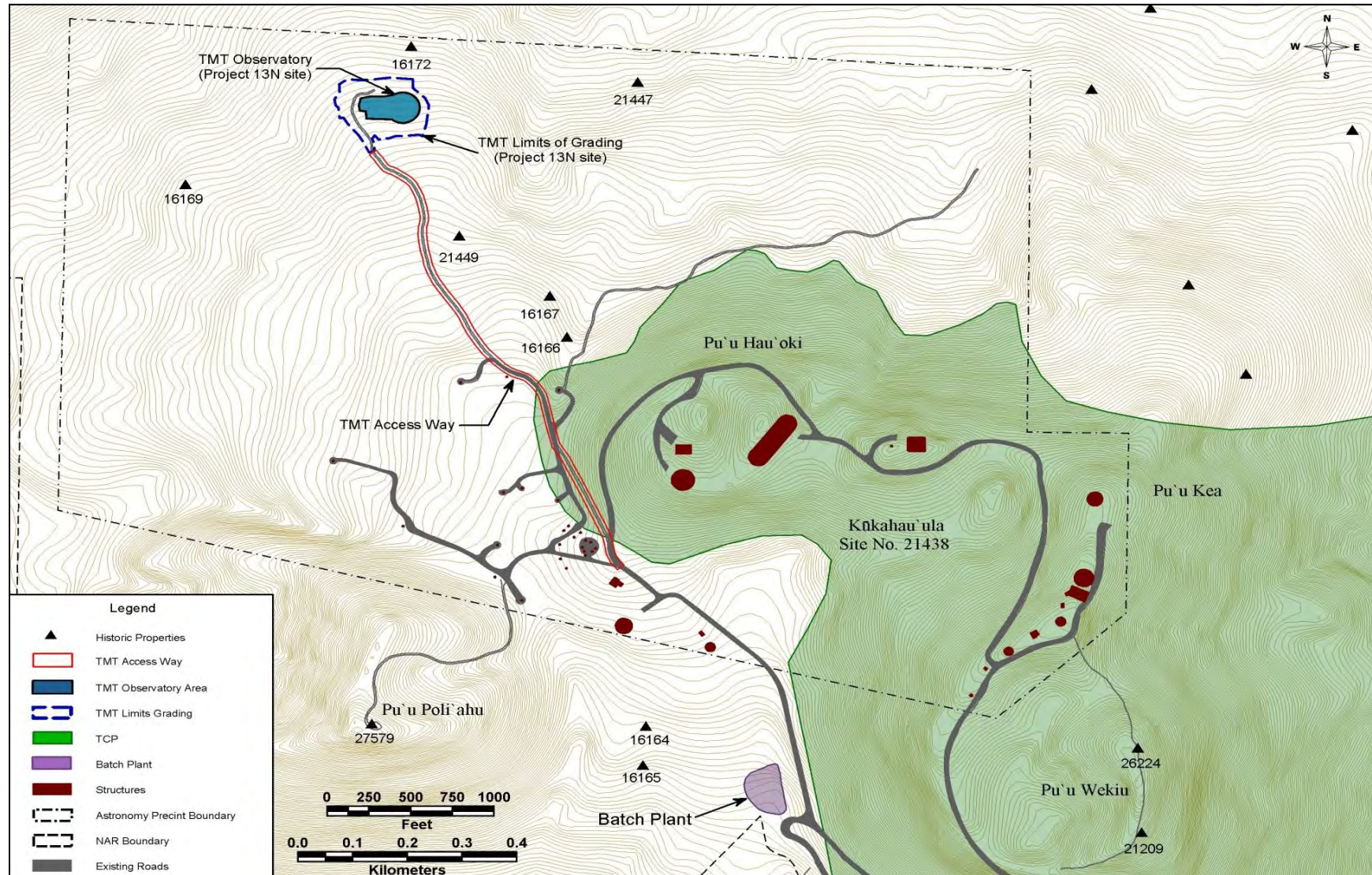
Figure 2-1 shows the individual historic properties that have been identified in the vicinity of the TMT Project area. There are no historic properties located within 200 feet of the limits of grading at the proposed TMT Observatory 13N site. Approximately 1,100 feet of the 3,400 foot long Access Way serving the TMT Observatory would cross Kūkahau'ula. Kūkahau'ula has been described and referred to as a traditional cultural property (TCP) by SHPD within DLNR.⁶ The Kūkahau'ula TCP is a historic property (SIHP No. 50-10-23-21438) occupying an area of approximately 463 acres. Kūkahau'ula, which consists of a group of pu'u commonly known as Pu'u Hau'oki, Pu'u Wēkiu, and Pu'u Kea, has been determined to be a historic property by SHPD owing to its association with legendary figures and on-going Native Hawaiian cultural practices.

⁶ In conformance with SHPD's practice, Kūkahau'ula is referred to as the Kūkahau'ula TCP.

SHPD has also determined that Kūkahau'ula is significant under all five criteria (A, B, C, D and E), as defined in HAR § 13-275-6.

There are no individual historic properties located within 500 feet of the Batch Plant. The Kūkahau`ula TCP is located approximately 50 feet to the east of the Batch Plant area.

Figure 2-1: Historic Properties in the Vicinity of the TMT Project Areas



2.2.2 Natural Resources

Natural resources refer to both the floral and faunal biotic elements of the physical environment. The CMP, including the NRMP subplan, as well as studies conducted during the preparation of the EIS for the TMT Project provide detailed descriptions of the natural resources in the area. Those descriptions are briefly summarized here.

Area E, the Access Way, and the Batch Plant Staging Area are located in the alpine stone desert ecosystem. The plant community in the alpine stone desert ecosystem consists of several species of mosses and lichens, and a limited number of vascular plants. The only resident faunal species in the alpine stone desert ecosystem above 12,800 feet on Mauna Kea are arthropods. At least 10 confirmed resident species of indigenous Hawaiian arthropod species have been collected near the summit including: wēkiu bugs (*Nysius wekiuicola*), lycosid wolf spiders (*Lycosa* sp.), two sheetweb spiders (genus *Erigone*), two mites (Family *Aystidae* and Family *Eupodidae*: both species unknown), two springtails (Family *Entomobryidae*: two species unknown), a centipede (*Lithobius* sp.), a noctuid moth (*Agrotis* sp.). Several other indigenous Hawaiian species have also been collected near the summit but their resident status is unconfirmed. Additional arthropod species, non-indigenous to Hawai'i, are thought to be resident to the summit area cinder cones. One of the indigenous arthropods, the wēkiu bug, is proposed as a candidate species for Federal listing under the Endangered Species Act. Please see Section 2.3 below for details regarding threatened and endangered species.

2.2.3 Recreational Resources

The CMP, including the PAP subplan, as well as the EIS for the TMT Project provide detailed descriptions of the recreational resources of the area. Those descriptions are briefly summarized here.

Numerous recreational activities take place on Mauna Kea. Visitors come to Mauna Kea each year to sightsee, view the stars, and tour the world-class observatories. The unique topography, location, and views draw many hikers to Mauna Kea to explore the few established, but unmarked, trails in the summit region and other trails at lower elevations. Skiing and snow play are popular activities among Big Island residents and visitors. Additionally, the Mauna Kea Forest Reserve, from an elevation above 7,000 feet, is a hunting unit where game may be hunted with bow and arrows and firearms.

Generally, sightseeing and stargazing activities take place in the vicinity of the summit region, and are removed from the TMT Observatory and Access Way. No hiking trails are near the TMT Observatory or Access Way. The Mauna Kea – Humu'ula Trail essentially ends at the Mauna Kea Access Road near the Batch Plant Staging Area, and some people park at the Batch Plant Staging Area to walk along the trail to Lake Waiau, but there are other parking areas to reach Lake Waiau. The TMT Observatory and Access Way are outside of snow play areas, and it is reasonably anticipated that they are also outside of hunting areas.

2.2.4 Scenic Resources

The CMP and the EIS for the TMT Project provide detailed descriptions of the scenic resources in the area. Those descriptions are briefly summarized here. The Island of Hawai'i's landscape

and visual resources are varied. The Hawai'i County General Plan (County of Hawai'i, 2005) includes a chapter on natural beauty that recognizes the importance of preserving the island's natural and scenic beauty. The chapter includes goals, policies and standards to identify and protect scenic vistas and viewplanes. Around the island the following natural beauty sites have been identified that include Mauna Kea:

- View of Mauna Kea and Mauna Loa from Pāhoa-Kea'au, Volcano-Kea'au Roads, and various Puna subdivisions
- Viewpoint of Hilo Bay with Mauna Kea in background
- Mauna Kea State Park area

In addition, the South Kohala Development Plan (County of Hawai'i, 2008) includes a policy to preserve Waimea's sense of place. To do this, the plan recommends the strategy to "protect the pu'u of Waimea that have cultural, historical and visual importance" and which have "grand views of Mauna Kea".

Locating the TMT Observatory on Mauna Kea would not substantially affect scenic vistas and viewplanes identified in the Hawai'i County General Plan or the South Kohala Development Plan. The TMT Observatory would not be visible in the view of Mauna Kea from Pāhoa-Kea'au, Volcano-Kea'au Roads, and various Puna subdivisions or from locations where Hilo Bay is visible with Mauna Kea in the background. Although the TMT Observatory may be visible in the view of Mauna Kea from portions of the South Kohala district and the area around Waimea, it will not block or substantially obstruct the views and viewplanes of the mountain.

Also, while the TMT Observatory would be a new visual element among the existing observatories within the views of Mauna Kea (for approximately 14 percent of the island area, and visible to approximately 15.4 percent of the population, or approximately 23,000 people from their residences), it will not substantially obstruct or block existing views of Mauna Kea from around the island. Existing observatories are visible in most of this area. The TMT Observatory alone would be visible from approximately 1.2 percent of the area of the island (*where no other observatory may be seen*). Using the 2000 U.S. Census average household size of 2.75 people for the County of Hawai'i, 72 people live in this new area.

2.2.5 Geology

The CMP, including the NRMP subplan, as well as the EIS for the TMT Project provide detailed descriptions of the geology of the area. Those descriptions are briefly summarized here.

Area E is entirely underlain by a single lava flow, and consists of uniformly dense, fine-grained lavas. The flow was emplaced as viscous pāhoehoe, although some 'a'a fragmental material may have originally overlain the surface. The eruption that produced this overall flow likely produced multiple flow layers that overlaid one another as the eruption progressed; multiple complex layers may be found at depth during excavation. The pu'u that was the source for this flow is located near the SMA core.

The bulk of the Access Way would be on the same lava flow, but the southern-most roughly 700 feet of the Access Way would be located on the Pu'u Hau'oki cinder cone.

2.3 Presence of Threatened/Endangered Species

The CMP, including the NRMP subplan, as well as the EIS for the TMT Project provide detailed descriptions of the natural resources, including potentially present threatened and endangered species. Those descriptions are briefly summarized here.

No currently-listed threatened or endangered species are known to occur in the Astronomy Precinct.⁷ The Mauna Kea silversword (*Argyroxiphium sandwicense*), an endangered species, is known to occur at lower elevations. A recent arthropod and botanical survey of the Project areas in the Mauna Kea summit region did not encounter any species listed as endangered or threatened under either Federal or State of Hawai'i endangered species statutes.

The wēkiu bug is currently a candidate for Federal listing under the Endangered Species Act and is known to occur only in certain cinder cone habitats above an elevation of approximately 11,700 feet on Mauna Kea; they are most common in Type 2 habitat (cinder cone ridges and slopes) but are also known to frequent Type 3 habitat (loose, steep cinder cone slopes). The great majority (greater than 95 percent) of the area that would be disturbed by construction of the proposed TMT Observatory and Access Way consists of Type 4, 5, and 6 wēkiu bug habitat, habitats that are not preferred by wēkiu bugs. Surveys conducted in 2008 and 2009 showed these to be free of wēkiu bugs. Of the area that would be disturbed, only one percent consists of Type 3 habitat, which the 2009 survey showed had a few members of this species. No wēkiu bugs were identified in the affected Type 3 habitat in 2008.

One species currently considered a species of concern by the US Fish and Wildlife Service (USFWS), the Douglas' bladderfern (*Cystopteris douglasii*), is known to occur in the Mauna Kea summit region. The Douglas' bladderfern was found throughout Area E; it is known to be widespread, occurring on all main Hawaiian Islands, and on Mauna Kea is more common to the east, in the vicinity of Area F. Area E is not considered critical habitat for the Douglas' bladderfern. Also, the 'ua'u (*Pterodroma sandwichensis*) the endangered Hawaiian petrel, may have historically utilized the lower portions of the alpine shrublands and grasslands on Mauna Kea, but none have been observed near Project sites.

2.4 Constraints

2.4.1 Topography

Area E can generally be described as rocky, mountainous terrain, although slopes within the area are not necessarily steep, with an overall grade of 9 percent. Within the TMT Observatory 13N site the elevation ranges from roughly 13,130 feet mean sea level (msl) to 13,190 feet msl, a difference of approximately 60 feet. Although the topography does not pose a significant constraint on the Project, the geotechnical properties of the underlying lava flows will put constraints on the foundation for the TMT Observatory. Based on ground surface observations it

⁷ An individual commenting on the Draft EIS reported that an 'io (*Buteo solitaries*), the endangered Hawaiian Hawk, has been observed circling above the summit region on occasion. 'Io are known to use a broad range of forest habitats and are not frequent visitors to elevations greater than roughly 7,000 feet, and do not reside in the summit region; however individuals can be observed in the area occasionally.

is not believed that significant lava tubes exist; however, geotechnical borings need to be completed to confirm subsurface conditions.

Approximately one-tenth of the roughly 5-acre TMT Observatory 13N site has been previously disturbed. Approximately one-third of the existing Access Way right-of-way has been graded during previous work in the area; this includes areas that were graded as part of the SMA Telescope project and others that were graded in the 1960s for site testing at the 13N site. The Batch Plant site was graded initially during a road paving project and was subsequently used during the construction of several observatories; no additional grading work is anticipated as part of the TMT Project.

2.4.2 Existing Covenants, Easements & Restrictions

Through General Lease Number S-4191, the University leases the MKSR from DLNR. The TMT Observatory, Access Way, and Batch Plant Staging Area are all within the MKSR. A portion of the Access Way would be within an area of a non-exclusive easement between the University and Smithsonian Institution for its Submillimeter Array (SMA); however, the easement indicates the area where the Access Way would be located is a "Common Access Road".

2.5 Existing Land Uses

The CMP, including the PAP subplan, as well as the EIS for the TMT Project provide detailed descriptions of the existing land uses in the area. Those descriptions are briefly summarized here.

All land within the State of Hawai'i is classified as one of four major land use districts: conservation, agriculture, rural, or urban. Beginning at an elevation of approximately 7,000 feet and extending to the summit, the lands of Mauna Kea are classified as a Conservation District. This classification is the most restrictive of the four, and permits a very limited range of land uses (HRS § 205-2). The objective is to conserve, protect, and preserve the state's natural resources through appropriate management and use meant to promote their long-term sustainability and the public health, safety, and welfare. Identified uses of conservation lands can be permitted and administered by DLNR through the State Office of Conservation and Coastal Lands (OCCL) (HRS § 183C-3).

Existing land uses occurring on Mauna Kea include:

- Cultural and religious activities.
- Astronomy activities, primarily related to observatories located in the MKSR.
- Additional educational purposes.
- Recreational and commercial uses.

2.6 Existing Conservation District Use Permits

The following table lists the existing Conservation District Use Permits for the MKSR and the Hale Pōhaku Mid-Level facilities:

Table 2-1: Prior Conservation District Use Permits, Mauna Kea Science Reserve & Mid-Level Facilities

Telescope Facilities	
UH 0.6-M, Planetary Patrol (removed 1994)	HA-954, 1977 (post facto)
UH 0.6-M Air Force (removed 2008)	HA-954, 1977 (post facto)
UH 2.2-meter	HA-954, 1977 (post facto)
Canada-France-Hawaii Telescope (CFHT Observatory)	HA-527, 1974
United Kingdom Infrared Telescope (UKIRT Observatory)	HA-653, 1975
NASA Infrared Telescope Facility (IRTF Observatory)	HA-653, 1975
Caltech Submillimeter Observatory (CSO)	HA-1492, 1982
James Clerk Maxwell Telescope (JCMT Observatory)	HA-1515, 1983
W. M. Keck Observatory (Keck Observatory)	
Keck I	HA-1646, 1984
Keck II	HA-2509, 1991
-Carport	Site Plan Approval, 1997
-Temporary Optical Test Sites	HA-SPA-21, 1998
Very Long Baseline Array Antenna (VLBA)	HA-2174, 1988
Japan National Large Telescope (Subaru Observatory)	HA-2462, 1991
-Subaru Concrete Walkway	Site Plan Approval, 1997
-Subaru Seepage Pit Collar	SPA-HA-05-08, 2004 (post facto)
Gemini Northern 8-meter Telescope (Gemini Observatory)	HA-2691, 1993
Smithsonian Submillimeter Array (SMA Observatory)	HA-2728, 1994
UH Hilo 0.9-meter	HA-3406, 2007
Hale Pōhaku Mid-Level Facilities	
Subdivision & Construction of Hale Pōhaku Mid-Level Facilities	HA-1430, 1982
- Removal of Solar Hot Water Heating System	SPA-HA-03-34, 2002
- Installation of Five Septic Tanks	SPA-HA-05-18, 2005'
- Minor Renovations to Visitor Information Station	SPA-HA-06-17, 2005
Subdivision to Create ~21-acre Site for Permanent Mid-Level Facilities	HA 1819, 1986
Other Permits and Approvals	
Site Testing	HA-1314, 1981
Road, Power, Conceptual Management Plan	HA-1573, 1983
- Management Plan	HA-1573, 1985
- Revised Management Plan	HA-1573A, 1995 (DLNR co-applicant)
- Upgrade of Summit Power & Communications Distribution System	Site Plan Approval, 1995
- Fiber-Optics from Pōhakuloa to Hale Pōhaku	SPA-HA-96-05, 1996
Wēkiu Bug Habitat Restoration	OA-SPA-01-03, 2000
Temporary Site Testing within Northwest Plateau	HA-3225D, 2005
Fiber Optic Cables from Gemini to CFHT	SPA-HA-06-49, 2006
Restoration of Jeep Road up to Poli'ahu	SPA-HA-10-04, 2009

2.7 Access

The CMP, including the PAP subplan, as well as the EIS for the TMT Project provide detailed descriptions of access to and within the MKSR. Those descriptions are briefly summarized here.

Other than for commercial activities, public access to the summit is currently unrestricted. Saddle Road, Route 200, connects Hilo to Māmalahoa Highway near Waimea and reaches an elevation of 6,632 feet above mean sea level (msl) at its highest. Near that location the Mauna Kea Access Road branches off toward Mauna Kea. From Saddle Road past Hale Pōhaku, Mauna Kea Access Road extends to near the summit and loops along the Pu'u Kea, Pu'u Hau'oki, and an unnamed pu'u to reach the existing observatories. The Mauna Kea Access Road is 16.3 miles long, has two lanes, guard rails in places, limited shoulders, and slopes of up to 20 percent. Hale Pōhaku is approximately 6 miles up Mauna Kea Access Road from Saddle Road, and the 4.6 mile long segment just past Hale Pōhaku is unpaved, though the road is paved again above 11,600 feet. A portion of the summit loop is unpaved between the Keck Observatory and the SMA.

The existing observatories mostly have short paved or unpaved driveways off the main road. The unpaved SMA service roadways are the most extensive roads other than the main Mauna Kea Access Road. One branch of the SMA road extends toward Area E. Where the SMA road ends, an unimproved 4-wheel drive road extends into and runs through the middle of Area E to the 13N site, where it ends.

2.8 Soils

No soils in the conventional sense are present in Area E, as the only fragmental material present has not had sufficient time for weathering to become soil in the arid, alpine environment. This material consists of unconsolidated debris derived from glacial erosion and mechanical weathering of the adjacent lavas and nowhere is more than a foot or two in thickness. This fragmental material is present in most low-lying areas though, and could be classified as a non-weathered soil.

3.0 Proposed Land Use

3.1 Detailed Description of the Proposed Land Use

The following subsections describe the various components that make up the proposed TMT Project that are within the Conservation District:

- Section 3.1.1 covers the proposed TMT Observatory, which consists of the 30-meter telescope itself, the instruments that are attached to it to record data, the enclosing dome, the attached building housing support and maintenance facilities, and parking. The Observatory is located on what is generally referred to as the 13-North (13N) site within the Astronomy Precinct of the MKSR.
- Section 3.1.2 describes the proposed TMT Access Way, which consists of a road and underground utilities (power and telecommunications) improvements that will be constructed to connect the TMT Observatory with existing roads and utilities.
- Section 3.1.3 briefly discusses the proposed use of the existing Batch Plant Staging Area during construction of the TMT Observatory and Access Way. Approximately 4 acres in size, this area is located at the top of the Mauna Kea Access Road, and its use as a construction staging area has been authorized as a temporary accessory use in several previous CDUP approvals (e.g., those for the Subaru, Keck II, and SMA telescope facilities).
- Section 3.1.4 describes the upgrades that would be made to the existing electrical transformers and related equipment within the Hawaiian Electric and Light Company (HELCO) substation near Hale Pōhaku and to the underground electrical wires from that substation to the start of the Access Way. The HELCO substation is within the Mauna Kea Forest Reserve, TMK 4-4-15:1, and the underground electrical wires pass through the Mauna Kea Forest Reserve (TMK 4-4-15:1), the Ice Age NAR (TMK 4-4-15:10), and the MKSR (TMK 4-4-15:9). Existing facilities will be used to provide telecommunication service as far as the box located near the SMA site. New facilities within the TMT Access Way will provide telecommunication service from that point onward to the TMT Observatory. All of the existing utility lines are allowed under CDUP HA-1573.

