CONSERVATION DISTRICT USE PERMIT APPLICATION

Thirty Meter Telescope Project

Island of Hawai‘i

Applicant:
University of Hawai‘i at Hilo

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ACRONYMS AND ABBREVIATIONS

Acronyms	Meaning
ACURA	Association of Canadian Universities for Research in Astronomy
AO	Adaptive optics
AUI	Associated Universities, Inc.
BLNR	Board of Land and Natural Resources
BMP	Best Management Practice
Caltech	California Institute of Technology
CDUA	Conservation District Use Application
CDUP	Conservation District Use Permit
CFHT	Canada-France-Hawai‘i Telescope
CFR	Code of Federal Regulations
CIA	Cultural Impact Assessment
CMP	Comprehensive Management Plan
CRMP	Cultural Resources Management Plan
CSO	Caltech Submillimeter Observatory
dB	Decibels
DLNR	Department of Land and Natural Resources (State of Hawai‘i)
DP	Decommissioning Plan
DOFAW	Division of Forestry and Wildlife
EA	Environmental Assessment
EIS	Environmental Impact Statement
EISPN	Environmental Impact Statement Preparation Notice
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-To-Know Act
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
GHz	Gigahertz
HAR	Hawai‘i Administrative Rules
HDOH	State of Hawai‘i Department of Health
HDOT	State of Hawai‘i Department of Transportation
HELCO	Hawaiian Electric and Light Company
HRS	Hawai‘i Revised Statutes
HVAC	Heating, Ventilating, and Air Conditioning
IfA	Institute for Astronomy
IRTF	Infrared Telescope Facility
JCMT	James Clerk Maxwell Telescope
kV	Kilovolt
kVA	kilovolt-ampere
kW	Kilowatt
LLC	Limited Liability Company
LOS	Level-Of-Service

MKMB	Mauna Kea Management Board
MKSR	Mauna Kea Science Reserve
MKSS	Mauna Kea Observatories Support Services
MSDS	Material Safety Data Sheets
MSL	Mean sea level
MW	Megawatt
NAR	Natural Area Reserve
NASA	National Aeronautics and Space Administration
NAOC	National Astronomical Observatories of the Chinese Academy of Sciences
NAOJ	National Astronomical Observatory of Japan
NEPA	National Environmental Policy Act
NGLT	Next Generation Large Telescope
NPDES	National Pollutant Discharge Elimination System Permit
NRAO	National Radio Astronomy Observatory
NRMP	Natural Resources Management Plan
NSF	National Science Foundation
OCCL	Office of Conservation and Coastal Lands
OHA	Office of Hawaiian Affairs
OMKM	Office of Mauna Kea Management
OSHA	Occupational Safety and Health Administration
PAP	Public Access Plan
PCSI	Pacific Consulting Services, Inc.
RCRA	Resource Conservation and Recovery Act
RDP	Research and Development Plan
SDP	Site Decommissioning Plan
SDRP	Site Decommissioning and Removal Plan
SHO	Safety and Health Officer
SHPD	State Historic Preservation Division
SHPO	State Historic Preservation Officer
SIHP	State Inventory of Historic Places
SPRP	Spill Prevention and Response Plan
SRP	Site Restoration Plan
SMA	Submillimeter Array
TCP	Traditional Cultural Property
TMK	Tax Map Key
TMT	Thirty Meter Telescope
UC	University of California
UH	University of Hawai‘i
UH Hilo	University of Hawai‘i at Hilo
UKIRT	United Kingdom Infrared Telescope
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tanks

VLBA	Very Long Baseline Array
VIS	Visitor Information Station
VOG	Volcanic smog
WMP	Waste Minimization Plan

Conservation District Use Application (CDUA)

For DLNR Use	
File #	
Reviewed by	
Date	
Accepted by	
Date	
180-Day Exp.	
EA/EIS Required	
PH Required	
Decision	
Date	

Project Location/Address: Mauna Kea Loop Road

District/County: Hāmākua District Island: Hawai'i

Subzone: Resource Tax Map Key(s): 4-4-15:9 – Mauna Kea Science Reserve

Subzone: Tax Map Key(s):

Total Area of Parcel in sq. ft. or acres: 11,288 acres

Area of Proposed Use in sq. ft. or acres: 8.7 acres

Indicate which of the following approvals are being sought, as specified in the Hawaii Administrative Rules (HAR), Chapter 13-5.