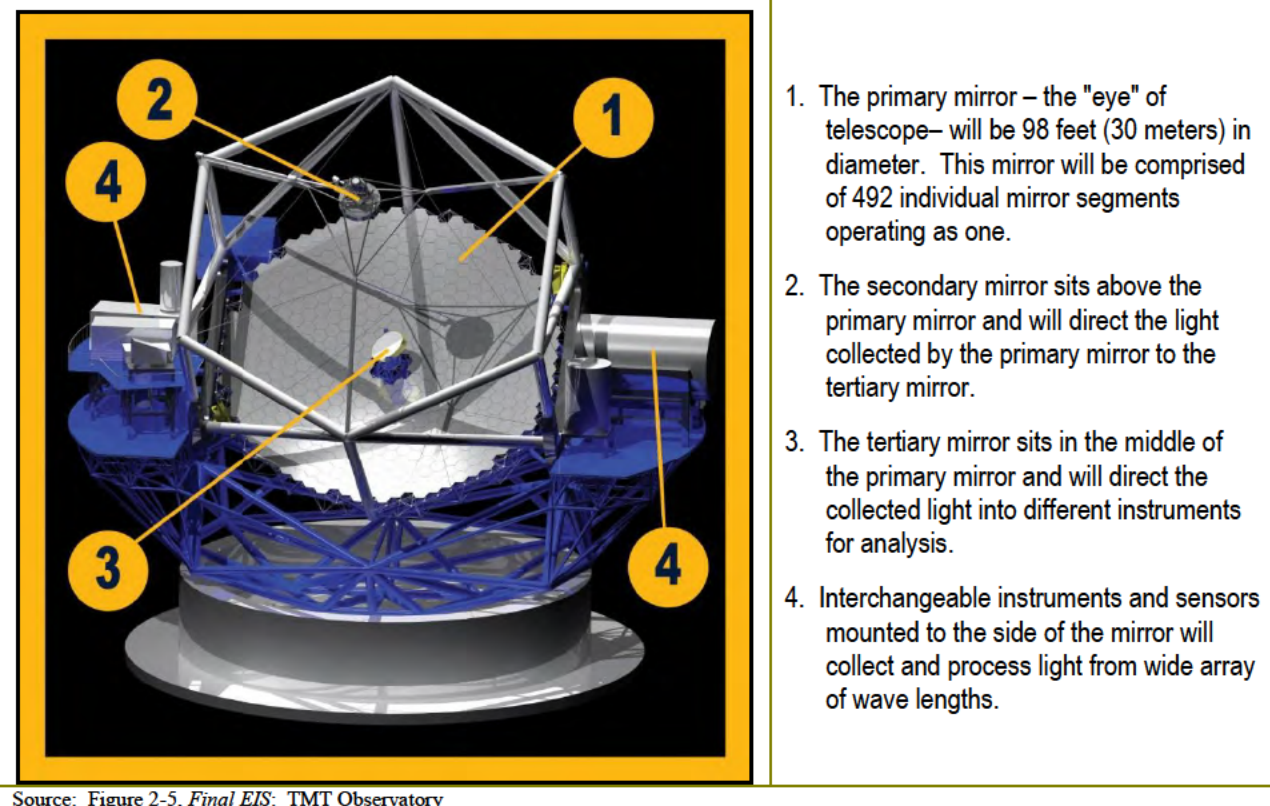
In addition to these facilities and activities, construction and operation of the TMT Project would entail several other uses that do not require a new CDUP. These include the use of existing roadways to transport construction workers and materials from the place where they live/are landed on the island, use of existing bedrooms within the University of Hawai'i's Mid-Level Support Facility, known as Hale Pōhaku (TMK 4-4-15:12), and the construction and operation of support facilities in Hilo and elsewhere. All of these facilities are described in the *Final Environmental Impact Statement for the Thirty Meter Telescope Project*.

3.1.1 TMT Observatory

Telescope Design

The core of the TMT Observatory is the 30-meter aperture telescope, referred to as the TMT. Figure 3-1 illustrates the telescope assembly. The numbers correspond to the features listed to the right of the sketch.

Figure 3-1: Thirty Meter Telescope Overview



Source: Figure 2-5, Final EIS: TMT Observatory

TMT Observatory Design

The TMT Observatory Corporation has developed the design in consultation with OMKM through its design review process. It will continue to work closely with OMKM as the Project progresses. Whenever possible, the architects and engineers will incorporate sustainable technologies and energy efficient technologies into facility design and operations, in accordance with CMP Management Action IM-11.⁸

The proposed observatory includes the following:

- The telescope described in Section (a). The center of the surface of the primary mirror will be located approximately 66 feet above the ground surface.

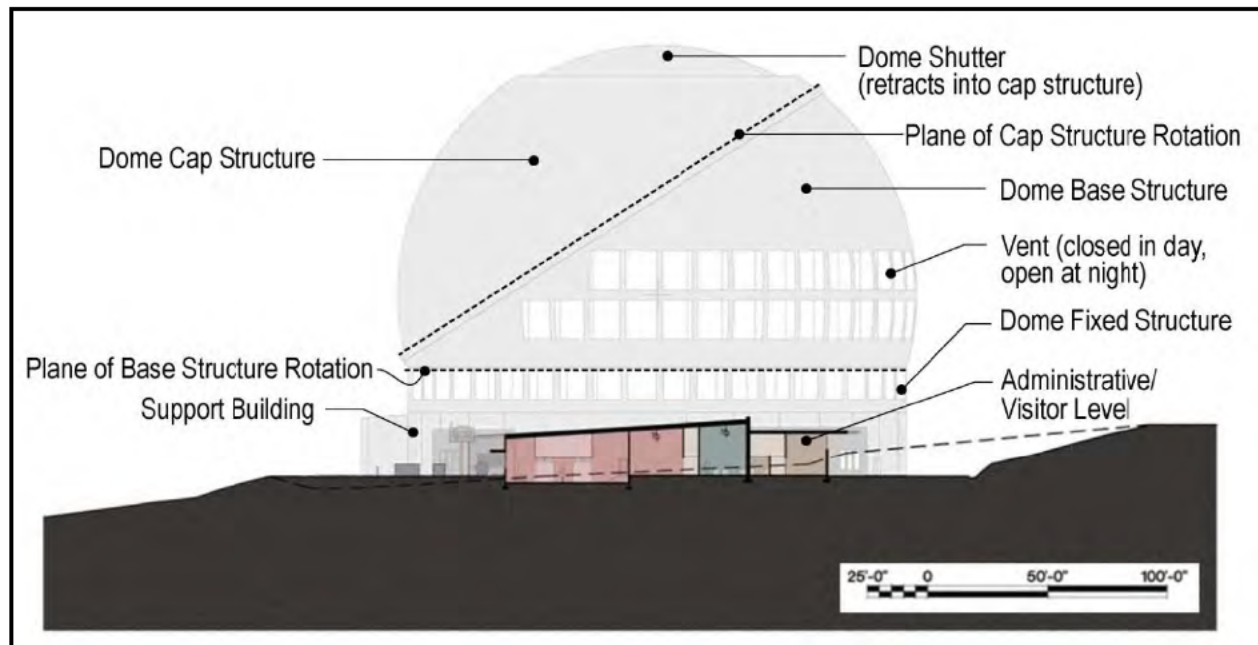
⁸ CMP Management Action IM-11 encourages existing facilities and new development to incorporate sustainable technologies, energy efficient technologies, and LEED standards, whenever possible, into facility design and operations.

- The instruments mounted around the primary mirror used to image and analyze both the visible part of the spectrum and the infrared spectrum (number 4 in Figure 3-1).
- The TMT adaptive optics (AO) system.⁹ The TMT will be the first large optical/infrared observatory to integrate AO into its original design. AO systems correct the image distortion that is caused by the atmosphere. The AO system will project up to eight laser beams into the atmosphere to create an asterism, or group, of "guide stars" that are used to determine the atmospheric distortion of the visible and infrared light from distant objects and correct for it. The TMT AO system will generate each of these eight beams using a 25-watt laser; the laser light will appear yellow (0.589 microns – the sodium D2 line).
- The dome housing the telescope will be a Calotte¹⁰ type enclosure with the following characteristics (as depicted in Figure 3-2).
 - The total dome height will be 184 feet above the finished grade, with an exterior radius of 108 feet.
 - The dome shutter will be 102.5 feet in diameter and it will retract inside the dome when opened.
 - The dome will rotate on two planes, one horizontal at the base structure 26.5 feet above the finished grade and the other at roughly 25 degrees as the cap structure, enabling the telescope to view from straight up into the sky down to 25 degrees above the horizon.
 - The Calotte dome base, cap, and shutter structures will appear rounded and smooth and have a reflective aluminum-like exterior coating.
 - The fixed cylindrical structure below the rotating base will enclose 34,304 square feet, and extend to 26.5 feet above grade. The fixed structure will be lava-colored.
 - The dome base structure and dome fixed structure will have a combination of 98 vents that will be closed during the day and will open at night. The vents will be used to maintain temperature equilibrium between interior and exterior air at night and manage air flow through and around the dome.
- The support building will be attached to the dome (see Figure 3-2). The building will have a roof area of approximately 21,000 square feet, a gross interior floor area of roughly 18,376 square feet, a primarily flat roof, and be lava-colored. The support building will include the following spaces:
 - Mirror coating and staging area.
 - Laboratory and shop spaces, including a computer room, engineering and electronics laboratories, and mechanical shop.

⁹ "Adaptive optics" (AO) is a technology used to improve the performance of optical systems by reducing the effects of rapidly changing optical distortion. AO works by measuring the distortions in the wavefront that occur when it passes through the earth's atmosphere and compensating for them. When used with an AO system, the TMT will provide sharper images than the most capable existing optical/infrared observatories by a factor of three, and greater sensitivity by a factor of ten or more.

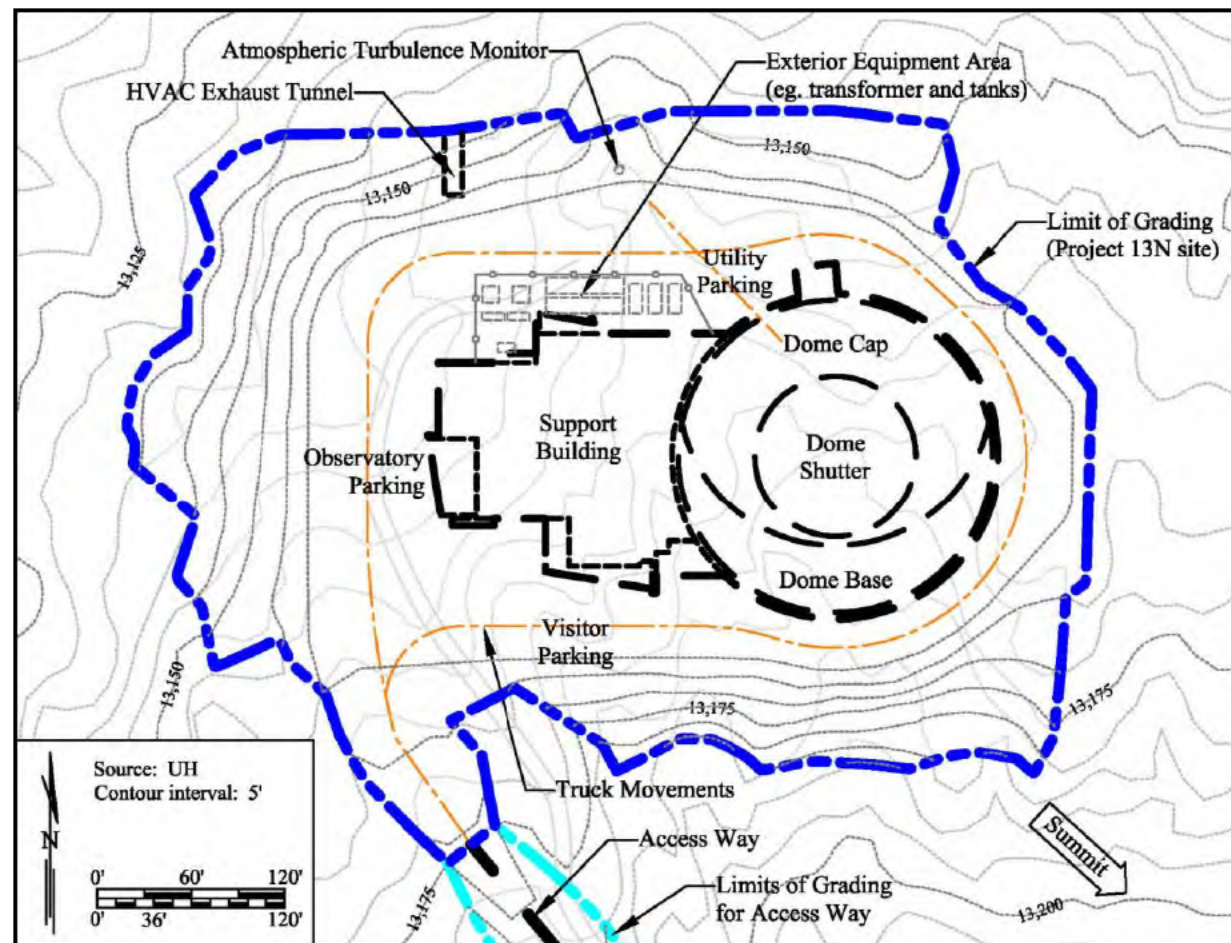
¹⁰ A Calotte type dome features a circular shutter and two planes of rotation instead of the rectangular shutter and single plane of rotation characteristic of standard domes. Benefits of a Calotte type dome include (a) overall smaller dome size, (b) improved air flow/lower air turbulence around the dome, (c) simplified mechanical components, and (d) better shedding of snow.

Figure 3-2: TMT Observatory Cross-Section



Source: Figure 2-6, *Final EIS: TMT Observatory*

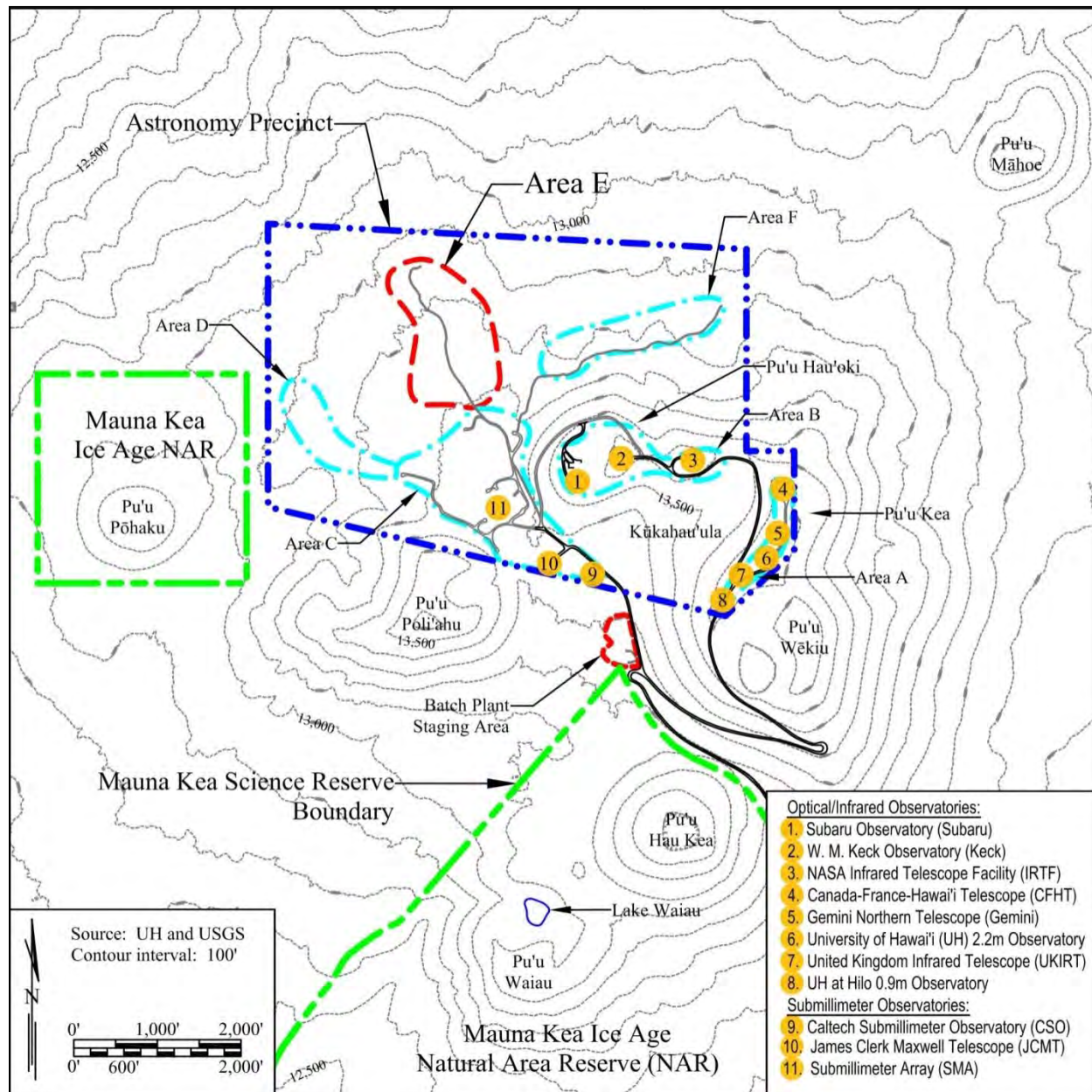
Figure 3-3: TMT Observatory Plan View and Grading Plan



- Utility spaces – including electrical services, chillers, a generator, pumps for fire suppression and other non-potable water needs, restrooms, and fluid dynamic bearing pumps that control the movement of the telescope.
- Administration space, including offices and a kitchenette.
- A roughly 6,000 square foot exterior equipment area on the north side of the support building will include two electrical transformers and electrical service switchboards; three 5,000-gallon underground storage tanks (UST) – one for water storage, one for domestic waste storage, and one double-walled for chemical waste storage; two 25,000-gallon UST for water storage as part of the fire suppression system; and one double-walled 2,000-gallon above-ground storage tank for diesel fuel to power the emergency generator.
- A tunnel that will serve as an exhaust duct for heating, ventilation, and air conditioning (HVAC) equipment will be present on the northwestern portion of the graded area.
- Parking area for observatory staff and delivery vehicles. Parking areas will be unpaved and located outside of the support facility. A guard rail will be placed along the top of the slope on the north and west sides of the graded area where there will be a drop off.
- An atmospheric turbulence monitor will be mounted on a roughly 30 foot tall tower located on the north side of the graded area, just beyond the guard rail. The monitor is a roughly 8-foot square weather station.

The entire footprint of the TMT Observatory dome, support building, and parking area will be roughly five acres, including the area of disturbance during construction. A half-acre portion of this area has previously been disturbed by the existing 4-wheel drive road and site testing equipment; the original disturbance occurred during site testing in the 1960s, site testing was also performed in this area for the TMT Project in the 2000s.

Figure 3-4: Mauna Kea Summit Region: Existing Facilities, Features, & Future Development Areas



Source: Figure 2-3, *Final EIS: TMT Observatory*

3.1.2 Access Way

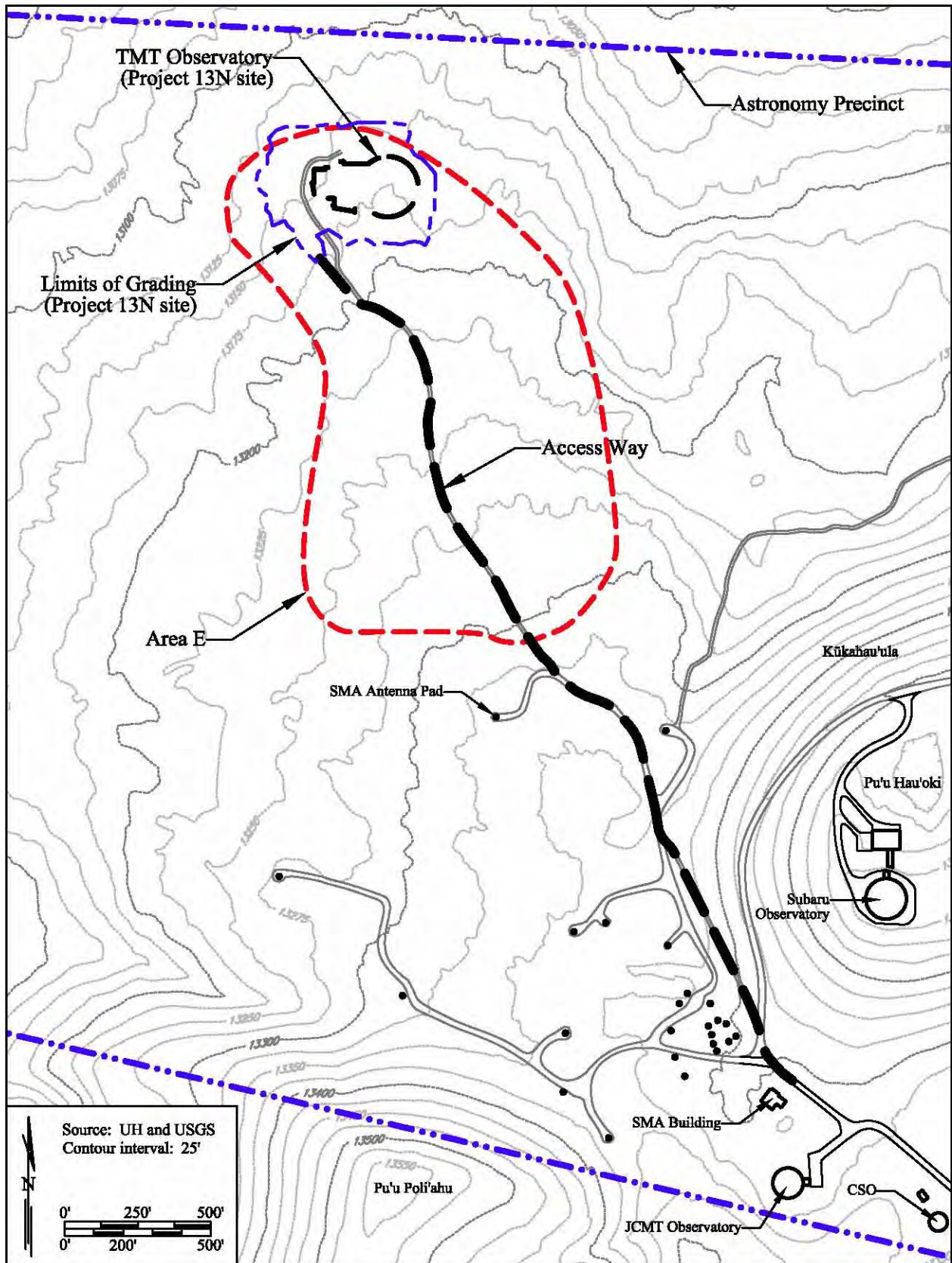
Currently, utility services exist along the Mauna Kea Access Road to a point near the intersection of the Mauna Kea Loop Road and the SMA roadway. The proposed Access Way would start at that point and extend to the TMT Observatory; for the most part it would follow either existing 4-wheel drive roads or the wider roads that serve the SMA facility. The Access Way that TMT has proposed is limited to a single-lane (from a previous design of two-lanes) over the southernmost portion of the Access Way (i.e., the portion that crosses Pu'u Hau'oki); the remainder is two lanes (see Appendix B for design and construction details). The vast majority

of the Access Way route follows and goes over existing roads, including a single-lane, 4-wheel drive road that was previously developed for access and testing of the 13N site in the 1960s. A portion of the route was graded during construction of the SMA facility as well. Only a 200-foot long section of the 3,400-foot long Access Way does not directly follow an existing road.

The switch boxes needed to extend electrical power and communication service to the TMT Observatory would be placed above ground next to the existing ones across the road from the SMA building. To the extent possible utilities from that point northward to the TMT Observatory site will be placed beneath the road to reduce the footprint of disturbance. The University will ensure that any easement required for this utility is obtained.

As with the TMT Observatory design, the University and TMT have collaborated in developing the Access Way design. Because the proposed Access Way route passes through areas for which the operators of the SMA project have a non-exclusive easement, both parties have worked with SMA staff to ensure that the two uses are compatible. The coordination is ongoing, but it has proceeded to the point where only the routing shown in Figure 3-5 is being proposed.

Figure3-5: TMT Observatory Access Way



The acreage that would be disturbed by construction of the proposed TMT Access Way is shown in the table below.¹¹ A portion of the area was previously disturbed by the existing 4-wheel drive and SMA roads as indicated in the table. The University has conducted pre-submittal consultations with SHPD and believes that the proposed Access Way is also the most preferable from the viewpoint of minimizing effects on Kūkahau'ula.

Table 3-1: Summary of Access Way Disturbances

	Access Way Area in Acres
Total Disturbance	3.6
Portion of Total that has Previously been Disturbed	1.9

3.1.3 Batch Plant Staging Area

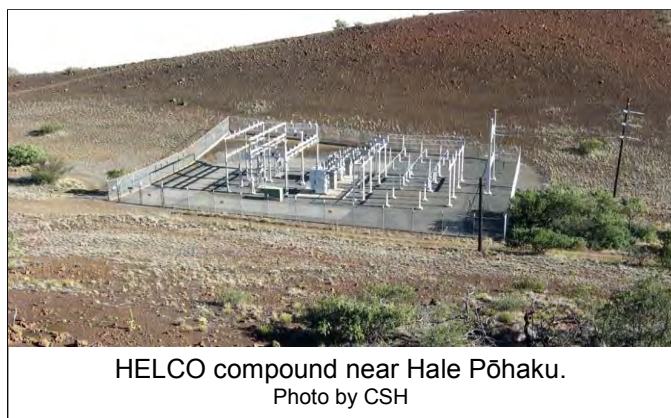
The Batch Plant Staging Area is a roughly 4-acre area northwest of where the Mauna Kea Access Road forks near the summit (as shown in Figure 3-4). This area would be used primarily for storing bulk materials and a concrete Batch Plant, as it has been in the past during construction of other observatories and roads.



Batch Plant Staging Area

3.1.4 Electrical Upgrades

HELCO would upgrade the two transformers within its Hale Pōhaku Substation, which is located approximately 2,000 feet southwest of the main headquarters building at Hale Pōhaku and about 1,000 feet from Mauna Kea Access Road. The new transformers would replace the existing transformers on a one-for-one basis, and the existing fenced compound would not be expanded.



HELCO compound near Hale Pōhaku.
Photo by CSH

In addition to the work within the substation, HELCO plans to upgrade the existing electrical service from the transformer compound near Hale Pōhaku to the existing utility boxes across the road from the SMA building. It will do this by replacing the existing wire conductors with new higher-capacity conductors in the existing underground conduits. The conduits are located approximately 50 feet west of the Mauna Kea Access Road for most of the distance to the summit area; one portion of the power

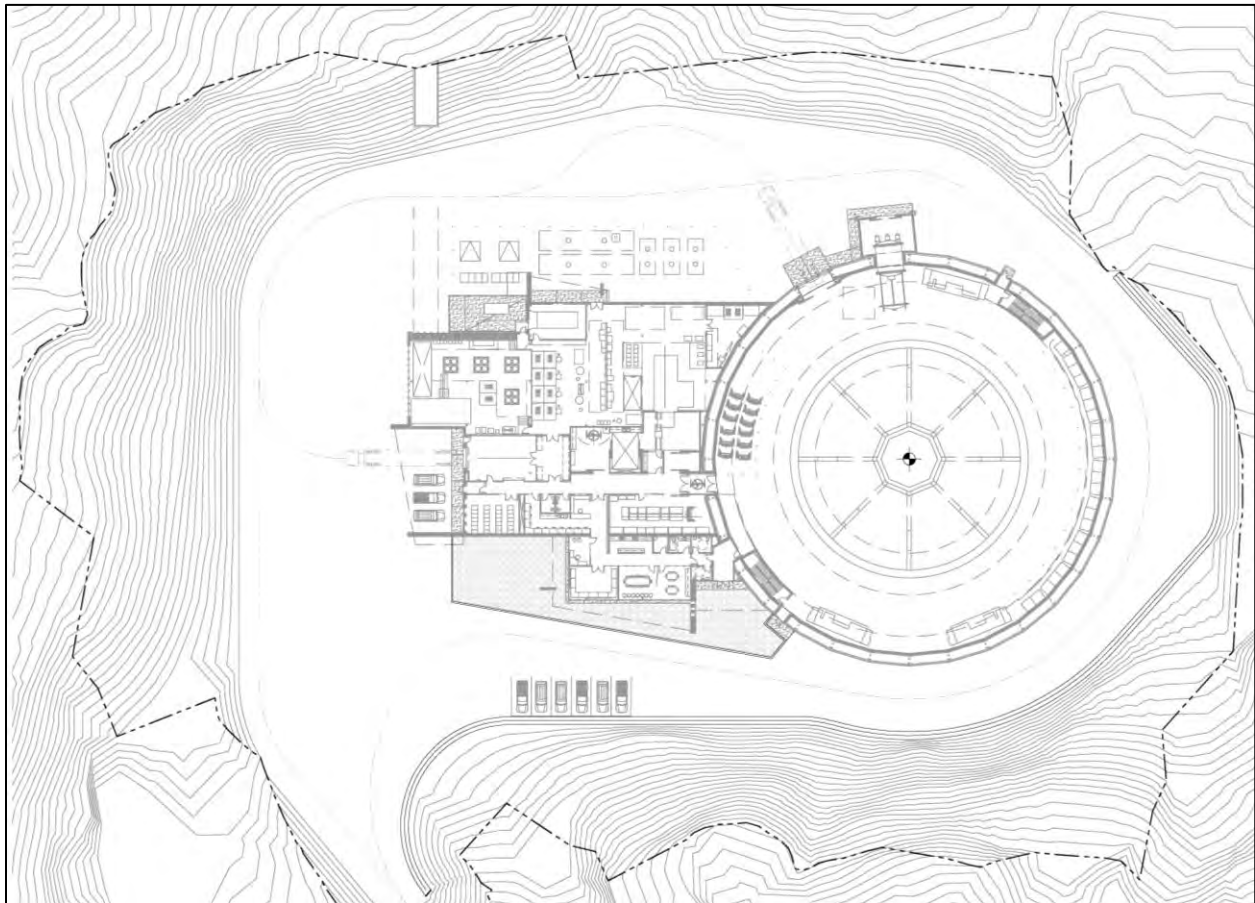
¹¹ The proposed Access Way design is a refinement of one of the routes covered in the *Final EIS*.

line alignment follows a former access road alignment that is now within the Ice Age NAR. Because existing pull boxes are available approximately every 300 feet along the conduit, no new ground disturbance will be needed for the upgrade, but HELCO will need to access the pull boxes to install the new cable. The University will consult with DLNR to determine if there are any other additional easement requirements in connection with these activities.

3.2 Site Plan

Figure 3-6 illustrates the site plan for the TMT Observatory. Detailed site plans are provided as attachments to the Construction Plan in Appendix B.

Figure 3-6: Site Plan



3.3 Identified Use for Resource Subzone

The Conservation District Rules (HAR § 13-5), which regulates land use in the Conservation District, establishes five subzones. They are the Protective subzone, the Limited subzone, the Resource subzone, the General subzone, and the Special subzone. For each subzone, the Conservation District Rules describes the objective of the level of protection and management and identifies permitted uses. All of the new uses that are proposed in this permit application are within the Conservation District Resource subzone. The objective of the Resource subzone is to

allow development of identified uses when they are accompanied by proper management that ensures sustained use of natural resources in these areas.

Astronomy facilities are an identified use in the Resource subzone (see HAR § 13-5-24(c) [R3/D1]) under an approved management plan. This means that astronomy facilities with appropriate management have been deemed to be consistent with proper management of the natural resources in that subzone.¹² In addition to being an identified use, as discussed throughout this CDUA, both the University and the TMT Observatory Corporation are committed to managing the natural and cultural resources throughout the MKSR in a way that fulfills the objective of the Resource subzone of the Conservation District. The proposed TMT Project would help meet the objectives of the Resource subzone by using the excellent astronomical resources that Mauna Kea possesses to maintain the MKSR at the forefront of astronomical research while implementing and supporting overall management activities that will promote the sustained use of the natural resources in the subzone.

The proposed project would be developed and operated in compliance with the Conservation District Rules and with all conditions that may be attached to the Conservation District Use Permit. The proposed use is consistent with the provisions of the CMP and subplans, the approved management documents for the UH Management Areas on Mauna Kea.

3.4 Relationship to Existing and Proposed Land Uses

Overall, the TMT Project will not result in a significant impact on current or proposed land uses in the Conservation District, Resource subzone. The Project staff would be trained not to interfere with cultural and religious practices. The Project would benefit the educational uses of the mountain by providing the most advanced tool for astronomical research in the world and providing opportunities for the public to visit and learn about the high-technology science taking place and the discoveries made. Recreational and commercial uses would not be significantly impacted by the Project. No hiking trails would be affected and the TMT Observatory and Access Way are outside of snow play areas. The Project is anticipated to result in a beneficial effect on tourism, stargazing, and sightseeing since people may want to see the world's most advanced observatory and the most powerful ground based telescope on earth. However, others may perceive the TMT Observatory differently and, therefore, choose not to visit the summit region.

Because the Access Way would be near the core of the SMA facility, dust from Project vehicles could collect on the SMA antennas and potentially impact the operations of the SMA. The Project would be sufficiently removed from other observatories so that they would not be impacted by the Project. To mitigate the potential impact to the SMA observatory due to dust from vehicles traveling on the Access Way through the SMA, approximately 1,600-foot-long portion of the Access Way would be paved.

¹² Other uses permitted in the Resource subzone with proper management include: (R-1) Agriculture; (R-2) Artificial Reefs; (R-4) Commercial Forestry; (R-5) Landscaping; (R-6) Marine Construction; (R-7) Mining and Extraction; and (R-8) Single Family Residences.

3.5 Project Sequencing

Project sequencing is discussed in detail in the Construction Plan, attached hereto as Appendix C; sequencing is briefly summarized below.

- | | |
|------------------------------------|---|
| 1. October 2011 – June 2012: | Summit Pre-Construction – Access Way construction |
| 2. October 2011 – December 2011: | Rough grading of 13N Site |
| 3. January 2012 – August 2012: | Pier/foundation excavation and utilities |
| 4. September 2012 – February 2013: | Pier and tunnel concrete |
| 5. September 2012 – February 2013: | Fixed enclosure foundation and concrete slab |
| 6. March 2013 – August 2013: | Fixed enclosure structural steel |
| 7. September 2013 – May 2016: | Rotating enclosure erection |
| 8. April 2015 – June 2015: | Summit facility rough grading and excavation |
| 9. July 2015 – December 2015: | Summit facility foundation and tunnel |
| 10. July 2015 – December 2015: | Summit facility concrete slab and backfill |
| 11. January 2016 – June 2016: | Summit facility steel |
| 12. April 2016 – June 2016: | Fixed enclosure wall panels |
| 13. July 2016 – March 2017: | Summit facility shell, utilities, and site work |
| 14. July 2016 – March 2017: | Completion |

3.6 Project Operations and Maintenance

The Project operational period would commence following construction and first light, in approximately 2018. Project operation would generally consist of maintaining the observatory during the day and operating the telescope for scientific observations overnight. During the life of the TMT Observatory astronomical observations would be made by scientists from around the world. A staff of up to 140 people would be necessary to operate and maintain the observatory. It is expected that an average of 24 employees would work at the TMT Observatory during the daytime, with a minimum of 15 and a maximum of 43 possible depending on activities. Each night, approximately 6 system operators would be present at the TMT Observatory. All other members of the TMT staff would work at the Headquarters, which would be located outside of the Conservation District on the UH Hilo campus. Visiting scientific observers and support astronomers would primarily observe remotely from the Headquarters.

Maintenance of the TMT Observatory is discussed in detail in the Maintenance Plan provided in Appendix D. The largest single maintenance function would be the cleaning and resurfacing of the TMT mirrors. The TMT's primary mirror consists of 492 segments and each segment would be recoated every two years. Therefore, the recoating process will be continuous and ongoing.

3.7 Environmental Assessment

The TMT Project complies with Hawai'i Revised Statutes (HRS) Chapter 343, Environmental Impact Statement Law and Chapter 200 of Title 11, Hawai'i Administrative Rules (HAR), Department of Health, Environmental Impact Statement Rules through the following steps:

- September 23, 2008: An EIS Preparation Notice/Environmental Assessment (EISPN/EA) prepared pursuant to HRS Chapter 343 was issued for the Project.
- May 23, 2009: The Draft EIS was issued for the Project for public and agency review, and public meetings were held to receive comments from the public and agencies during the 45-day review period, which ended on July 7, 2009.
- May 19, 2010: The Final EIS for the Project was accepted by the Governor.
- June 8, 2010: Office of Environmental Quality Notice of Acceptance of the Final EIS.

The Final EIS provides details concerning the potential Project impacts. Those impacts are briefly summarized below.

The potential Project impacts were evaluated within the framework of the Project's compliance with all applicable rules, regulations, and requirements for its action type and location. There are two broad opinions concerning the Project's potential impact on cultural practices and beliefs: (a) that Hawaiian culture and astronomy can co-exist on Mauna Kea and impacts can be mitigated; and (b) any development on Mauna Kea would result in a significant adverse impact that could not be mitigated. Potential less than significant adverse impacts associated with the Project include:

- Disturbance of a small portion of the Kūkahau'ula TCP and development within the Mauna Kea Summit Region Historic District.
- Displacement of a limited area of non-sensitive lava flow habitat and not unique geologic resources.
- Visual impacts associated with the TMT Observatory, primarily to the northern portion of the island.
- Increase in number of trips to the summit area of Mauna Kea and associated production of dust and noise.
- Use of energy to power the Project.
- Temporary effects during construction, primarily noise and traffic.

Substantial potential benefits are primarily related to the employment opportunities created by the Project, direct contributions to the local and State economies, and realizing the Project's objectives. In addition, the lease between TMT and the University would include sublease rent, which could be used to help OMKM implement the CMP and subplans, and observing time for UH.

From a cumulative perspective, the impact on cultural resources has been, and would continue to be, substantial, adverse, and significant. The cumulative impact to geological resources in the Astronomy Precinct has been substantial, adverse, and significant, primarily related to

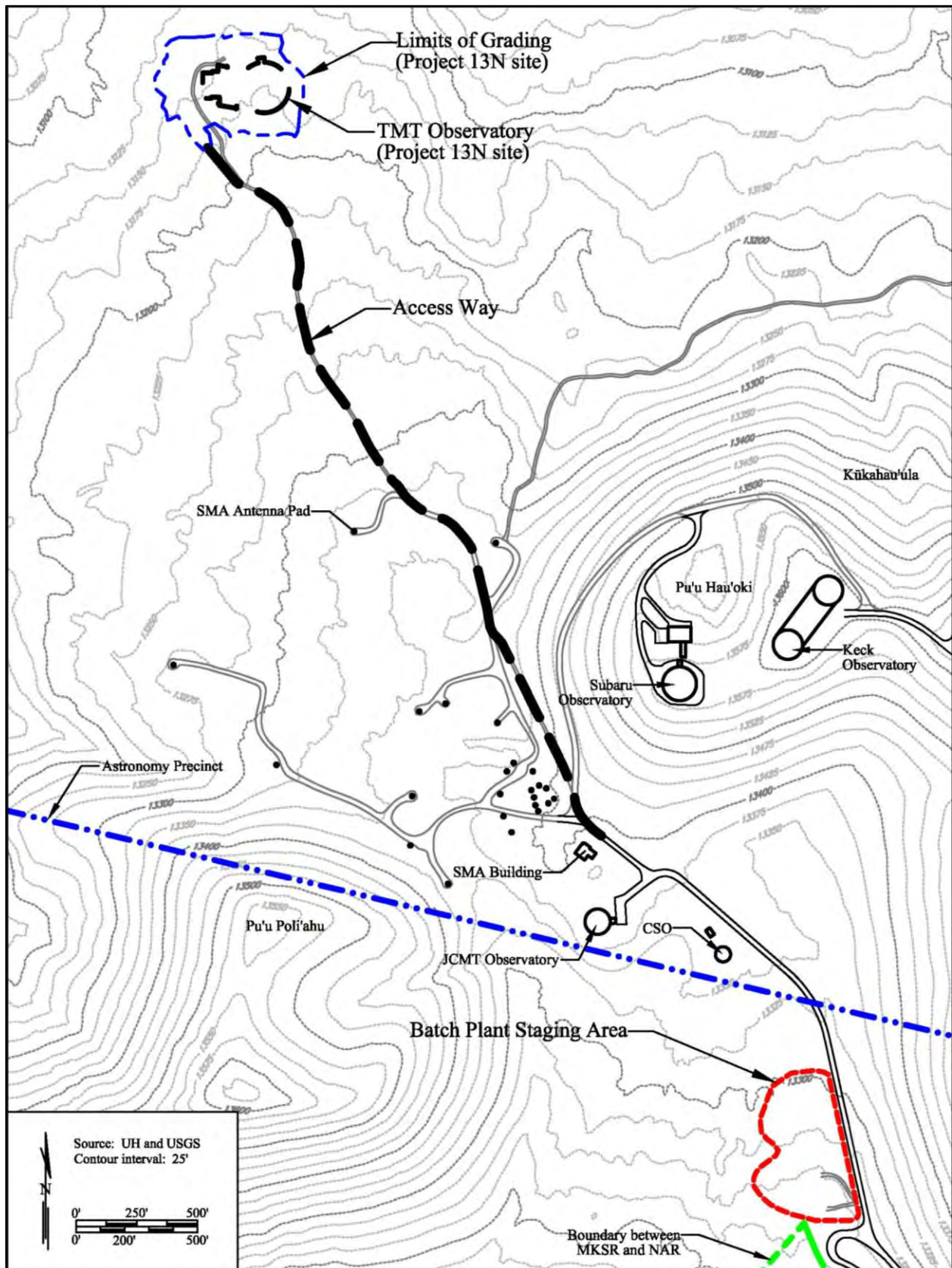
modifications of cinder cone morphology. The cumulative impact to the alpine shrublands and grasslands and māmane subalpine woodlands has also been substantial, adverse, and significant, primarily due to grazing by hoofed animals. The magnitude of significance of cumulative impact to the alpine stone desert ecosystem is not yet fully determined.

The cumulative socioeconomic impact has been and would continue to be substantial and beneficial.

3.8 Site Plan Showing Location of all Existing and Proposed Uses

Figure 3-7 provides a site plan showing the location of proposed TMT uses (TMT Observatory, Access Way, and Batch Plant Staging Area) and existing uses in the vicinity of the TMT uses.