- X Board Permit
- ___ Departmental Permit
- ___ Emergency Permit
- ___ Temporary Permit
- ___ Site Plan Approval

APPLICANT

Legal Name: University of Hawai'i c/o of University of Hawaii at Hilo

Street Address: 200 West Kawili Street

City, State and Zip+4 Code: Hilo, HI 96720

Contact Person & Title: Dr. Donald Straney, Chancellor

Phone No.: 808-974-7444 Fax No.: 808-933-3304

Email: dstraney@hawaii.edu

Interest in Property: General Lease No. S-4191 covering TMK 4-4-15:9

***Signature:** Donald M Straney **Date:** SEP -2 2010

*If for a Corporation, Partnership, Agency or Organization, must be signed by an authorized officer.

PROPERTY OWNER(S) (if other than the applicant)

Name: State of Hawai'i

Street Address: 1151 Punchbowl Street, Room 130

City, State and Zip+4 Code: Honolulu, HI 96813

Contact Person & Title: Laura Thielen, Chairperson, Board of Land and Natural Resources

Phone No.: (808) 587-0400 Fax No.: (808) 587-0390

Email:

***Signature:** **Date:**

*For private lands with multiple landowners, landowners whose property interests constitute or exceed 85% of the fee ownership of the subject parcel(s) shall sign the application.

AGENT

Name: None

Street Address:

City, State and Zip+4 Code:

Contact Person & Title:

Phone No.: Fax No.:

Email:

Signature: **Date:**

Emergency Contact Information

Contact Person and Title: Phone No.:

Please specify all prior CDUPs received for the subject parcel.

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-M	HA-954, 1977 (post facto)
Canada-France-Hawaii Telescope	HA-527, 1974
Fiber Optic Cables from Gemini to CFHT	SPA-HA-06-49, 2006
United Kingdom Infrared Telescope	HA-653, 1975
NASA Infrared Telescope Facility	HA-653, 1975
Caltech Submillimeter Observatory	HA-1492,1982
James Clerk Maxwell Telescope	HA-1515, 1983
W. M. 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	HA-2174, 1988
Japan National Large Telescope (Subaru)	HA-2462, 1991
-Subaru Concrete Walkway	Site Plan Approval, 1997
-Subaru Seepage Pit Collar	SPA-HA-05-08, 2004 (post facto)
Gemini Northern 8-M Telescope	HA-2691, 1993
Smithsonian Submillimeter Array	HA-2728, 1994
UH Hilo 0.9M Telescope	HA-3406, 2007
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
Restoration of Jeep Road up to Poli‘ahu	SPA-HA-10-04, 2009

1 Detailed Description of Proposed Use

1.1 BACKGROUND

The proposed observatory and other facilities covered by this application are located in the 11,288-acre Mauna Kea Science Reserve (MKSR) (TMK 4-4-15:9) on the upper slopes of Hawai‘i Island’s Mauna Kea Volcano. First leased by the State of Hawai‘i Department of Land and Natural Resources (DLNR) to the University of Hawai‘i (UH or University) in 1968, the current lease on the MKSR expires in 2033.

Figure 1.1 shows the mountain’s position on the island relative to major towns and roadways. Figure 1.2 shows the MKSR boundaries and the location of other important features and their boundaries on the upper slopes of Mauna Kea. Figure 1.3 focuses on the summit region of the mountain, showing the names of the pu‘u, the major existing facilities, and important natural features such as Lake Waiau.

The Mauna Kea summit region is designated as part of the State of Hawai‘i Conservation District Resource subzone and as such, uses on the land are subject to the Conservation District rules (HAR 13-5) and permit conditions. In addition, uses on the land are subject to the *Mauna Kea Science Reserve Master Plan* (UH 2000) and *Mauna Kea Comprehensive Management Plan* (CMP) and subplans (UH 2009a). As State land it is administered by the State of Hawai‘i Department of Land and Natural Resources (DLNR) as directed by the Board of Land and Natural Resources (BLNR). Effective January 1, 1968, the BLNR leased the land (General Lease S-4191) to the University of Hawai‘i; the lease terminates on December 31, 2033.