Figure 3-7: Site Plan showing Existing and Proposes Uses



3.9 Historic Preservation Concerns

As outlined in Appendix A to this plan, the TMT Observatory site, the Access Way, and the Batch Plant Staging Area are all within the Mauna Kea Summit Region Historic District -- Statewide Inventory of Historic Places (SIHP) No. 50-10-23-26869 -- as defined in the *Mauna Kea Historic Preservation Plan Management Components* (DLNR Historic Preservation Division, 2000). The District includes a concentration of significant historic properties that are linked through their setting, historic use, traditional associations, and ongoing cultural practices. Recorded historic properties include shrines, adze quarry complexes and workshops, burials, stone markers/memorials, temporary shelters, historic campsites, TCPs, a historic trail, sites of unknown function, and isolated artifact finds. All of these types of historic sites are contributing properties to the Historic District. The Historic District has been determined by the SHPD to be significant under all five criteria (A, B, C, D and E), as defined in HAR § 13-275-6.

Ongoing cultural practices associated with historic properties in the Summit Region include: pilgrimage with accompanying prayer, shrine construction and offerings; collection of water from Lake Waiau; piko deposition; scattering of cremation ashes; burial blessing. These cultural practices are particularly focused on the TCPs in the summit region, including Kūkahau`ula. The Batch Plant Staging Area is adjacent to/across the road from Kūkahau`ula, and the proposed Access Way would extend across the western flank of Pu`u Hāu`oki, one of the pu`u that make up Kūkahau`ula, where the current 4-wheel drive road currently exists. The construction of the Access Way would specifically have an adverse effect on Kūkahau`ula while the general construction activities associated with the TMT would have an adverse effect on ongoing cultural practices.

Appendix A outlines a number of proposed direct and indirect measures that are intended to mitigate the adverse effects the construction of the TMT Observatory may have on historic properties and ongoing cultural practices associated with those properties. Mitigation measures include the adoption of construction methods intended to minimize ground disturbance and subsequent visibility, "give backs" such as funding the restoration of the former jeep trail up Pu`u Poli`ahu, archaeological and cultural monitoring during construction, and four days a year of reduced activity at the TMT Observatory on days identified by Kahu Kū Mauna as days of cultural importance.

3.10 Natural Hazard Assessment

The most significant natural hazards are seismic activity and high wind. Hawai'i Island is one of the most seismically active areas on Earth, and about two dozen earthquakes with magnitude 6 or greater have been documented on Hawai'i since the devastating earthquakes of 1868. Therefore, the Project would comply with applicable seismic safety regulations and standards in the design of structures to meet applicable codes to ensure life safety of personnel and visitors. Also, the design of the Observatory incorporates techniques to minimize the seismic risk of potential damage to the telescope and associated equipment. With these measures, the likelihood of damage is lessened.

High winds are common in the summit region and can reach high speeds during storms such as hurricanes and winter storms. Given the size and type of the structure, these high winds are the

most significant design criteria of the observatory dome. The TMT dome has been designed to withstand winds in excess of 100 miles per hour.

The potential for renewed volcanic activity in the summit region of Mauna Kea is extremely remote; Mauna Kea last erupted about 4,600 years ago, and the volcano is considered to be dormant. The Project faces no potential impacts from floods, due to its location and the area's geologic composition, and the Project elevation is well-above the established tsunami evacuation zone. There is no potential for a naturally-occurring fire at the Project location because of the extremely low level of vegetative cover in the summit region. While tropical storms and hurricanes occur in Hawai'i, they are not anticipated to be of concern beyond the high winds, which are discussed above.

4.0 Management & Controls

The CMP and subplans are the primary management documents that guide management of the significant resources in the UH Management Areas on Mauna Kea. OMKM is the University entity responsible for implementing the CMP and subplans. As discussed throughout this document, in order to ensure proper management of resources, the TMT Management Plan adopts the objectives, purpose, strategies, and management actions set forth in the CMP and subplans (CRMP, NRMP, PAP and Decommissioning Plan).

This Section outlines the management actions called for in the CMP and subplans that are applicable to the TMT Project and the measures TMT would take to implement these management actions in order to best manage Mauna Kea's varied resources. In addition, this Section also outlines the Best Management Practices and Conservation Methods and Applications that would be used to mitigate the effects of the TMT Project on Mauna Kea resources in the TMT Project area.

4.1 CMP Management Actions

The CMP sets forth a number of management actions that are directly applicable to the TMT Project. These are items, as detailed in the tables below, that TMT would proactively comply with. In addition, the CMP sets forth several management actions that are indirectly applicable to the TMT Project. These are items that OMKM is responsible for implementing. TMT will comply with OMKM's implementation of these management items.

It should be noted that the management actions set forth in the CMP are identical to those set forth in each of the subplans. The following table lists the management actions specified in the CMP and subplans and identifies their applicability to the TMT Project. The table also provides cross references on where these management actions are located in the different subplans. The following rationale was used in determining the applicability of each management action.

Directly Applicable:	Management actions that TMT would need to abide by in the design, construction, operation, and decommissioning of its facilities and activities within the UH Management Areas. How these management actions are applicable to the TMT Project and the means by which the TMT Project intends to abide by these management actions are discussed in more detail below.
Indirect:	Management actions that are not directly applicable to the TMT Project. TMT, however, would need to be aware of and comply with the outcome of the implementation of management actions by the University in the future. Based on the outcome of the management actions, requirements affecting the TMT Project directly or indirectly may occur. As appropriate, TMT may need to adjust operations to comply with those outcomes at some time in the future. TMT may also wish to adopt measures in advance of some management actions to help achieve or support the desired outcome of the management action.
Not Applicable:	Management actions that would not directly implicate the TMT Project. In general, these actions apply to OMKM and/or other entities and enactment of these management actions would not affect TMT operations. These management actions are not discussed below.

Table 4-1: Management Actions Detailed in the CMP and Subplans

CMP	Subplans	Management Action	Applicability to TMT Project
7.1.1 Native Hawaiian Cultural Resources			
CR-1	NRMP 4.4.2 CRMP 4.3.3 PAP 4.2, 5.2, 6.1	Kahu Kū Mauna shall work with families with lineal and historical connections to Mauna Kea, cultural practitioners, and other Native Hawaiian groups, including the Mauna Kea Management Board's Hawaiian Culture Committee, toward the development of appropriate procedures and protocols regarding cultural issues.	Not Applicable
CR-2	CRMP 2.4.2.1	Support application for designation of the summit region of Mauna Kea as a Traditional Cultural Property, per the National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 et seq. in consultation with the larger community.	Not Applicable
CR-3	NRMP 4.4.2 CRMP 4.3.3 PAP 4.2, 5.2, 6.1	Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape.	Directly Applicable
CR-4	CRMP 4.2.1.1	Establish a process for ongoing collection of information on traditional, contemporary, and customary cultural practices,	Not Applicable
CR-5	CRMP 4.2.1.3 PAP 6.3, 6.8	Develop and adopt guidelines for the culturally appropriate placement and removal of offerings.	Indirect
CR-6	CRMP 4.2.1.5 PAP 2.7.2, 6.3	Develop and adopt guidelines for the visitation and use of ancient shrines.	Indirect
CR-7	CRMP 4.2.1.6	Kahu Kū Mauna shall take the lead in determining the appropriateness of constructing new Hawaiian cultural features.	Indirect
CR-8	CRMP 4.2.1.7	Develop and adopt a management policy for the UH Management Areas on the scattering of cremated human remains.	Indirect
CR-9	CRMP 4.2.1.8 PAP 6.8	A management policy for the cultural appropriateness of building ahu or "stacking of rocks" will need to be developed by Kahu Kū Mauna who may consider similar policies adopted by Hawai'i Volcanoes National Park.	Indirect
CR-10	CRMP 4.3.1 PAP 5.2	Develop and implement a historic property monitoring program to systematically monitor the condition of the historic district and all historic properties, including cultural sites and burials.	Not Applicable
CR-11	CRMP 4.3.7	Complete archaeological survey of the portions of the Summit Access Road corridor under UH management.	Not Applicable
CR-12	CRMP 4.2.7	Consult with Kahu Kū Mauna about establishing buffers (preservation zones) around known historic sites in the Astronomy Precinct, to protect them from potential future development.	Indirect
CR-13	CRMP 4.3.2, 4.3.7	Develop and implement a burial treatment plan for the UH Management Areas in consultation with Kahu Kū Mauna Council, MKMB's Hawaiian Culture Committee, the Hawai'i Island Burial Council, recognized lineal or cultural descendants, and SHPD.	Not Applicable

CMP	Subplans	Management Action	Applicability to TMT Project
CR-14	CRMP 4.3.1.6 PAP 2.5.1	Immediately report any disturbance of a shrine or burial site to the rangers, DOCARE, Kahu Kū Mauna, and SHPD.	Directly Applicable
7.1.2 Natural Resources			
NR-1	NRMP 4.2.3	Limit threats to natural resources through management of permitted activities and uses.	Indirect
NR-2	NRMP 4.2.3.7, 4.3 PAP 2.7.1, 6.3	Limit damage caused by invasive species through creation of an invasive species prevention and control program.	Directly Applicable
NR-3	NRMP 4.2.3.8	Maintain native plant and animal populations and biological diversity.	Indirect
NR-4	NRMP 4.2.3.11	Minimize barriers to species migration, to help maintain populations and protect ecosystem processes and development.	Indirect
NR-5	NRMP 4.2.3.11	Manage ecosystems to allow for response to climate change	Indirect
NR-6	NRMP 4.4 PAP 2.7.1, 4.2, 5.2, 6.1, 6.3, 6.6	Reduce threats to natural resources by educating stakeholders and the public about Mauna Kea's unique natural resources.	Directly Applicable
NR-7	NRMP 4.1, 4.2.3.1	Delineate areas of high native diversity, unique communities, or unique geological features within the Astronomy Precinct and at Hale Pōhaku and consider protection from development.	Indirect
NR-8	NRMP 4.2.3.7, 4.3	Consider fencing areas of high native biodiversity or populations of endangered species to keep out feral ungulates (applies to areas below 12,800 ft elevation).	Not Applicable
NR-9	NRMP 4.3, 4.4	Increase native plant density and diversity through an out planting program.	Not Applicable
NR-10	NRMP 4.3	Incorporate mitigation plans into project planning and conduct mitigation following new development.	Directly Applicable
NR-11	NRMP 4.3	Conduct habitat rehabilitation projects following unplanned disturbances.	Directly Applicable
NR-12	NRMP 4.3	Create restoration plans and conduct habitat restoration activities, as needed.	Directly Applicable
NR-13	NRMP 4.1.3.3, 4.3, 5.1.3 PAP 4.2, 4.5	Increase communication, networking, and collaborative opportunities, to support management and protection of natural resources.	Indirect
NR-14	NRMP 5.2 PAP 5.1, 5.2, 6.4, 6.7, 7	Use the principles of adaptive management when developing programs and methodologies. Review programs annually and revise any component plans every five years, based on the results of the program review.	Indirect
NR-15	NRMP 4.1	Conduct baseline inventories of high-priority resources, as outlined in an inventory, monitoring, and research plan.	Not Applicable
NR-16	NRMP 4.1 PAP 6.4	Conduct regular long-term monitoring, as outlined in an inventory, monitoring, and research plan.	Not Applicable
NR-17	NRMP 4.1.2.3	Conduct research to fill knowledge gaps that cannot be addressed through inventory and monitoring.	Not Applicable

CMP	Subplans	Management Action	Applicability to TMT Project
NR-18	NRMP 4.1, 4.5	Develop geo-spatial database of all known natural resources and their locations in the UH Management Areas that can serve as baseline documentation against change and provide information essential for decision-making.	Not Applicable
7.1.3 Education and Outreach			
EO-1	NRMP 4.1 CRMP 4.3.3 PAP 2.7.1, 4.2, 5.2, 6.1, 6.3, 6.6	Develop and implement an education and outreach program.	Directly Applicable
EO-2	NRMP 4.4.2 PAP 6.1, 6.6	Require orientation of users, with periodic updates and a certificate of completion, including but not limited to visitors, employees, observatory staff, contractors, and commercial and recreational users.	Directly Applicable
EO-3	NRMP 4.4 CRMP 4.3.3 PAP 6.1	Continue to develop, update, and distribute educational materials	Indirect
EO-4	NRMP 4.4.2 PAP 4.2, 5.2, 6.2	Develop and implement a signage plan to improve signage throughout the UH Management Areas (interpretive, safety, rules and regulations).	Not Applicable
EO-5	NRMP 4.3, 4.4.2 CRMP 4.3.3 PAP 6.2	Develop interpretive features such as self-guided cultural walks and volunteer-maintained native plant gardens.	Not Applicable
EO-6	NRMP 4.4.2 PAP 5.2, 6.1	Engage in outreach and partnerships with schools, by collaborating with local experts, teachers, and university researchers, and by working with the 'Imiloa Astronomy Center of Hawai'i.	Indirect
EO-7	NRMP 4.4.2 CRMP 5.3 PAP 5.2, 6.3, 6.8	Continue and increase opportunities for community members to provide input to cultural and natural resources management activities on Mauna Kea, to ensure systematic input regarding planning, management, and operational decisions that affect natural resources, sacred materials or places, or other ethnographic resources with which they are associated.	Not Applicable
EO-8	NRMP 4.4.2	Provide opportunities for community members to participate in stewardship activities.	Not Applicable
7.1.4 Astronomical Resources			
AR-1	PAP 5.1	Operate the UH Management Areas to prohibit activities resulting in negative impacts to astronomical resources.	Indirect
AR-2	NRMP 4.2.3.2	Prevent light pollution, radio frequency interference and dust.	Directly Applicable
7.2.1 Activities and Uses			
ACT-1	NRMP 4.2, 4.4 PAP 2.5.2, 5.2, 7	Continue and update managed access policy of 1995 Management Plan.	Indirect

CMP	Subplans	Management Action	Applicability to TMT Project
ACT-2	NRMP 3.1.1.2 PAP 5.2, 6.4, 6.6, 6.7	Develop parking and visitor traffic plan.	Indirect
ACT-3	NRMP 5.1.2 CRMP 4.1.1 PAP 4.2, 4.4, 4.5, 4.6, 5.2, 6.1, 6.2, 6.5, 6.6, 6.7	Maintain a presence of interpretive and enforcement personnel on the mountain at all times to educate users, deter violations, and encourage adherence to restrictions.	Not Applicable
ACT-4	NRMP 4.2.3.1 CRMP 4.1.2 PAP 2.5.1, 2.5.2, 2.6.3, 5.2, 6.3, 6.5	Develop and enforce a policy that maintains current prohibitions on off-road vehicle use in the UH Management Areas and that strengthens measures to prevent or deter vehicles from leaving established roads and designated parking areas.	Not Applicable
ACT-5	NRMP 4.2.3.1 CRMP 4.2.3.4 PAP 3.3.7, 5.2, 6.2, 6.3	Implement policies to reduce impacts of recreational hiking.	Not Applicable
ACT-6	NRMP 4.2.3.1 CRMP 4.2.3.2 PAP 3.3.5, 5.2, 6.1, 6.3, 6.4	Define and maintain areas where snow-related activities can occur and confine activities to slopes that have a protective layer of snow.	Not Applicable
ACT-7	NRMP 6.2.3 CRMP 4.2.3.1 PAP 2.5.3, 2.6.2, 3.3.3, 5.2	Confine University or other sponsored tours and star-gazing activities to previously disturbed ground surfaces and established parking areas.	Not Applicable
ACT-8	NRMP 3.1.3.5 3.2.12 CRMP 4.2.3.3 PAP 2.5.1, 3.3.6, 5.2	Coordinate with DLNR in the development of a policy regarding hunting in the UH Management Areas.	Not Applicable
ACT-9	NRMP 3.1.4 PAP 2.5.3, 2.5.4, 3.3.3, 4.3, 5.2, 6.1, 6.7	Maintain commercial tour permitting process; evaluate and issue permits annually.	Not Applicable
ACT-10	NRMP 3.1.4.2 PAP 2.5.3, 3.3.3, 4.3, 6.1, 6.7	Ensure OMKM input on permits for filming activities.	Not Applicable
ACT-11	NRMP 1.4.2.3	Seek statutory authority for the University to regulate commercial activities in the UH Management Areas.	Not Applicable
ACT-12	NRMP 4.2.3.1, 4.2.3.7, 4.2.3.9 CRMP 4.2.6	Ensure input by OMKM, MKMB and Kahu Kū Mauna on research permits and report results to OMKM.	Not Applicable

CMP	Subplans	Management Action	Applicability to TMT Project
7.2.2 Permitting and Enforcement			
P-1	NRMP 1.4.3 PAP 2.4, 2.5, 2.5.1, 2.5.2, 2.5.3, 5.1	Comply with all applicable federal, state, and local laws, regulations, and permit conditions related to activities in the UH Management Areas.	Directly Applicable
P-2	NRMP 1.4.3.2	Strengthen CMP implementation by recommending to the BLNR that the CMP conditions be included in any Conservation District Use Permit or other permit.	Indirect
P-3	NRMP 1.4.3.2	Obtain statutory rule-making authority from the legislature, authorizing the University of Hawai'i to adopt administrative rules pursuant to Chapter 91 to implement and enforce the management actions.	Not Applicable
P-4	NRMP 4.4 PAP 4.2, 5.2, 6.1, 6.2, 6.5	Educate management staff and users of the mountain about all applicable rules and permit requirements.	Directly Applicable
P-5	NRMP 5.1 PAP 4, 6.5	Continue coordinating with other agencies on enforcement needs.	Not Applicable
P-6	NRMP 1.4.2.3, 3.1.3.2, 5.1 PAP 4.4, 4.5, 4.6, 5.2, 6.5, 6.6	Obtain legal authority for establishing, and then establish, a law enforcement presence on the mountain that can enforce rules for the UH Management Areas on Mauna Kea.	Not Applicable
P-7	NRMP 1.4.2.3	Develop and implement protocol for oversight and compliance with Conservation District Use Permits.	Indirect
P-8	NRMP 3.1.4 PAP 2.5.3, 3.3.3, 4.3, 4.5, 4.6, 6.5	Enforce conditions contained in commercial and Special Use permits.	Indirect
7.3.1 Infrastructure and Maintenance			
IM-1		Develop and implement an Operations Monitoring and Maintenance Plan	Indirect
IM-2	NRMP 4.4	Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	Directly Applicable
IM-3	CRMP 4.1.3	Conduct historic preservation review for maintenance activities with potential adverse effect on historic properties	Directly Applicable
IM-4	NRMP 4.2.3.7	Evaluate need for and feasibility of a vehicle wash station near Hale Pōhaku, and requiring that vehicles be cleaned.	Indirect
IM-5	NRMP 4.2.3.5 CRMP 4.1.4, 4.3.4	Develop and implement a Debris Removal, Monitoring and Prevention Plan.	Indirect
IM-6	NRMP 3.2.4, 4.1.4.2, 4.2.3.4 PAP 2.6.3, 6.3, 6.4	Develop and implement an erosion inventory and assessment plan.	Indirect

CMP	Subplans	Management Action	Applicability to TMT Project
IM-7	CRMP 4.3.4.1	Prepare a plan, in collaboration with the Department of Defense, to remove military wreckage from a remote area of the UH Management Areas, while ensuring protection of natural and cultural resources.	Not Applicable
IM-8	NRMP 4.2.3	Assess feasibility of paving the Summit Access Road.	Not Applicable
IM-9	NRMP 3.1.1.2.3 PAP 5.2, 5.4, 6.7	Evaluate need for additional parking lots and vehicle pullouts and install if necessary.	Indirect
IM-10	NRMP 3.1.3.1, 3.2.3, 4.2.3.3 PAP 5.2, 6.4, 6.6, 6.7, 6.8	Evaluate need for additional public restroom facilities in the summit region and at Hale Pōhaku, and install close-contained zero waste systems if necessary.	Not Applicable
IM-11		Encourage existing facilities and new development to incorporate sustainable technologies, energy efficient technologies, and LEED standards, whenever possible, into facility design and operations.	Directly Applicable
IM-12	NRMP 4.2.3.3	Conduct energy audits to identify energy use and system inefficiencies, and develop solutions to reduce energy usage.	Directly Applicable
IM-13	NRMP 3.1.1.2.3	Conduct feasibility assessment, in consultation with Hawai'i Electric Light Company, on developing locally-based alternative energy sources.	Not Applicable
IM-14		Encourage observatories to investigate options to reduce the use of hazardous materials in telescope operations.	Directly Applicable
7.3.2 Construction Guidelines			
C-1	NRMP 3.2, 4.2	Require an independent construction monitor who has oversight and authority to insure that all aspects of ground based work comply with protocols and permit requirements.	Directly Applicable
C-2	NRMP 4.2.3	Require use of Best Management Practices Plan for Construction Practices.	Directly Applicable
C-3	NRMP 4.2.3.1	Develop, prior to construction, a rock movement plan.	Directly Applicable
C-4		Require contractors to provide information from construction activities to OMKM for input into OMKM information databases.	Directly Applicable
C-5	CRMP 4.2.7	Require on-site monitors (e.g., archaeologist, cultural resources specialist, entomologist) during construction, as determined by the appropriate agency.	Directly Applicable
C-6	CRMP 4.2.7	Conduct required archaeological monitoring during construction projects per SHPD approved plan.	Directly Applicable
C-7	NRMP 4.4	Education regarding historical and cultural significance.	Directly Applicable
C-8	NRMP 4.4	Education regarding environment, ecology and natural resources.	Directly Applicable
C-9	NRMP 4.2.3.7	Inspection of construction materials.	Directly Applicable

CMP	Subplans	Management Action	Applicability to TMT Project
7.3.3 Site Recycling, Decommissioning, Demolition and Restoration			
SR-1	NRMP 4.3.3.4.1	Require observatories to develop plans to recycle or demolish facilities once their useful life has ended, in accordance with their sublease requirements, identifying all proposed actions.	Directly Applicable
SR-2	NRMP 4.3.3.4.1	Require observatories to develop a restoration plan in association with decommissioning, to include an environmental cost-benefit analysis and a cultural assessment.	Directly Applicable
SR-3	NRMP 4.3.3.4.1	Require any future observatories to consider site restoration during project planning and include provisions in subleases for funding of full restoration.	Directly Applicable
7.3.4 Considering Future Land Use			
FLU-1	NRMP 5.1.1	Follow design guidelines presented in the 2000 Master Plan.	Directly Applicable
FLU-2	NRMP 4.3.3.1	Develop a map with land-use zones in the Astronomy Precinct based on updated inventories of cultural and natural resources, to delineate areas where future land use will not be allowed and areas where future land use will be allowed but will require compliance with prerequisite studies or analysis prior to approval of Conservation District Use Permit.	Not Applicable
FLU-3		Require cataloguing of initial site conditions for use when conducting site restoration.	Directly Applicable
FLU-4	NRMP 4.1.4.11	Require project specific visual rendering of both pre- and post-project settings to facilitate analysis of potential impacts to view planes.	Directly Applicable
FLU-5	NRMP 4.1.4.4	Require an airflow analysis on the design of proposed structures to assess potential impacts to aeolian ecosystems.	Directly Applicable
FLU-6	NRMP 4.3.3.3	Incorporate habitat mitigation plans into project planning process.	Directly Applicable
FLU-7	NRMP 3.1.1.2.6	Require use of close-contained zero-discharge waste systems for any future development in the summit region, from portable toilets to observatory restrooms, if feasible.	Directly Applicable
7.4.1 Operations and Implementation			
OI-1		Maintain OMKM, MKMB, and Kahu Kū Mauna in current roles, with OMKM providing local management of the UH Management Areas, and MKSS providing operational and maintenance services.	Indirect
OI-2	NRMP 5.1 CRMP 5.2 PAP 5.1, 5.2, 6.1, 6.4, 6.5	Develop training plan for staff and volunteers.	Indirect
OI-3	NRMP 5.1 PAP 5.1	Maintain and expand regular interaction and dialogue with stakeholders, community members, surrounding landowners, and overseeing agencies to provide a coordinated approach to resource management.	Indirect
OI-4	PAP 6.6	Establish grievance procedures for OMKM, to address issues as they arise.	Indirect

CMP	Subplans	Management Action	Applicability to TMT Project
OI-5	CRMP 4.1.6, 4.3.5 PAP 6.1, 6.4, 6.5, 6.7	Update and implement emergency response plan.	Indirect
7.4.2 Monitoring Evaluation and Updates			
MEU-1	NRMP 4.1.3.3 PAP 6.4, 6.6, 7	Establish a reporting system to ensure that the MKMB, DLNR, and the public are informed of results of management activities in a timely manner.	Directly Applicable
MEU-2	NRMP 5.2 CRMP 5.5 PAP 7	Conduct regular updates of the CMP that reflect outcomes of the evaluation process, and that incorporate new information about resources.	Indirect
MEU-3	PAP 7	Revise and update planning documents, including the master plan, leases, and subleases, so that they will clearly assign roles and responsibilities for managing Mauna Kea and reflect stewardship matters resolved with DLNR.	Indirect

The following tables detail the measures TMT intends to implement to comply with the CMP Management Actions directly applicable to the TMT Project. As previously noted, TMT would comply with OMKM's implementation of management actions indirectly applicable to the TMT Project.

4.1.1 Cultural Resource Management

This section sets forth the management actions that TMT would comply with that are intended to protect, preserve, and enhance the cultural resources of the UH Management Areas on Mauna Kea. As described in Section 3, cultural resources include historic properties and cultural practices. According to the CMP, the desired outcome of implementation of these management actions is an increase in understanding and appreciation of Native Hawaiian history and cultural practices related to Mauna Kea to ensure that these practices are protected and respected.

Table 4-2: Cultural Resources Management Actions (CMP Section 7.1.1)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
CR-3	NRMP 4.4.2 CRMP 4.3.3 PAP 4.2, 5.2, 6.1	Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape.	<p>A consistent theme of the CMP is that culturally sensitive and appropriate educational efforts are the most effective and efficient method of managing and protecting Mauna Kea's resources. Observatory staff and visitors to Mauna Kea should be educated regarding Mauna Kea's cultural landscape, including cultural practices, historic properties and their sensitivity to damage, and the rules and regulations associated with their protection and preservation. TMT would develop and implement such educational efforts and would comply with this CMP management action through the following:</p> <ul style="list-style-type: none"> • <u>Cultural and Natural Resources Training Program</u>: TMT would implement a Cultural and Natural Resources Training Program that will encompass the CMP requirement, including training TMT employees to respect, honor, and not interfere with cultural or

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
			<p>religious practices and practitioners and teaching ways to reduce their impact on the cultural resources of the mountain. The training will also include imparting an understanding of Polynesian perspectives of astronomy and way-finding to the TMT staff.</p> <ul style="list-style-type: none"> • <u>TMT Outreach Office</u>: TMT would establish an outreach office and fund two full-time TMT workers to staff the office. The outreach office is intended to collaborate with community groups including 'Imiloa and Native Hawaiian groups to support and fund programs specific to Hawaiian culture and archaeological resources. • <u>Mauna Kea Resources Exhibit</u>: Through its outreach office and in coordination with OMKM and 'Imiloa, TMT would support the development of exhibits regarding cultural, natural, and historic resources that could be used at the Mauna Kea Visitor Information Station (VIS), 'Imiloa, TMT facilities, or other appropriate locations. Exhibits will include informational materials that explore the connection between Hawaiian culture and astronomy. • <u>Community Cultural Training and Events</u>: TMT would support, including through financial contributions and the utilization of its outreach office staff, cultural training and annually host a cultural event or training. Examples of this include activities such as a star gazing program at the annual Makahiki festival, workshops on stone adze making, and workshops on how to recognize archaeological sites and their importance. • <u>Sublease Rent</u>: TMT would pay sublease rent to the University, which would be directed toward Mauna Kea management through the Mauna Kea Special Management Fund. These funds may be used by OMKM to support educational efforts to generate public awareness about the importance of preserving the cultural landscape of Mauna Kea. <p>It should be noted that many of the above actions which TMT would implement address the cumulative impacts of astronomy related development on Mauna Kea, not simply just the TMT Project. This TMT Management Plan is intended to assist in managing all of Mauna Kea's resources in the UH Management Areas, including the resources impacted by the TMT Project as well as other telescope facilities on Mauna Kea.</p>
CR-14	CRMP 4.3.1.6 PAP 2.5.1	Immediately report any disturbance of a shrine or burial site to the rangers, DOCARE, Kahu Kū Mauna, and SHPD.	TMT would comply with this management action and report any disturbance to any shrine or burial site to OMKM. Furthermore, as outlined in Section 3.15 of the TMT Final EIS, TMT would develop an Archaeological Monitoring Plan in accordance with HAR § 13-279. Cultural and archaeological monitors will be present at construction sites on Mauna Kea and have authority to stop work if cultural finds are made, including historic properties. They will also inform workers of the possibility of inadvertent cultural finds, including human remains.

4.1.2 Natural Resource Management

This section sets forth the management actions that TMT would comply with that are intended to protect, preserve, and enhance the natural resources of the UH Management Areas on Mauna Kea. The CMP management actions regarding natural resources were developed with the following concepts in mind:

1. The high-elevation areas of Mauna Kea represent a unique global resource that should be preserved for future generations.
2. Management activities shall be focused on limiting the impacts of human activities on natural resources.
3. The planning and execution of natural resources management programs will involve input from the larger community, including scientists, educators, volunteers, and the public—as well as from natural resource managers.
4. Long-term global environmental factors such as climate change must be taken into account when planning natural resource management activities.
5. Natural resources management planning will use an ecosystem approach.¹³
6. Adaptive management techniques will be used.
7. The biological and physical resources found in high elevation areas of Mauna Kea and the unique ecosystems that encompass them deserve further study by researchers and managers.

According to the CMP, the desired outcome of these management actions is to increase understanding of the status of natural resources (biotic and abiotic), and identify threats to these resources in order to better protect and preserve unique geological features, ecosystem functions, subalpine and alpine habitats, and biological communities through adaptive management of stressors and threats.

¹³ An ecosystem consists of the plants, animals, and microorganisms within an area; the environment that sustains them; and their interactions. An ecosystem can be as tiny as an isolated wetland containing only a few species or as large as a tropical rainforest containing thousands of species.

Table 4-3: Natural Resources Management Actions (CMP Section 7.1.2)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
NR-2	NRMP 4.2.3.7, 4.3 PAP 2.7.1, 6.3	Limit damage caused by invasive species through creation of an invasive species prevention and control program.	<p>Although OMKM will be developing a mountain-wide Invasive Species Prevention and Control Program, in relation to the TMT Project, TMT would develop an Invasive Species Prevention and Control Program to aggressively reduce the potential for invasive species introduction, especially during construction of the TMT Project. This Program will be developed in coordination with OMKM. In summary, this Program will include the following:</p> <ul style="list-style-type: none"> • Requirements that everyone who plans to pass beyond Hale Pōhaku brush down their clothes and shoes to remove invasive plant seeds and invertebrates. • Regular inspections and washing, at lower elevation facilities such as the TMT Headquarters, of observatory vehicles and other items that are regularly transported between the TMT Observatory and lower elevations. • Regular monitoring of the habitat along the Access Way and around the TMT Observatory and the interior of the TMT Observatory for invasive species, and eradication of such species when/if found. • Inspection, by a biologist, of major shipments of new equipment bound for the TMT Observatory prior to transportation beyond the TMT Headquarters.
NR-6	NRMP 4.4 PAP 2.7.1, 4.2, 5.2, 6.1, 6.3, 6.6	Reduce threats to natural resources by educating stakeholders and the public about Mauna Kea's unique natural resources.	TMT intends to work with OMKM and 'Imiloa to develop exhibits for the VIS and 'Imiloa regarding important natural resources of Mauna Kea. In addition to this and as previously detailed, TMT would develop a Cultural and Natural Resources Training Program to educate TMT staff, stakeholders and TMT visitors regarding Mauna Kea's unique and fragile resources. The VIS and 'Imiloa exhibits and the Training Program are intended to impress upon those who participate the importance of effectively stewarding and managing Mauna Kea's varied resources.
NR-10	NRMP 4.3	Incorporate mitigation plans into project planning and conduct mitigation following new development.	TMT has actively incorporated mitigation planning into its project planning process. As detailed in Section 3.4 of the Final EIS, in planning the TMT Observatory Access Way, TMT made a concerted effort to limit disturbance and displacement of sensitive wēkiu bug habitat, including the paving of a portion of the Access Way to reduce the generation of dust where the Access Way is adjacent to sensitive habitat. As discussed later in this Management Plan, TMT would develop a Ride-Sharing Program for TMT staff which will minimize the amount of TMT related traffic on Mauna Kea as well as reducing the Project's impact on air quality. In addition, TMT would work with OMKM to develop and implement a wēkiu bug habitat restoration study. Depending on the results of this study, it could be used to support the design and implementation of a wēkiu bug habitat restoration plan in the future.

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
NR-11	NRMP 4.3	Conduct habitat rehabilitation projects following unplanned disturbances.	With regards to any unplanned disturbances, TMT would conduct habitat rehabilitation projects to address the disturbance, if any. It should be noted that TMT would implement BMPs to limit the potential for unplanned disturbances.
NR-12	NRMP 4.3	Create restoration plans and conduct habitat restoration activities, as needed.	As detailed above, TMT would work with OMKM to develop and implement a habitat restoration study. Depending on the results of this study, it could be used to support the design and implementation of a Habitat Restoration Plan in the future. In addition to this, TMT would monitor arthropod activity in the vicinity of the Access Way portion impacting sensitive, Type 3 wēkiu bug alpine cinder cone habitat. Monitoring will be performed prior to, during, and for at least two years after construction in this area.

4.1.3 Education & Outreach

Education includes providing information about natural, cultural, and astronomical resources to the public, through on-site and off-site materials and programs. Outreach includes activities to increase public participation in the stewardship of Mauna Kea, community consultation, and community involvement in resource management activities through volunteer-based programs. The desired outcome of implementation of these management actions is to build and maintain a constituency to engage in active and meaningful stewardship of Mauna Kea, through education and involvement of the public, to support, enhance conservation, and sustain the natural, cultural, and astronomical resources of Mauna Kea.

It should be noted that the CMP identifies lack of education as a source of unintentional impact to Mauna Kea's unique cultural and natural resources. TMT would devote substantial resources towards educational and outreach efforts intended to address this need and mitigate impacts to Mauna Kea's resources.

Table 4-4: Education and Outreach Management Actions (CMP Section 7.1.3)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
EO-1/6	NRMP 4.1, 4.4.2 CRMP 4.3.3 PAP 2.7.1, 4.2, 5.2, 6.1, 6.3, 6.6	Develop and implement an education and outreach program and engage in outreach and partnerships with schools, by collaborating with local experts, teachers, and university researchers, and by working with the 'Imiloa Astronomy Center of Hawai'i.	TMT would implement several measures to ensure that it is educating, reaching out to, and engaging in partnerships with the public at large: <ul style="list-style-type: none"> • TMT would establish an outreach office that would regularly engage the public, particularly the Native Hawaiian community. • TMT would support, including through financial contributions and the utilization of its outreach office staff, cultural training and annually host a cultural event or training. Examples of how this measure might be implemented include activities such as star gazing program at the annual Makahiki festival, workshops on stone adze making, or on how to recognize

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
			<p>archaeological sites and their importance.</p> <ul style="list-style-type: none"> • TMT, through its outreach office and in coordination with OMKM and 'Imiloa, would support the development of exhibits regarding cultural, natural, and historic resources that could be used at the VIS, 'Imiloa, TMT facilities, or other appropriate locations. Exhibits will include information materials that explore the connection between Hawaiian culture and astronomy. • TMT's outreach office would work with 'Imiloa and Native Hawaiian groups to support/fund programs specific to Hawaiian culture and archaeological resources. • TMT would develop and implement a Cultural and Natural Resources Training Program in consultation with OMKM that will include educational instruction and materials designed to impart an understanding of Mauna Kea's cultural landscape and provide guidance regarding appropriate behavior in the summit area plus an understanding of Mauna Kea's natural resources and how to protect them. • TMT will request permission to attend, on an agreed upon schedule, meetings of the Kahu Kū Mauna Council. A TMT representative will be available to review cultural impact issues, should there be any, related to the TMT Project. • TMT would provide periodic tours of the TMT Observatory, with the Native Hawaiian community invited at least two weeks prior to the tour. • TMT would contribute to the funding of translating modern astronomy lessons into Hawaiian language for use at Hawaiian language charter schools. • TMT would have an open door policy so that TMT's outreach office could be contacted by the Native Hawaiian community to discuss issues that may arise from time to time. • TMT intends to closely collaborate with OMKM on various issues, projects and programs
EO-2	NRMP 4.4.2 PAP 6.1, 6.6	Require orientation of users, with periodic updates and a certificate of completion, including but not limited to visitors, employees, observatory staff, contractors, and commercial and recreational users.	<p>Staff of and visitors to the TMT Observatory need to be sensitive to the fact that they are in a unique place considered sacred by Native Hawaiians. TMT would develop a Cultural and Natural Resources Training Program that will include educational instruction and materials designed to:</p> <ul style="list-style-type: none"> • Impart an understanding of Mauna Kea's cultural landscape and provide guidance regarding appropriate

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
EO-3	NRMP 4.4 CRMP 4.3.3 PAP 6.1	Continue to develop, update, and distribute materials explaining important aspects of Mauna Kea.	<p>behavior in the summit area.</p> <ul style="list-style-type: none"> • Describe the status, condition, and diversity of natural resources present on the mountain, including biotic and physical elements. • Outline the potential and existing threats to the natural resources. • Summarize the protection afforded the natural resources in various rules and regulations. • Provide expectations and requirements to avoid habitat damage, including but not limited to: <ul style="list-style-type: none"> - A prohibition on off-road vehicle use. - The requirements of the Invasive Species Prevention and Control Program detailed below. - Watch for and avoid impact with nēnē along the roads. - Restrictions on smoking and other potential sources of fire. • Provide steps to take and consider personal safety and potential hazards of working on the mountain. <p>The training program would be updated regularly to incorporate UH Management Area-wide updates by OMKM. All people involved in TMT Observatory operation and maintenance activities, including but not limited to scientists and support staff, shall receive the training on an annual basis. It is contemplated that this training program may be opened to other parties including to the staff of other telescope facilities so as to mitigate the cumulative impacts of astronomy related development on Mauna Kea's resources.</p>

4.1.4 Astronomical Resources

Mauna Kea's unique environment makes it a premiere location for astronomical observation and research. Astronomical resources shall also be protected. The University's lease of the summit area provides that the MKSR shall be operated as a buffer zone to prevent the intrusion of activities incompatible with the use of the land as a scientific complex or observatory. The CMP specifically identifies light and dust interference as well as certain types of electronic interference as incompatible with astronomical uses.

Table 4-5: Astronomical Resources Management Actions (CMP Section 7.1.4)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
AR-2	NRMP 4.2.3.2	Prevent light pollution, radio frequency interference and dust.	TMT intends to take various measures to prevent light pollution, radio frequency interference and dust. To address light pollution, TMT would limit the use of external lighting such as vehicle lights by limiting the number of night-time vehicle trips to and from the TMT Observatory. To address radio frequency

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
			interference, TMT would also limit the amount of cell phone and walkie talkie usage on the summit of Mauna Kea. Finally, to control dust, TMT would take several measures such as spraying water on the TMT Access Way to limit the amount of dust during construction activities and instituting a Ride-Sharing Program which will require all personnel working at the TMT Observatory to ride-share in observatory vehicles beyond Hale Pōhaku, or a lower elevation location, to the summit area. The TMT vehicles would be selected based on balancing the needs for fuel efficiency, low emissions, and safety for transportation to the summit. An average of five vehicles would be used for day-time trips and two for night-time trips. This required ride sharing would reduce the total number of Project trips beyond Hale Pōhaku to the summit area to approximately 9 trips per day (7 staff trips and 2 other trips, such as deliveries), thus, lessening the Project's impact on air quality. In addition, a portion of the road within the Access Way would be paved to reduce dust generation. The section to be paved would start where the pavement currently ends on the Mauna Kea Loop road near the SMA driveway and continue through the SMA area. This portion of the Access Way is the portion nearest the existing observatories that could be impacted by dust.

4.1.5 Permitting & Enforcement

Successful stewardship of the UH Management Areas on Mauna Kea will come, in part, from balancing development and public access with the enforcement of rules. The desired outcome of the following management actions is to achieve compliance with existing and any new policies and regulations designed to manage and minimize human impacts, to preserve and protect Mauna Kea's resources.

Table 4-6: Permitting and Enforcement Management Actions (CMP Section 7.2.2)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
P-1	NRMP 1.4.3 PAP 2.4, 2.5, 2.5.1, 2.5.2, 2.5.3, 5.1	Comply with all applicable federal, state, and local laws, regulations, and permit conditions related to activities in the UH Management Areas.	TMT has and will continue to comply with all applicable federal, state, and local laws, regulations, and permit conditions related to the TMT Project. For example, in compliance with Chapter 343, Hawai'i Revised Statutes, TMT developed an Environmental Impact Statement intended to be used by decision-makers reviewing the TMT Project.

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
P-4	NRMP 4.4 PAP 4.2, 5.2, 6.1, 6.2, 6.5	Educate management staff and users of the mountain about all applicable rules and permit requirements.	TMT would develop a Cultural and Natural Resources Training Program that would be updated regularly. This program would contain information regarding applicable rules and requirements governing uses on Mauna Kea, including but not limited to pertinent Conservation District Rules, OMKM policies and procedures, and administrative rules developed by OMKM. All people involved in TMT Observatory operation and maintenance activities, including but not limited to scientists and support staff, would receive the training on an annual basis.

4.1.6 Infrastructure & Maintenance

The infrastructure of the UH Management Areas on Mauna Kea includes observatories, support facilities, and associated support elements (e.g., roadways, electric power supply, communications network). Activities to maintain infrastructure are on-going, so minimizing the impact to resources from maintenance activities is essential. In general, there is a need to minimize the impacts of facilities and the maintenance actions required to keep them operating.

TMT would work with OMKM and the Mauna Kea Observatory Support Services (MKSS) to identify strategies and protocols to reduce impacts to resources associated with infrastructure and maintenance practices. Specifically, TMT intends to comply with the following management actions in relation to TMT Project maintenance activities.

Table 4-7: Infrastructure and Maintenance Management Actions (CMP Section 7.3.1)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
IM-2		Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	TMT would develop a Cultural and Natural Resources Training Program that would educate TMT personnel about Mauna Kea's unique resources and how operations and/or activities could potentially impact those resources and how TMT personnel should conduct themselves or carry out their duties that would prevent impacts to the resources.
IM-3	CRMP 4.1.3	Conduct historic preservation review for maintenance activities with potential adverse effect on historic properties.	In the event that a TMT maintenance activity has the potential to adversely affect a historic property, TMT would develop a Cultural and Archaeological Monitoring Plan for that activity. Such activities would be those that require movement or disturbance of any previously undisturbed material; no such maintenance activities are anticipated at this time. The monitoring plan would have similar aspects as the monitoring plan outlined in Appendix A for the initial construction of the TMT Project. A qualified archaeologist, selected by OMKM and a cultural specialist, would be on-site to monitor any impacts, real or potential, of maintenance activity on archaeological and historic properties. The monitoring plan would be reviewed and approved by SHPD prior to implementation.

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
IM-11		Encourage existing facilities and new development to incorporate sustainable technologies, energy efficient technologies, and LEED standards, whenever possible, into facility design and operations.	See IM-12 below. However, given the specialized nature of the structure and the need to reduce potential impacts to cultural and natural resources in the summit region, the Project could not achieve any LEED standards for the TMT Observatory.
IM-12	NRMP 4.2.3.3	Conduct energy audits to identify energy use and system inefficiencies, and develop solutions to reduce energy usage.	TMT would work with OMKM on energy efficiency issues, including conducting energy audits and developing solutions to reducing energy usage. TMT recognizes the importance of maximizing energy efficiency and has incorporated such design elements into the design of TMT's facilities. TMT has instituted an active program to analyze the Project's energy efficiency and implementing the appropriate energy saving strategies and designs. Plans include solar hot water systems, photo voltaic power systems, energy efficient light fixtures, efficient Energy Star rated electrical appliances at all facilities and maximizing the use of natural ventilation and lighting.
IM-14		Encourage observatories to investigate options to reduce the use of hazardous materials in telescope operations.	TMT would institute a Waste Minimization Plan that will include an annual audit of products and processes to identify materials used by and waste produced by the Project and if/how these materials could be replaced by less toxic materials and waste could be reduced, reused, or recycled.

4.1.7 Construction Guidelines

Construction activities have the potential for direct and indirect impacts to Mauna Kea's unique resources. Careful planning, however, can minimize these impacts. Plans and protocols are especially important since construction workers are temporary, unfamiliar with the site, and have to conduct activities over short durations, often under difficult conditions. The desired outcome of the following management actions is to minimize adverse impacts to resources during all phases of construction, through use of innovative best management practices. TMT would comply with the following CMP management actions in relation to TMT construction activities. It should be noted that Section 4.3 details the Best Management Practices TMT intends to implement during construction phase activities.

Table 4-8: Construction Management Actions (CMP Section 7.3.2)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
C-1	NRMP 3.2, 4.2	Require an independent construction monitor who has oversight and authority to insure that all aspects of ground based work comply with protocols and permit requirements.	During all construction related activities, an independent, on-site construction monitor would be present at all appropriate times who would have authority to order any and all construction activity cease if and when, in the construction monitor's judgment, (a) there has been a violation of the permit that warrants cessation of construction activities, or (b) that continued construction activity would unduly harm cultural resources; provided that the construction monitor's order to cease construction activities be for a period not to exceed seventy two (72) hours for each incident. All orders to cease construction issued by the construction monitor would immediately be reported to OMKM and DLNR. It should be noted that TMT would develop Cultural and Archaeological Monitoring Plans, which would require an independent construction monitor who will have oversight and authority to insure that all aspects of ground based work comply with protocols and permit requirements. A draft of this plan is provided in a section of the Draft Historic Preservation Mitigation Plan (Appendix A). These plans would comply with the Hawai'i Administrative Rules Governing Standards for Archaeological Monitoring Studies and Reports (HAR § 13-279) and be reviewed and approved by SHPD prior to implementation. These construction phase plans would require that any ground disturbing construction activity be monitored by both a cultural observer and an archaeologist.
C-2	NRMP 4.2.3	Require use of Best Management Practices Plan for Construction Practices.	TMT would develop and implement a Best Management Practices Plan for Construction Practices (BMP) that will cover a range of topics including dust generation and a protocol for construction vehicle washing. In addition, an outline of the best management practices for construction which TMT would develop is located in Sections 4.6 and 4.7 of this TMT Management Plan.
C-3	NRMP 4.2.3.1	Develop, prior to construction, a rock movement plan.	Prior to the commencement of construction activities, TMT would develop a Rock Movement Plan that would identify the location and type of source material (cinder, rocks), provide estimates on the volume of material to be excavated and moved, provide details regarding the extraction and movement process, and identify a storage and/or disposal location.
C-4		Require contractors to provide information from construction activities to OMKM for input into OMKM information databases.	In coordination with OMKM, TMT would develop and implement a Reporting Plan that would require contractors to provide information from construction activities to ensure the open flow of information between TMT, its contractors, and OMKM.

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
C-5	CRMP 4.2.7	Require on-site monitors (e.g., archaeologist, cultural resources specialist, entomologist) during construction, as determined by the appropriate agency.	An independent, on-site construction monitor would be present at all appropriate times during construction of the Project. In addition to this, TMT would develop Cultural and Archaeological Monitoring Plans which would enable the construction monitor to have oversight and authority to insure that all aspects of ground based work comply with protocols and relevant permit requirements. Similarly, whenever construction, operations or maintenance activities include earth movement or disturbance, a qualified archaeologist, selected by OMKM, and a cultural resources specialist would be on site to monitor any impacts, real or potential, of construction activities on archaeological and historical resources.
C-6	CRMP 4.2.7	Conduct required archaeological monitoring during construction projects per SHPD approved plan.	An on-site construction monitor and archaeologist would be present when construction activities on the Project take place. Furthermore, TMT has developed a Draft Historic Preservation Mitigation Plan which discusses and incorporates archaeological monitoring. This Plan was developed in conjunction with consultation with SHPD and Kahu Kū Mauna and is attached hereto as Appendix A. Further consultation with various parties is envisioned for this Plan. Once finalized, this Plan will be submitted to SHPD for approval prior to implementation.
C-8	NRMP 4.4	Education regarding environment, ecology and natural resources.	As detailed previously, TMT would develop a Cultural and Natural Resources Training Program that would require all construction managers, contractors, supervisors, and all construction workers be trained regarding the potential impact to cultural and archaeological resources and the measures to prevent such impact.
C-9	NRMP 4.2.3.7	Inspection of construction materials.	<p>TMT would develop and implement an Invasive Species Prevention and Control Program to address the potential impact for the introduction of invasive species during construction. Components of the program during the construction phase of the Project will include:</p> <ul style="list-style-type: none"> • <u>Materials Control and Reduction</u>. All shipments will be repacked at the Port Staging Area so that only essential packing material is used for the final transportation to the construction site. This will reduce the volume of material potentially harboring invasive species, aid inspection, and minimize the waste generated at the construction sites. In addition: <ul style="list-style-type: none"> - Contractors will be required to inspect shipping crates, containers, and packing materials before shipment to Hawai'i. - Pallet wood will be free of bark and treated to prevent the transport of alien species. - Items that could serve as a food source for invasive species, such as food waste and food wrappers, will be collected separately from other debris and removed from the Mauna Kea summit region construction sites at the end of each day. • <u>Washing/Cleaning</u>. Materials and clothing will be washed or otherwise cleaned prior to proceeding above Saddle Road. This

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
			<p>will be done at lower elevation base yards, such as the Port Staging Area, and could include:</p> <ul style="list-style-type: none"> - A requirement that everyone brushes down their clothes and shoes to remove invasive plant seeds and invertebrates. - A requirement that waste containers be regularly pressure-washed using steam and/or soap to reduce odors that may attract bugs. - A requirement for pressure wash-down of all construction vehicles and heavy equipment. <ul style="list-style-type: none"> • <u>Inspections</u>. Prior to proceeding beyond the Saddle Road, all construction materials, equipment, crates, and containers carrying materials and equipment will be inspected and certified free of invasive species by a trained biologist, selected by OMKM and approved by DLNR. • <u>Monitoring</u>. Construction areas above Saddle Road, including the Batch Plant Staging Area, Access Way, and TMT Observatory sites will be monitored regularly based on a schedule developed with OMKM. The monitoring will be carried out by a trained biologist. • <u>Control</u>. Invasive species identified during monitoring will be controlled to prevent spread. Control measures will be developed and approved by OMKM and implemented by staff trained by a trained biologist, selected by OMKM. • <u>Education/Training</u>. The Invasive Species Prevention and Control Program will include an educational component to the Cultural and Natural Resources Training Program. It will require that construction personnel be trained to understand the sensitivity of the alpine environment and to follow the above steps, as applicable to their position. • <u>Updates</u>. The Invasive Species Prevention and Control Program will be further developed and expanded as necessary and will be part of project plans and specifications for construction bidding.

4.1.8 Site Recycling, Decommissioning, Demolition & Restoration

TMT intends to decommission, demolish and restore the TMT Project site in compliance with the Decommissioning Plan. This measure is intended to mitigate some of the Project's impacts on Mauna Kea's resources in the UH Management Areas. According to the CMP, *decommissioning* relates to the process when a facility is deemed obsolete and a determination has been made by the facility lessee to remove the telescope and restore the site. *Demolition* pertains to the actions that result when a structure is no longer needed and the user must remove all equipment and infrastructure from the site, including the structure. *Restoration* refers only to those remedial actions that take place following demolition of observatories. TMT intends to comply with the following management actions.

Table 4-9: Decommissioning Management Actions (CMP Section 7.3.3)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
SR-1	NRMP 4.3.3.4.1	Require observatories to develop plans to recycle or demolish facilities once their useful life has ended, in accordance with their sublease requirements, identifying all proposed actions.	Please see SR-3 below.
SR-2	NRMP 4.3.3.4.1	Require observatories to develop a restoration plan in association with decommissioning, to include an environmental cost-benefit analysis and a cultural assessment.	Please see SR-3 below.
SR-3	NRMP 4.3.3.4.1	Require any future observatories to consider site restoration during project planning and include provisions in subleases for funding of full restoration.	The TMT Observatory and the extent of the Access Way exclusively used to access the TMT Observatory would be dismantled and the site restored at the end of the TMT Observatory's life, in compliance with the provisions and conditions of the BLNR approved Decommissioning Plan and amendments. Deconstruction and site restoration efforts would be managed by TMT with oversight by OMKM. TMT intends to decommission and deconstruct the TMT Observatory upon the end of the Observatory's useful life and would reasonably restore the Observatory site and Access Way. TMT decommissioning, deconstruction and site restoration is further discussed in Section 4.5 below. TMT has included in the planned TMT Project operation budget an annual set aside of funds intended to be used for decommissioning of the TMT Observatory and Access Way. The Project anticipates decommissioning and site restoration requirements would be included in the sublease.

4.1.9 Future Land Use

Although the CMP is mainly focused on managing Mauna Kea's resources, it appropriately and necessarily addresses issues related to new land uses and activities and their potential impact on resources. Specifically, the CMP provides guidance and criteria to evaluate proposed projects from the standpoint of their potential impacts to cultural and natural resources.

TMT has and would continue to comply with CMP management actions related to future land uses in the UH Management Areas on Mauna Kea.

Table 4-10: Future Land Use Management Actions (CMP Section 7.3.4)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
FLU-1	NRMP 5.1.1	Follow design guidelines presented in the 2000 Master Plan.	TMT has complied with the design guidelines presented in the 2000 Master Plan and the Master Plan Project Review/Approval Process. This Process consisted of several steps designed to ensure compliance with the Master Plan. TMT completed the pre-design, schematic design and design development review phases and has been subjected to review by the design review committee which includes volunteer community professionals and the MKMB. Construction documents would be submitted by OMKM following the granting of a CDUP and prior to construction activity.
FLU-3		Require cataloguing of initial site conditions for use when conducting site restoration.	In order to aid in the eventual restoration TMT has and would continue to document the TMT Observatory and Access Way sites prior to the start of construction. This would be accomplished with high-resolution surface and aerial photography, and surveys to document existing natural conditions and elevations.
FLU-4	NRMP 4.1.4.11	Require project specific visual rendering of both pre- and post-project settings to facilitate analysis of potential impacts to view planes.	TMT has provided specific visual renderings of both pre- and post-project settings to facilitate analysis of potential impacts to view planes. The Final EIS for the TMT Project, specifically Section 3.5.3, provides several visual renderings that assist the reader in analyzing the Project's visual impacts.
FLU-6	NRMP 4.3.3.3	Incorporate habitat mitigation plans into project planning process.	As detailed in this TMT Management Plan, the TMT Observatory would be located in Area E on the northern plateau of Mauna Kea. This site was chosen partially because it would not disturb a large amount of preferred wēkiu bug habitat. About 5 percent of the lava flow terrain of Area E and the Access Way areas can be classified as Type 5 wēkiu bug habitat, with the remainder being Type 4. These types of habitat are considered to be marginal wēkiu bug habitat, which is theorized to be occupied only during extreme population outbreaks. Wēkiu bugs have not been collected in Area E or similar nearby habitat in large quantities. In addition, TMT would work with OMKM on the development and implementation of a habitat restoration study.
FLU-7	NRMP 3.1.1.2.6	Require use of close-contained zero-discharge waste systems for any future development in the summit region, from portable toilets to observatory restrooms, if feasible.	TMT would install a zero-discharge waste system at the TMT Observatory. Therefore, there would be no discharge of any wastewater, including domestic wastewater and mirror washing wastewater, at the summit by the Project. All wastewater would be collected and transported off the mountain for treatment and disposal.

4.1.10 Monitoring, Evaluation & Updates

OMKM is responsible for the day-to-day management of the UH Management Areas on Mauna Kea. The sharing of information in regards to compliance with CMP management actions and BLNR imposed conditions is vital to OMKM's responsibilities. TMT would comply with the following management action and would submit regular reports to OMKM regarding TMT's implementation of the TMT Management Plan and compliance with BLNR-imposed conditions of use.

Table 4-11: Monitoring and Evaluation Management Actions (CMP Section 7.4.2)

CMP	Subplans	CMP Management Action	TMT Action to Comply with CMP Management Action
MEU-1	NRMP 4.1.3.3 PAP 6.4, 6.6, 7	Establish a reporting system to ensure that the MKMB, DLNR, and the public are informed of results of management activities in a timely manner.	As detailed in Section 5 of this TMT Management Plan, TMT would provide OMKM annual reports regarding the implementation of this TMT Management Plan.

4.2 Project Construction Mitigation measures

The contractor(s) selected to build the TMT Observatory and Access Way will be required to comply with the mitigation measures outlined in the Final EIS. Specific provisions regarding this will be included in contract documents. This will include preparing (if not provided within this CDUA), obtaining, and complying with the following plans and permits:

- **Reporting Plan.** A Reporting Plan will be developed by the contractor and TMT and implemented in coordination with OMKM to provide information from construction activities to OMKM. This plan and its implementation will comply with CMP Management Action C-4.
- **Project-specific Safety and Accident Prevention Plan.** The contractor will prepare this plan.
- **Historic Preservation Mitigation Plan.** A draft of this plan is attached as Appendix A. This plan requires an independent construction monitor who will have oversight and authority to insure that all aspects of ground based work comply with protocols and permit requirements. This plan and its implementation will comply with CMP Management Actions C-1, C-5, and C-6 plus HAR section 13-279.
- **Cultural and Natural Resources Training Program.** Construction workers will be required to receive annual cultural and natural resources training in compliance with CMP Management Actions C-7 and C-8.
- **Invasive Species Prevention and Control Program.** This program is described in Section 4.4.3 below and will be further refined by the selected contractor. This plan will comply with CMP Management Action C-9.
- **Waste Minimization Plan.** The contractor will prepare this plan.
- **Ride-Sharing Program.** The contractor will prepare this plan based on the framework provided in Section 3.15.2 of the Final EIS.

- Fire Prevention and Response Plan. The contractor will prepare this plan based on the framework provided in Section 3.15.2 of the Final EIS, if applicable.
- Rock Movement Plan. A Rock Movement Plan will be developed prior to construction in compliance with CMP Management Action C-3. The plan will detail excavation and grading activities. TMT will balance the excavated (cut) material with the need for fill (material brought in to raise the ground level) so that there will be a slight amount of excess cut material.
- National Pollutant Discharge Elimination System (NPDES) permit. The Project will obtain a Notice of General Permit Coverage (NGPC) for general construction activities. The contractor will prepare a Site-Specific Best Management Practice (BMP) plan and submit it to the State of Hawai'i Department of Health (HDOH) for review prior to construction. The BMP plan will include a Materials Storage/Waste Management Plan and Spill Prevention and Response Plan which will include measures outlined in Sections 3.15.1 and 3.15.2 of the Final EIS, including measures related to Erosion and Water Quality, Solid and Hazardous Materials and Waste, Air Quality and Lighting, and Additional Disturbance and Encroachment. The permit and component plans will comply with CMP Management Action C-2.
- Noise permit and noise variance. The contractor will obtain and comply with both a noise permit and a noise variance, as applicable.
- Oversize and Overweight Vehicles Permit (OOVP). The contractor will obtain and comply with an OOVP, as applicable.

4.2.1 Additional Disturbance and Encroachment

In addition to the NPDES BMP plan that will require flagging of the planned limits of disturbance, the location of nearby property boundaries will be surveyed to ensure that the limits of disturbance do not encroach on neighboring parcels. This will be done at the Batch Plant Staging Area to prevent encroachment on the Ice Age NAR.

4.2.2 Noise

The Project will meet with OMKM and Kahu Kū Mauna to identify cultural events that would be sensitive to construction noise in the vicinity of the TMT Observatory site and the Batch Plant Staging Area. The Project will endeavor to reduce construction noise and activities in the vicinity of cultural practices on up to four days a year identified by Kahu Kū Mauna. In addition, a connection to HELCO-supplied power will be sought early in the construction process to reduce the need to operate generators.

4.2.3 Ride-Sharing Program

The Project will institute a Ride-Sharing Program. Participation will be required for workers at the TMT Observatory construction site. The program will require that construction workers use designated contractor vehicles to travel beyond Hale Pōhaku. This measure is designed to limit traffic on the Mauna Kea Access Road and limit the potential introduction of invasive species.

With an average construction crew of 50 to 60, it is estimated 9 or 10 vehicles will be required to transport the crew on a daily basis.

4.2.4 Roadways

Due to the expected increase of heavy traffic during construction there is a chance for more rapid deterioration of the unpaved portions of the Mauna Kea Access Road surface; TMT will arrange for the more frequent grading of the unpaved roadway.

4.3 Project Operational Mitigation Measures

"Mitigation Measures" identify Project-specific measures that may be needed that go beyond compliance with applicable existing rules, regulations, and requirements, to reduce a potentially significant impact, as applicable. The compliance with existing applicable rules, regulations, and requirements is considered a part of the existing regulatory environment, and is described above. The mitigation measures identified below have been developed to avoid, minimize, rectify, or reduce the Project's potential substantial adverse environmental impacts. Mitigation measures have been considered throughout the Project planning process and incorporated into the Project design and construction plans.

4.3.1 Cultural Practices and Beliefs

Mitigation measures that go beyond what is required by the CMP and other applicable requirements related to cultural practices and beliefs include the following:

- Reduced TMT Observatory operations to minimize daytime activities on up to four days in observance of Native Hawaiian cultural practices. TMT will work with OMKM and Kahu Kū Mauna to determine days for such observances. While the observatory will be operated during these periods, this measure will involve having only a skeleton crew at the observatory, no vehicles will be visible, noise will be reduced, and no visitors will be allowed.
- The Access Way has been designed to reduce the impact to cultural resources by modifying Option 3 to a single lane configuration, even though this design is not desirable from an observatory operation standpoint.
- To mitigate the Access Way's effect on Kūkahau'ula, the Access Way will be paved to reduce dust generation from traffic and the pavement will have a reddish color to blend with the surroundings. In addition, the embankment facing will be treated so as to blend into the natural environment to the extent feasible. A wire type guardrail which will be treated so as to blend in with the surrounding natural environment will also be utilized. No retaining walls will be used and all utility lines will be buried and pull boxes will be camouflaged to blend with the natural surroundings.
- TMT will fund the restoration of the access road on Pu'u Poliahu.
- TMT will partially restore the batch plant area after completion of construction
- TMT will support, through financial contributions and the utilization of its outreach staff, cultural training and annually host a cultural event or training. Examples of how this

measure will be implemented include activities such as a star gazing program at the annual Makahiki Festival, workshops on stone adze making, or on how to recognize archaeological sites and their importance. This measure was partially developed based on input from participants in the CIA for the Project.

- TMT will support, through financial contributions and the utilization of its outreach staff, the translation of chants and mele and the use of their teachings; the focus will include both (a) translation, and (b) developing programs that can be used in schools to spread what is learned about Hawaiian science and genealogy.
- Through its outreach office and in coordination with OMKM and 'Imiloa, TMT will support the development of exhibits regarding cultural, natural, and historic resources that could be used at the VIS, 'Imiloa, TMT facilities, or other appropriate locations. Exhibits will include informational materials that explore the connection between Hawaiian culture and astronomy.
- TMT will contribute to the funding of translating modern astronomy lessons into Hawaiian language for use at Hawaiian language charter schools. This measure was partially developed based on input from participants in the CIA for the Project.
- TMT will maintain an open door policy so that TMT's outreach management can be contacted by the Native Hawaiian community to discuss issues.
- Initial and then annual or as-needed tours of the TMT Observatory will be provided, with the Native Hawaiian community invited at least two weeks prior to the tour.
- TMT will request permission to attend, on a quarterly basis, meetings of the Kahu Kū Mauna. A TMT representative will be available to review cultural impact issues, should there be any, related to the Project.
- The TMT facilities will be furnished with items to provide a sense of place and encourage and remind personnel of the cultural sensitivity and spiritual quality of Mauna Kea. This will be done to serve as a constant reminder of the lessons learned during the required annual cultural training to respect, honor, and not restrict or interfere with cultural or religious practices.
- TMT will implement a Ride-Sharing Program to reduce the number of vehicle trips between Hale Pōhaku and the TMT Observatory. This step could further reduce the Project's impact to the spiritual and sacred quality of Mauna Kea by reducing dust, transient noise, and general movements in the summit region.
- TMT's outreach efforts (two full-time staff) will work with 'Imiloa and Native Hawaiian groups to support/fund programs specific to Hawaiian culture and archeological resources.
- A \$1 million annual Community Benefits Package (CBP) will be provided by the TMT Observatory Corporation that will be administered by the THINK Fund Board of Advisors. It is envisioned that THINK Fund purposes could include grants, scholarships, programs, internships, and summer jobs for students at Hawaiian charter schools.

4.3.2 Archaeological/Historic Resources

Mitigation measures related to archaeological and historic resources include the following:

- In compliance with the CMP and to mitigate potential effects on cultural practices and Historic Properties, among other things, a Cultural and Natural Resources Training Program will be developed and implemented. As discussed in the CMP, the Cultural and Natural Resources Training Program will include educational instruction and materials designed to:
 - Impart an understanding of Mauna Kea's cultural landscape, including cultural practices, historic properties and their sensitivity to damage, and the rules and regulations regarding the protection of historic properties.
 - Make it clear that any disturbance of a historic property is a violation of HRS Chapter 6E-11 and punishable by fine.
 - Provide guidance and information as to what constitutes respectful and sensitive behavior while in the summit area.

The training program will be updated regularly to incorporate UH Management Area-wide updates by OMKM. All individuals involved in TMT Observatory operation and maintenance activities, including but not limited to scientists and support staff, will receive the training on an annual basis.

- To mitigate the TMT Observatory's visual effect within the Historic District:
 - In compliance with the 2000 Master Plan, the TMT Observatory has selected the 13N site within Area E, which, as the 2000 Master Plan details, was selected to minimize the Project's visual effect.
 - The Project has attempted to reduce the TMT Observatory's visual impact to the extent possible. Steps include design efforts to reduce its size, finish the support building and fixed structure exterior with a lava color, and finish the dome with a reflective aluminum-like finish similar to the Subaru Observatory.
- To mitigate the Access Way's effect on Kūkahau'ula and the Historic District, the Access Way:
 - Has been designed to reduce disturbance by modifying Option 3 to a single lane configuration, even though this design is not desirable from an observatory operation standpoint.
 - Will have pavement and a guardrail with a reddish color to blend with the surroundings.
- To mitigate the generation of wastewater in the summit region, the Project will implement a zero discharge wastewater system and remove all wastewater from the mountain for treatment.
- To mitigate the chance of an accidental release of a hazardous substance, the Project will comply with applicable rules, regulations, and requirements, plus implement measures to reduce the potential for accidental spills of hazardous substances and reduce the potential impact of those events should they occur.

- To mitigate effects related to noise and dust, the Project will implement a Ride-Sharing Program to reduce the number of vehicle trips between Hale Pōhaku and the TMT Observatory.
- To mitigate the presence of the TMT Observatory during culturally significant events that take place within the Historic District, TMT Observatory daytime operations will be reduced to minimize activities on up to four days in observance of Native Hawaiian cultural practices. TMT will work with OMKM and Kahu Kū Mauna to determine days for such observances. While the observatory will be operated during these periods, this measure will involve having only a skeleton crew at the observatory, no vehicles will be visible, noise will be reduced, and no visitors will be allowed.
- To mitigate the general development of the TMT Observatory, the following additional mitigation measures will be implemented:
 - The Project will work with OMKM and 'Imiloa to develop exhibits for the VIS and 'Imiloa regarding cultural and archaeological resource.
 - TMT's outreach efforts (two full time staff) will work with 'Imiloa and Native Hawaiian groups to support/fund programs specific to Hawaiian culture and archeological resources.

4.3.3 Biologic Resources

The Project will comply with existing regulations and requirements, which will mitigate many of the potential impacts. The Project's policies to comply with applicable rules and regulations will include the following CMP Management Actions:

- Management Action NR-6: Implementation of a Cultural and Natural Resources Training Program. This program will require that TMT personnel receive an annual orientation regarding natural resources.
- Management Action NR-2: Implementation of an Invasive Species Prevention and Control Program. This program will outline steps to be taken to avoid the potential impacts associated with invasive species.
- Management Action FLU-6: The following has occurred or will be implemented:
 - The Access Way has been designed to limit disturbance and displacement of sensitive habitat and will be paved where adjacent to sensitive habitat to reduce dust-related impacts.
 - Construction-phase measures will be implemented to reduce impacts to sensitive habitat. In addition arthropods will be monitored in the area of the Access Way.
 - TMT will work with OMKM on the development and implementation of a habitat restoration study.

Mitigation measures that go beyond what is required by the CMP and other applicable requirements related to biological resources include the following.

- The Access Way has been designed to reduce disturbance by modifying Option 3 to a single lane configuration, even though this design is not desirable from an observatory operation standpoint.

- The Project will work with OMKM and 'Imiloa to develop exhibits for the VIS and 'Imiloa regarding natural resources.
- TMT will implement a Ride-Sharing Program. This program will reduce the number of vehicle trips a day to the summit, including pickup and deliveries to about 9 trips. Dust generated along unpaved section of the Mauna Kea Access Road and the Access Way will be reduced relative to the number of trips reduced by the program.

4.3.4 Visual and Aesthetic Resources

Mitigation measures that go beyond what is required by the CMP and other applicable requirements related to visual and aesthetic resources include the following.

- The location of the TMT Observatory is the primary mitigation for the Project's potential visual impacts. Because the location proposed for the TMT Observatory is north of and below the summit of Mauna Kea it will be substantially less visible than if it were to be placed in a more visible location, such as the summit ridge or pu'u.
- The visual impacts of the TMT Observatory, which will house a telescope with a primary mirror 98 feet (30 meters) in diameter, are also due to the size of the dome enclosure. The diameter of the dome is 216 feet. Because the center of the dome will be placed only 36 feet above grade, the observatory will have a height of approximately 180 feet above grade level. While this will be the tallest observatory on Mauna Kea, it has been designed to minimize the height of the structure, in turn minimizing the visual impacts. The telescope itself has been designed to be much shorter, with a focal ratio¹⁴ of f/1.0, to allow for the smallest dome possible. In addition, the enclosure has been designed to fit very tightly around the telescope, leaving just enough room for a person, only about 20 inches, between the telescope and the dome. For comparison purposes, the Keck Observatory consists of two telescopes each with mirrors 33 feet in diameter with a focal ratio of f/1.75; the diameter of each Keck dome is 121 feet. If the TMT Observatory were to use the same ratio of mirror-to-dome size, it would result in a dome with a diameter of 364 feet, almost twice the current measurement.
- Finally, the color, or coating, of the dome enclosure has substantial visual implications. The coating of the dome enclosure will be an aluminum-like coating, similar to that used on the Subaru Observatory. In general, an aluminum-like coating reflects the morning sunrise and evening sunset light and stands out during this period, however, during most of the day the coating reflects the sky, and reduces the visibility of the observatory.
- The support building attached to the observatory dome has been reduced in size, as the design continues to incorporate items to reduce its visibility from Kūkahau'ula, the summit cinder cone complex that is a State Historic Property. The building will be lava-colored and the parking areas will not be visible from Kūkahau'ula, except the visitor parking area.
- The Access Way incorporates design components to mitigate its visual impact. These measures include coloring the pavement and guardrail a reddish color to better blend with

¹⁴ Focal ratio (f/) is defined as the ratio of the focal length of the mirror to its diameter.

the surroundings and using a wire type guardrail to reduce its visibility. In addition, the embankment facing will be treated so as to blend into the natural environment to the extent feasible.

4.3.5 Geology, Soils, and Slope Stability

Through compliance with existing regulations and requirements, Project impacts on geologic resources, soils, and slope stability will be less than significant and no additional mitigation is required. To comply with applicable rules and regulations, the Project's design features will include:

- Grading in compliance with applicable standards; and
- Compliance with applicable seismic safety regulations and standards in the design of structures to meet applicable codes to ensure life safety of personnel and visitors.

In addition to these compliance measures, the Project will implement the following mitigation measures:

- There are noteworthy examples of glacial features near the Access Way, and such features are presently unappreciated. Interpretive signs will be placed along the Access Way identifying these noteworthy examples of glacial features to enhance public interpretation/education efforts. The number and placement of signs will be determined through consultation and coordination with OMKM. Installation of interpretive signs is consistent with CMP Management Action EO-4, which calls for improvements to interpretive, safety, and regulatory signs throughout the UH Management Areas.
- The Project will work with OMKM and 'Imiloa to develop exhibits that reflect the nationally-recognized natural resources of the MKSR, which is within the Mauna Kea National Natural Landmark. These exhibits will be utilized by the VIS and 'Imiloa, as appropriate.
- The design of the Observatory will incorporate techniques to minimize the seismic risk of potential damage to the telescope and associated equipment. With these measures, the likelihood of damage will be lessened.

4.3.6 Water Resources and Wastewater

Through compliance with existing regulations and requirements, the Project's impacts on water resources will be less than significant and no additional mitigation will be required. The Project's design features and policies to comply with applicable rules and regulations will include:

- The Project will use storm water dry wells and perform grading to maximize groundwater recharge.
- The Project will install water efficient fixtures and implement a water saving practices to reduce the demand for freshwater resources.

- In compliance with CMP Management Action FLU-7, a zero-discharge waste system will be installed at the TMT Observatory so there will be no discharge of any wastewater at the summit.
- Facility engineering measures will be taken to provide proper chemical and fuel storage enclosures to protect against the release of chemicals or fuel to the environment, including double-walled piping and tanks for fuel and mirror washing wastewater.
- The Project will develop and implement a Spill Prevention and Response Plan that will outline measures to appropriately use and store chemicals and require inspections to ensure that systems are working properly and any necessary maintenance measures are taken.

4.3.7 Solid and Hazardous Waste and Material Management

Implementation of the design and engineering features, techniques, and management procedures to comply with existing regulations and requirements will ensure that the Project's impact will be less than significant, and no additional mitigation is required for solid and hazardous waste and material management. The Project's design features and policies to comply with applicable rules and regulations include:

- Collecting all solid waste in secured and covered storage containers and trucking it down the mountain for proper disposal at an off-site disposal facility.
- Instituting a Waste Minimization Plan, that will include an annual audit to identify waste produced by the Project and how that waste could be reduced, reused, or recycled. Implementation of waste minimization practices during design has eliminated the use of mercury Project-wide, and the use of acetone and MEK at the TMT Observatory.
- Storing a minimal amount of hazardous materials on site.
- Implementation of a Materials Storage/Waste Management Plan and component Spill Prevention and Response Plan.
- Recycling solid and non-hazardous waste material and reusing them to the extent possible.
- Designs that include specialized space and contained system to collect chemical waste from the mirror stripping, coating, and washing area floor drain and laboratory.
- Leak detection systems and daily inspection of equipment handling hazardous materials.
- Mandatory training of all personnel handling hazardous materials and waste.
- Regular inspections by a Safety and Health Officer.

4.3.8 Socioeconomic Conditions and Public Services and Facilities

These socioeconomic mitigation measures discussed below will ensure that as many local people as possible are trained and equipped to fill TMT jobs at most levels, with the further result that fewer than 140 of the Project's future employees will move to the Island of Hawai'i from elsewhere.

- Community Benefits Package (CBP). The CBP will be funded by the TMT Observatory Corporation and will be administered via The Hawai'i Island New Knowledge (THINK) Fund Board of Advisors. The THINK Fund Board of Advisors will consist of local Hawai'i Island community representatives. The CBP funding will commence upon the start of Project construction and continue throughout the TMT Observatory's presence, so long as the CDUP is not invalidated or construction stayed by court order. As part of the CBP, the TMT Observatory Corporation will provide \$1 million annually during such period to the THINK Fund; the dollar amount will be adjusted annually using an appropriate inflation index (the baseline from when inflation index will be applied will be the date of start of construction). It is envisioned that THINK Fund purposes could include:
 - Scholarships and mini-grants;
 - Educational programs;
 - College awards;
 - Educational programs specific to Hawaiian culture;
 - Educational programs specific to astronomy;
 - Educational programs specific to math and science; and
 - Community outreach.

Educational initiatives will focus on K-5, 6-8, 9-12, and college. The program could include support for students to visit 'Imiloa, TMT, and other observatories.

- Workforce Pipeline Program (WPP). TMT is committed to partner with UH Hilo, Hawai'i Community College (HawCC), and the Department of Education (DOE) to help develop, implement, and sustain a comprehensive, proactive, results-oriented WPP that will lead to a highly qualified pool of local workers who could be considered for hiring into most job classes and salary levels. Special emphasis will be given to those programs aimed at preparing local residents for science, engineering, and technical positions commanding higher wages. Therefore, there will be a significant component in the WPP for higher education on the Island of Hawai'i.

TMT began to refine the WPP with a workforce roundtable in September 2009. The roundtable initiated information exchanges and close coordination with current and new programs on Hawai'i Island. Among those organizations which TMT is currently working with are: UH Hilo, including UH Hilo science, technology, engineering and math (STEM) programs; HawCC; workforce programs that train, retrain, and place trainees in jobs; current observatories; the Department of Education; and charter schools. A dedicated TMT WPP manager will coordinate the program.

In addition, TMT is participating in a County of Hawai'i Workforce Investment Board initiative with the Mauna Kea Observatories to explore opportunities for marshaling existing community resources to introduce focused programs within the Hawai'i Island community to provide the observatories with a broader and stronger qualified local labor pool, as candidates for careers in the local astronomy enterprise. Key elements of the planned pipeline program include:

- Initiation of a TMT workforce committee including members from UH Hilo, HawCC, DOE, and Hawai'i Island workforce development groups.
- Identification of specific TMT job requirements that UH Hilo, HawCC, and DOE can use to create education and training programs, and ongoing support for the identified programs.
- TMT will earmark funds in its annual operations budget which can be used to support workforce development programs at suitable educational institutions.
- TMT support of the development and implementation of education and training programs, including at least 4 internships per semester, apprenticeships, and at least 10 summer jobs for students.
- Creation of a partnership between UH Hilo and TMT partner organizations, such as Caltech, the UC system, and Canadian universities to attract and develop top talent. This will include internships, degree programs, and student exchanges.
- Support of, and active participation in, on-going efforts to strengthen science, technology, engineering and math (STEM) education in Hawai'i Island K-12 schools and informal learning organizations. Examples include the Science and Engineering Fair, FIRST robotics competitions, and 'Imiloa Astronomy Center of Hawai'i.
- The program will be focused on long term investments to strengthen the current STEM skills infrastructure, programs, and curricula at UH Hilo, HawCC, and Big Island K-12 education organizations, especially those serving low income and first-generation college attending populations. Examples could be the development or support of astronomy, other sciences, and engineering education at UH Hilo as well as programs at HawCC that could provide well-qualified mechanical and electrical technicians. The scope of these investments will include strengthening language and culture programs and their integration with science and engineering to broaden the appeal of STEM disciplines to Hawai'i Island college students while earning and retaining community support.

The Project will start the WPP during the construction phase so that local youth of today have the qualifications and could be considered for hiring into most job classes and salary levels with the Project when the operational phase begins.

- Additional Measures. In addition to the CBP and WPP effort discussed above, the following measures will be implemented by the Project to ensure that the economic benefit potential for the community and the State is realized:
 - To the greatest extent feasible, employment opportunities will be filled locally. This will include advertising available positions locally first; however, to fill some positions, which typically require a worldwide search, advertisements will be simultaneously released both locally and to a wider audience.
 - At least three full-time positions will be established for community outreach. One of these positions will focus on the WPP and the others will perform general outreach activities. General outreach activities will include scientific and technical outreach to the local community and educational institutions to further the Project objectives to develop general science and technology education and

allied employment opportunities. One such activity will include working with OMKM and 'Imiloa to develop educational, interpretive, and outreach exhibits and programs, including informational materials that explore the connection between Hawaiian culture and astronomy.

- Support of, and active participation in, on-going efforts to strengthen science, technology, engineering and math (STEM) education in Hawai'i Island K-12 schools and informal learning organizations. Examples include the Science and Engineering Fair, FIRST robotics competitions, and 'Imiloa Astronomy Center of Hawai'i.
- A mentoring program for children will be developed to provide support for those interested in astronomy, technology, engineering, and math during the entire elementary school-to-university graduate school educational path, with an ultimate goal of strengthening STEM skills throughout Hawai'i Island.
- Scholarship programs for students interested in careers in astronomy, engineering, science, and technology will be established.

4.3.9 Land Use Plans, Policies, and Controls

The terms of the sublease between UH and the TMT Observatory Corporation, other than observing time and payment of common costs, may be used towards management of Mauna Kea resources, particularly implementation of management actions detailed in the CMP and subplans.. Pursuant to HRS § 304A-2170, these funds will be deposited into the Mauna Kea lands management special fund. According to HRS § 304A-2170, these funds could be used to:

- Manage Mauna Kea lands within the UH Management Areas, including maintenance, administrative expenses, salaries and benefits of employees, contractor services, supplies, security, equipment, janitorial services, insurance, utilities, and other operational expenses; and
- Enforce administrative rules adopted relating to the UH Management Areas of Mauna Kea.

Therefore, the Mauna Kea lands management special fund, including the TMT sublease rent, could be utilized to fund OMKM and its implementation of the CMP.

4.3.10 Roadways and Traffic

The Project is not expected to cause a significant impact on roadways and traffic, and no mitigation measures beyond compliance with applicable regulations, requirements, and standards, are required. Nevertheless, the Project will implement the following mitigation measures:

- The Project will institute a Ride-Sharing Program that will be mandatory for TMT Observatory employees traveling beyond Hale Pōhaku. TMT Observatory personnel will meet at various locations around the island and travel to the summit in observatory vehicles. The locations will include the Headquarters and/or park-and-ride lots. There will be an average of 5 vehicles for the day shift and 2 for the night shift, with 5 people per vehicle. With the implementation of the Ride-Sharing Program for employees plus

other trips (such as deliveries), it is estimated there will be an average of 9 trips to the TMT Observatory daily, an 11 percent increase over the existing number of trips beyond Hale Pōhaku.

- TMT will also consider off-peak work hours for Headquarters personnel, if warranted, at the time of completion of the facilities.
- A 1,600 foot portion of the Access Way will be paved to mitigate the potential impact to the SMA observatory due to dust from vehicles traveling on the Access Way near the core of the SMA. The paved section will extend from the current end of pavement near the SMA building through the SMA area. This measure will also mitigate the visual effect on cultural resources and effects of dust on natural resources.

4.3.11 Power and Communications

The Project is not expected to cause a significant impact on power and communications infrastructure, and no mitigation measures beyond compliance with applicable regulations, requirements, and standards, are required. Nevertheless, the Project will implement the following mitigation measures:

- A component of the Waste Minimization Plan, discussed above in Section 4.6.7, will be an annual audit of energy use by the Project. The audit will include examining methods available to reduce energy use.
- As part of TMT's design work, there is an active program to analyze the environmental heat loads and energy usage in the telescope enclosure and supporting facilities. Appropriate energy saving designs will be employed into all aspects of the buildings and facility design including: high R-rated¹⁵ insulation panels, radiant exterior barriers, high performance window glazing, and air infiltration sealing, for example.
- Energy saving devices will be incorporated into Project facilities such as: solar hot water systems, photo voltaic power systems, energy efficient light fixtures controlled by occupancy sensors, and efficient Energy Star rated electrical appliances at all facilities.

4.3.12 Noise

The Project is not expected to cause a significant noise impact, and no mitigation measures beyond compliance with applicable regulations, requirements, and standards, are required. Nevertheless, the Project will implement the following mitigation measures:

- Heating, Ventilation, and Cooling (HVAC) equipment will be placed indoors. By placing the equipment indoors the noise associated with HVAC equipment motors, evaporators, and condensers will be significantly reduced; the radius of the area exposed to noise levels greater than the Class A standard will also be reduced.
- The exhaust of the HVAC equipment will be directed through a tunnel duct that exits on the northwest side of the graded area, which faces away from noise sensitive areas. Measures along the route of the airflow will also be used to reduce the noise discharging

¹⁵ The R-value is a measure of thermal resistance; the higher the R-value, the better the material's insulation effectiveness.

outside of the TMT Observatory; measures could include acoustical louvers, tunnel duct wall treatments, and duct silencers. These measures will further reduce the radius of the area exposed to noise greater than the Class A standard.

- Other openings between the interior of the observatory and outdoors, such as air intake locations, will be furnished with measures to reduce noise discharging outside of the observatory, such as acoustical louvers.

In addition, the Project will institute a Ride-Sharing Program that will be mandatory for TMT Observatory employees traveling beyond Hale Pōhaku. There will be approximately five vehicle trips for the day shift and two for the night shift, assuming five per vehicle.

4.3.13 Climate, Meteorology, Air Quality, and Lighting

The Project is not expected to cause a significant impact on climate, meteorology, air quality, or lighting, and no mitigation measures beyond compliance with applicable regulations, requirements, and standards, are required. Nevertheless, the Project will implement the following mitigation measures:

- TMT will prepare and implement a Ride-Sharing Program that will require all personnel working at the TMT Observatory to ride-share in observatory vehicles beyond Hale Pōhaku, or a lower elevation location, to the summit area. The TMT vehicles will be selected based on balancing the needs for fuel efficiency, low emissions, and safety for transportation to the summit. An average of 5 vehicles will be used for day-time trips and 2 for night-time trips. This required ride sharing will reduce the total number of Project trips beyond Hale Pōhaku to the summit area to approximately 9 trips per day (7 staff trips and 2 other trips, such as deliveries), and will further reduce the potential impact of the Project on air quality.
- A roughly 1,600-foot-long portion of the Access Way will be paved through the SMA area. This will reduce the generation of dust in the summit region, particularly near the SMA where dust could interfere with SMA operations and the alpine cinder cone habitat where dust can impact wēkiu bug habitat.
- The TMT Observatory will coordinate the use of its AO laser guide stars with the other observatories on Mauna Kea using the existing Laser Traffic Control software system to minimize the interference between the various guide star systems in use, as well as their impact on other astronomical observations.

4.4 Conservation Methods and Applications

Although the TMT Project is located in the Conservation District, it is not specifically designed or oriented to implement conservation methods or applications, like an artificial reef, fish pond operation, commercial forestry, or other identified use might be. The Project is not a conservation project, it is scientific research endeavor that requires the resources found in the Conservation District to be successful (i.e. isolation, altitude, and lack of interfering light sources). The findings of the research performed by TMT may provide inspiration for the people around the world and Hawaii to conserve the earth's and the state's resources. Certain purposes of the Project have conservation themes or could lead to conservation attitudes, including:

- Knowledge growth. With TMT, many of the most fundamental questions of the coming decades could be addressed, such as: What is the nature and composition of the Universe?; How do stars and planets form?; and Is there life elsewhere in the Universe?
- Education. Seek answers to the fundamental question, expose the public to the discoveries made possible by the TMT, and utilize the TMT as an important educational tool and to attract top students and scholars in science to partner institutions.
- Outreach and Community. Integrate science and education with culture and sustainability in the Project is also a core objective of the Project. The TMT partner institutions are also committed to proper environmental stewardship and the concept of sustainability planning for operations of the observatory.

In addition, certain mitigation measures listed in Section 4.3 constitute conservation methods and applications. These include:

- Development and implementation of a Cultural and Natural Resources Training Program. This program will require that TMT personnel receive an annual orientation regarding natural and cultural resources.
- Development and implementation an Invasive Species Prevention and Control Program. This program will outline steps to be taken to avoid the potential impacts associated with invasive species.
- Support, through financial contributions and the utilization of its outreach staff, cultural training and annually host a cultural event or training. Examples of how this measure will be implemented include activities such as a star gazing program at the annual Makahiki festival, workshops on stone adze making, or on how to recognize archaeological sites and their importance. This measure was partially developed based on input from participants in the CIA for the Project.
- TMT will support, through financial contributions and the utilization of its outreach staff, the translation of chants and mele and the use of their teachings; the focus will include both (a) translation, and (b) developing programs that can be used in schools to spread what is learned about Hawaiian science and genealogy.
- Through its outreach office and in coordination with OMKM and 'Imiloa, TMT will support the development of exhibits regarding cultural, natural, and historic resources that could be used at the VIS, 'Imiloa, TMT facilities, or other appropriate locations. Exhibits will include informational materials that explore the connection between Hawaiian culture and astronomy.
- Contribute to the funding of translating modern astronomy lessons into Hawaiian language for use at Hawaiian language charter schools.
- TMT's outreach efforts (two full time staff) will work with 'Imiloa and Native Hawaiian groups to support/fund programs specific to Hawaiian culture and archeological resources.

The TMT Headquarters, located outside the Conservation District will also implement certain conservation methods and applications. These include:

- Energy saving devices will be incorporated into all Project facilities; plans include: solar hot water systems, photo voltaic power systems, energy efficient light fixtures controlled by occupancy sensors, efficient Energy Star electrical appliances at all facilities, and design with local knowledge to maximize the use of natural ventilation and lighting at the Headquarters.
- Development of a Waste Minimization Plan (WMP), which will include an annual energy audit of energy use by the Project. The Project's WMP will follow the State of Hawai'i's WMP and develop procedures for efficient operation through the use of appropriate planning techniques and methods and utilizing the best available technologies for operations to reduce solid waste generation. The WMP will be regularly updated to include the most current methods to reduce the amount of waste generated at the facility, as new products and practices become available. The WMP will call for the removal of all unnecessary packaging materials at the Headquarters receiving dock before transporting items to the summit. This will reduce the generation of solid waste at the TMT Observatory. The TMT waste minimization planning has found ways to avoid the use of materials that contain certain hazardous materials, including acetone and methyl ethyl ketone.

A TMT Energy Roundtable meeting was held on September 8, 2009, with representatives from HELCO, the Department of Energy (DOE)/National Renewable Energy Laboratory (NREL), Pacific International Center for High Technology Research (PICHT), and Hawai'i Clean Energy Initiative. The importance of maximizing energy efficiency in the design of TMT's facilities was emphasized at this meeting. As part of TMT's design work there is an active program to analyze the environmental heat loads and energy usage in the telescope enclosure and supporting facilities. Appropriate energy saving designs will be employed into all aspects of the buildings and facility design including: high R-rated insulation panels, radiant exterior barriers, high performance window glazing, and air infiltration sealing.

4.5 Decommissioning of Observatories

The decommissioning of observatories is an effective mitigation measure addressing the impacts of astronomy related development on Mauna Kea. As a measure addressing TMT's impact on Mauna Kea resources, the TMT Observatory and the extent of the Access Way exclusively used to access the TMT Observatory would be dismantled and the site restored at the end of the TMT Observatory's useful life in compliance with the Decommissioning Plan and amendments. In addition, as discussed below, the University intends to address the cumulative impact of astronomy related development on Mauna Kea by seeking the decommissioning, deconstruction, and site restoration of observatories. The University intends that the number of Mauna Kea observatories will be incrementally reduced as observatories reach the end of their useful life and it is determined that decommissioning and deconstruction is the most appropriate path to follow.

The Decommissioning Plan provides a framework for the eventual removal of observatories and site restoration that is acceptable to both the University and DLNR. It ensures that BLNR as lessor, the University as lessee and the individual observatories as sublessees have clear expectations of the decommissioning process. Decommissioning refers to a process that results in the partial or total removal of all structures associated with an observatory and the reasonable

restoration of the facility site, to the greatest extent possible, to its preconstruction condition. Below is a basic timeline of the decommissioning process.

Table 4-12: Decommissioning Timeline

Activity		Deadline
Notice of Intent		
Statement of intention to demolish, abandon, transfer and/or restore observatory property		At least five years prior to either the termination date of a sublease, or a sublessee's decision to cease operations, or as soon as is feasible if decommissioning is to take place less than five years after a decision is made to cease operations, whichever occurs first
Environmental Due Diligence Review		
Phase I Environmental Site Assessment		Completed within six (6) months of NOI filing
Phase II Environmental Site Assessment, human health/ecological risk assessment, remedial action plan (RAP), if needed		Within one (1) year of Phase I ESA
MKMB and DLNR-OCCL approval		Within six (6) months of Phase I ESA, Phase II ESA, risk assessment, or RAP
RAP implementation, if applicable		One (1) year or more prior to end of sublease or planned departure from the site, depending on project schedule
Site Deconstruction and Removal Plan		
Submission of Site Deconstruction and Removal Plan to UH and DLNR-OCCL		One to two (1-2) years prior to start of deconstruction
Conservation District Use Application, if needed ¹⁶		One to two (1-2) years prior to start of deconstruction
Other permits, as needed ¹⁷		One (1) year prior to start of deconstruction
OMKM Review; MKMB and DLNR-OCCL approval		Required prior to commencing implementation of SDRP
Site Deconstruction and Removal Plan Implementation		One (1) year or more prior to end of sublease, or planned departure from the site depending on project schedule. Completed according to sublease terms or negotiated schedule agreed to by the sublessee, UH and DLNR.
Site Restoration Plan		
Submission of Site Restoration Plan to UH and DLNR-OCCL		One to two (1-2) years prior to start of deconstruction
OMKM Review; MKMB and DLNR-OCCL Approval		Required prior to commencing implementation of SRP
Site Restoration Plan Implementation		One (1) year or more prior to end of sublease, or planned departure from the site, depending on project schedule. Completed according to sublease terms or negotiated schedule agreed to by the sublessee, UH and DLNR.
Monitoring		Begins upon completion of site restoration and continues for at least three (3) years.

¹⁶ CDUP application would likely cover deconstruction and removal plans, as well as restoration plans.

¹⁷ Permits would likely cover deconstruction and removal plans, as well as restoration plans.

4.5.1 Observatory Decommissioning - Mitigation of Astronomy Related Development

The decommissioning, deconstruction and site restoration of observatories is a key measure addressing the cumulative impacts of astronomy related development on Mauna Kea. The discussion below details the University's plans to seek the decommissioning, deconstruction and site restoration of observatories so as to reduce the number of observatories on Mauna Kea over the next twenty years. These steps will be taken in accordance with the Decommissioning Plan. It should be noted that the TMT Project also intends to decommission and deconstruct the TMT Observatory and the portion of the Access Way exclusively used by TMT as well as implement measures to reasonably restore the TMT Project site.

The University envisions a future of sustainable and responsible astronomy on the summit of Mauna Kea. This includes the decommissioning and deconstruction of observatories, site recycling and the siting of observatories in certain areas so as to minimize the effects of development. The University recognizes that future plans for Mauna Kea require balanced management to preserve, protect and enhance the cultural and natural resources of Mauna Kea. The long-term goal is to eventually have fewer observatories in the summit region, but maintain Mauna Kea's status as a world class center for education and research.

Currently, there are 11 observatories on Mauna Kea (eight optical/infrared, four radio). Attempts to predict the timeline for removing ground based optical/infrared observatories from service is very difficult. In May 2009, the California Institute of Technology (Caltech) announced its intention to decommission the Caltech Submillimeter Observatory (CSO) and remove it from the mountain during the period 2016 – 2018. Caltech has since reaffirmed its position to begin decommissioning in 2016 and intends to restore the CSO site consistent with the terms of its sublease with UH by 2018.

In addition, The University does not foresees recycling the United Kingdom Infrared Telescope (UKIRT) observatory site at the end of its sublease or earlier. The University plans on replacing the UH 2.2-meter observatory with another project in the coming years. For the remaining observatories, no decommissioning date is foreseen at the present time. Five of the optical/infrared observatories are relatively new: Keck, Subaru, Gemini, and the UH Hilo 0.9-meter. All have subleases that expire in 2033. Three of the optical/infrared observatories (CFHT, IRTF, and UKIRT) have been in operation for 30 years. Over the years, all have had major upgrades to their instrumentation and to other aspects of their facility. As a result, these observatories remain scientifically viable and could possibly remain in operation for another 20 years or more or be recycled. Table 4-13 presents the current number of observatories and Table 4-14 below details the number of observatories the University foresees in the MKSR by 2033.

Table 4-13: Current Number of Observatories

Observatory	Count
Current Observatories in the Astronomy Precinct	
Optical/infrared: CFHT, UH 2.2m, Gemini, IRTF, UHH 0.9m, Keck, Subaru, and UKIRT	8
Submillimeter/Radio: SMA, JCMT, and CSO	3
Current Observatories in MKSR but outside Astronomy Precinct	
Radio: VLBA	1
Total Observatories Currently in the MKSR	12

Table 4-14: Number of Observatories by 2033

Observatory	Count
Observatories to Remain or be Replaced in the Astronomy Precinct by 2033	
Optical/infrared: CFHT, UH 2.2m, Gemini, IRTF, UHH 0.9m, Keck, and Subaru	7
Submillimeter/radio: One of the three submillimeter observatories (SMA, JCMT, or CSO)	1
Observatories Estimated to be Removed and Not Replaced by 2033	
UKIRT and VLBA	
Two of the three radio telescopes (SMA, JCMT, or CSO)	
New Observatory on a New Site in the Astronomy Precinct by 2033	
Thirty Meter Telescope	1
Total Observatories in the MKSR by 2033	9

Moving forward, the University foresees that some observatories may be recycled where an important scientific case can be made. Otherwise, the University intends for observatories to be decommissioned and deconstructed and the site restored at the end of the observatory's useful life. It is clear that newer observatories such as Keck, Gemini, Subaru, SMA and the UH Hilo 0.9-meter will almost certainly continue to operate over the next twenty years. Depending on various circumstances, other facilities, however, are not likely to continue with their operation. This will lead to a reduction in the number of observatories on Mauna Kea over the next twenty years, thus, mitigating the overall cumulative impacts of astronomy related development on Mauna Kea.

4.5.2 TMT Project Decommissioning

The TMT Observatory and the extent of the Access Way exclusively used to access the TMT Observatory would be dismantled and the site restored at the end of the TMT Observatory's life in compliance with the Decommissioning Plan. Deconstruction and site restoration efforts would be managed by TMT with oversight by OMKM. It is envisioned that a process similar to the MKMB-approved Project Review Process would be established to review, guide, and recommend the disposition of a site, including site restoration. Reviewers would include OMKM, Kahu Kū Mauna, with MKMB approval required.

Site Decommissioning Plan

A Site Decommissioning Plan (SDP), as described in the Decommissioning Plan would be required from TMT to document the condition of the observatory site, outline its approach to decommissioning, and propose a plan for site restoration. The TMT SDP would be developed in stages consisting of the following four components.

Notice of Intent (NOI)

The purpose of the NOI is for the sublessee to propose whether their site will be removed, continued for use as an observatory by a third party, or retrofitted for a different use. The NOI will also contain the intentions for site restoration, and a site description that summarizes the overall condition and land use, including a description of all structures, equipment, and other appurtenances.

Environmental Due Diligence Review

For all cases of potential future use described in the NOI, a Phase I Environmental Site Assessment of the observatory property will be conducted and the results submitted to the University and DLNR, Office of Conservation and Coastal Lands (OCCL). The goal of this is to identify any hazardous substances or petroleum products that may have been released into the ground, groundwater, or surface water of the property. If recognized environmental conditions are identified in the Phase I, a more in-depth Phase II investigation may be required.

Site Deconstruction and Removal Plan (SDRP)

The SDRP will document the proposed methods for demolishing, in part or total, any and all observatory structures and related infrastructure; grading and grubbing the site; stockpiling fill materials; and solid waste recovery, reuse, and disposal. A SDRP will not be required if ownership of the observatory is intended to simply be transferred and no deconstruction/construction activities are proposed.

Specific factors that need to be considered during the development of the SDRP include:

- Cultural Sensitivity. Cultural considerations with respect to deconstruction will be identified as part of the SDRP assessment and evaluation.
- Extent of Infrastructure Removal and Deconstruction. The foundation will extend below grade and will require considerable excavation to remove and significant material to backfill the voids. There are two possibilities with regard to the removal of the TMT facility and infrastructure:
 - a. Complete infrastructure removal – the entire facility, including all underground utilities, pilings, and foundation would be removed to the extent practicable; or
 - b. Infrastructure capping – all or part of the underground portion of the facility would be left in place, capped with an impermeable material, and topped with materials similar to the surroundings.

Site Restoration Plan (SRP)

The SRP will present specific targets for site restoration and describe the methodology for restoring disturbed areas after the demolition/construction activities described in the SDRP are completed. The Decommissioning Plan provides that the two primary objectives of site restoration are (1) restoring the look and feel of the summit prior to construction of the observatories, and (2) providing habitat for the aeolian arthropod fauna.

The level of restoration to be performed and the potential impact of the restoration activities on natural and cultural resources during and post-activity must be carefully evaluated in the SRP. Specific factors that need to be considered during the development of the SRP include cultural sensitivity. Three levels of site restoration have been set forth in the CMP and the Decommissioning Plan. Establishing three levels recognizes that in addition to the potential benefits of site restoration, there are also potential impacts. The three levels of site restoration are:

1. Minimal – would include the removal of all man-made materials and the grading of the site.

2. Moderate – would include the removal of all man-made materials, grading of the site, and enhancing the structure of the physical habitat to benefit the arthropod (insect) community.
3. Full – would include return of the site to its original topography and restoration of the arthropod habitat.

The level of restoration to be performed by TMT would be negotiated between TMT, the University, and DLNR according to the TMT sublease terms and CDUP. Site restoration activities may involve using cinder or materials similar to the surroundings either to fill holes or to reconstruct topography. Consideration would be given to where fill material would come from, how excavation and removal of materials would impact the collection area and any habitat surrounding the restoration area, and what the cultural considerations are for bringing materials from a different place on to Mauna Kea.

Upon the completion of site restoration, monitoring of the restoration activities would begin and continue for at least three years. Results of monitoring activities would be submitted to OMKM.

Management Actions

The CMP also provides several decommissioning management actions, they are:

1. Consider future decommissioning during project planning and include provisions in subleases that require funding of full restoration (CMP Management Action SR-3).
2. Once the observatory's useful life has ended, develop a recycling and/or demolition plan (referred to as a SDRP and SRP in the Decommissioning Sub Plan) that considers items such as waste management and demolition best management practices (BMPs) (CMP Management Action SR-1).
3. CMP Management Action FLU-3 requires cataloguing the initial site conditions for use when conducting site restoration in the future.
4. Once the observatory's useful life has ended, develop a SRP in association with the SDRP, which will include an environmental cost-benefit analysis and a cultural assessment (CMP Management Action SR-2). The cost-benefit analysis of the three levels of restoration will consider restoration costs and related impacts, including the cultural assessment.

To address the first management action, the Project has (a) included in the design of the TMT Observatory and Access Way the use of almost all excavated material on those sites so that it would be available for use again during site restoration, and (b) included in the planned TMT Project operation budget annually setting aside funds that would be used for decommissioning of the TMT Observatory and Access Way. The Project anticipates decommissioning and site restoration requirements would be included in the sublease. TMT is committed to preparing the necessary plans, such as the SDP, SDRP, and SRP, in accordance with the general timeline presented in the Decommissioning Plan and providing an opportunity for the public to comment on the plans.

5.0 Monitoring & Reporting

This section discusses monitoring and reporting during the operational phase of the Project. The Construction Plan (Appendix B) provides strategies and components of monitoring and reporting during the construction phase of the Project. The Draft Historic Preservation Mitigation Plan (Appendix A) also provides greater detail concerning archaeological and cultural monitoring during construction.

5.1 Monitoring Strategies

Monitoring is performed to evaluate whether the management actions are achieving their goals. Overall, this Management Plan has been prepared to comply with the provisions of the CMP, and thereby, reduce the Project's impact on environmental resources in the area.

- On-Going:
 - Keep a log of incidents and observations occurring outside the TMT Observatory. This would include items such as observing wēkiu bugs or other wildlife in the area, observing cultural activities in the area, and observing visitors engaged in inappropriate activities. Information recorded in this log would be used to enhance the management of Mauna Kea resources in the TMT Project area.
 - Keep a log of incidents and observations occurring inside the TMT Observatory. This would include items such as observing ants or other potentially invasive species, disposal of wastewater, and spills.
 - Keep a log of emergency situations (i.e., health emergencies, accidents, and fire) and maintain records summarizing response actions, timeliness, and lessons learned.
 - Should any construction or unusual maintenance activities take place (e.g. ground disturbance or installation of large equipment that could potentially harbor invasive species), the appropriate measures outlined in the Construction Plan (Appendix B) and Mitigation Plan (Appendix A) would be implemented in consultation with OMKM.
 - Per CMP Management Action CR-14: Immediately report any disturbance of an archaeological site or burial site to the rangers, DOCARE, Kahu Kū Mauna, and SHPD.
- Annually:
 - Provide OMKM with information about TMT's activities, potential new actions, goals, and objectives in the coming year. Make any necessary revisions to (a) the annual Cultural and Natural Resources Training Program, and (b) other materials and plans used by TMT.
 - Complete the Project-wide energy audit.
 - Complete the Project-wide Waste Minimization Plan audit.
 - Complete audit of water use.

- Cooperate with OMKM with its twice annual inspection of the TMT Project site for evidence of CDUP and TMT Management Plan violations.
- Observe the surrounding habitat from the edge of the TMT graded area for evidence that the surrounding area has been impacted by new trails or other impacts or developments that are counter to the TMT Management Plan and training received by TMT staff.
- Every 5 years:
 - Perform annual actions, including coordination with OMKM on their Five-Year Progress Report. Make any necessary revisions to (a) the TMT Management Plan, (b) the annual Cultural and Natural Resources Training Program, and (c) other materials and plans used by TMT.
 - Obtain an aerial photograph of the TMT site area to evaluate if the surrounding area has been impacted by new trails or other developments that are counter to the TMT Management Plan and training received by TMT staff.

5.2 Time Duration of Management Plans

This TMT Management Plan shall be in force throughout the period of the CDUP. Therefore, the TMT Management Plan would be in force throughout the period that the TMT Observatory is being built, operated, and decommissioned.

Once this TMT Management Plan is approved as part of the CDUP for the TMT Project, it would be considered the approved Management Plan for the TMT Project. TMT would be responsible for implementing the TMT Management Plan and ensuring adherence to its provisions. The TMT Management Plan should be updated every five years, as necessary, based on (a) updates to the Mauna Kea CMP; (b) based on strengths or weaknesses revealed through the monitoring and reporting program; (c) relevant new or modified laws, regulations, and policies; and (d) modifications to the operation of the TMT Observatory.

5.3 Annual Reporting Requirements & Schedule

TMT would file both annual reports and five-year reports with OMKM. The annual and five-year reports would be prepared by TMT and submitted to OMKM by the last day of December. The reports would include information recorded in the on-going logs (outside log, inside log, and emergency log), records of annual staff Cultural and Natural Resources Training Program completion, and findings/outcomes of annual audits and inspections.

6.0 References

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