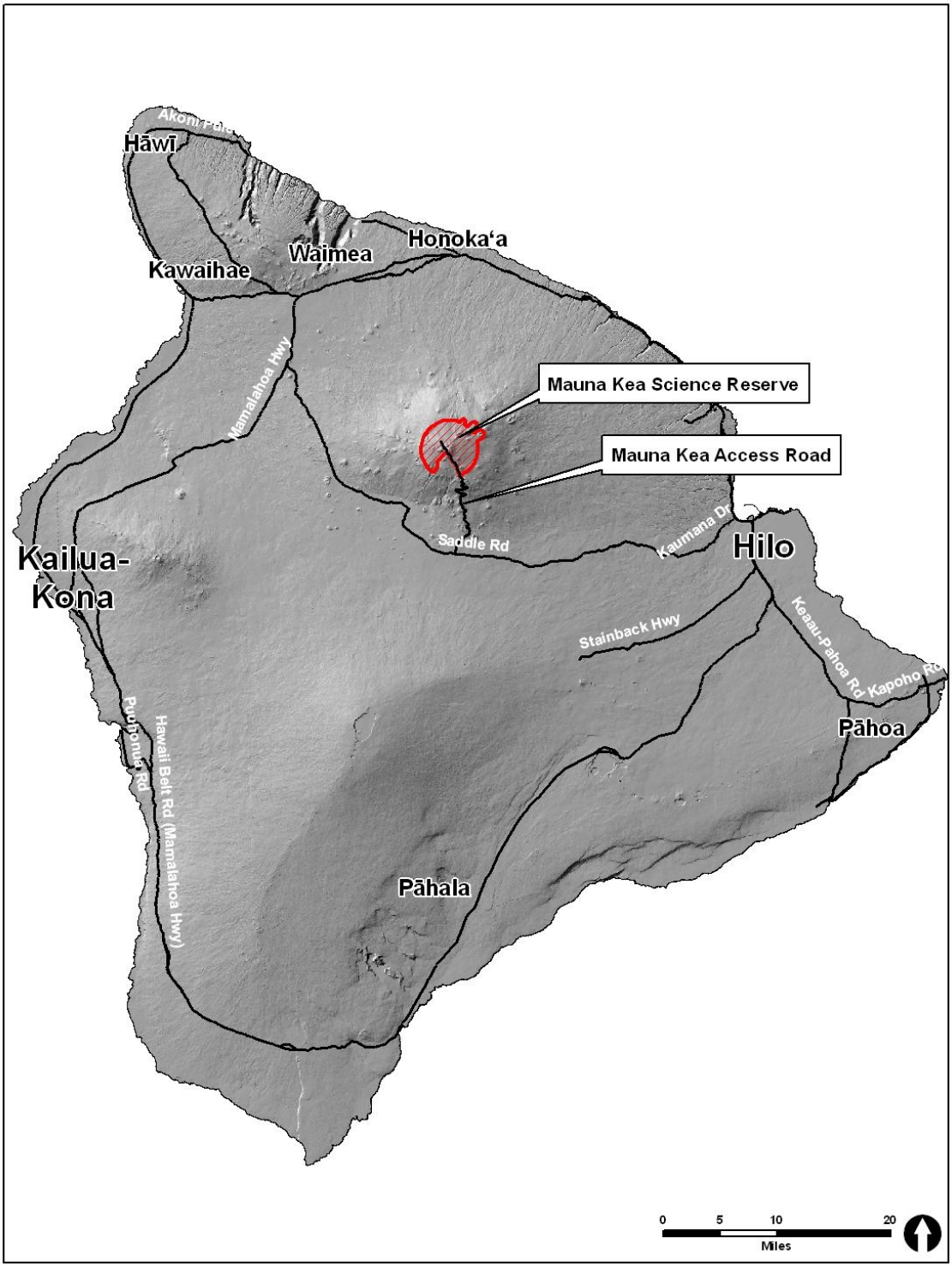
As shown in Table 1.1, thirteen astronomical facilities are operational in mid-2010. Nine of these are optical and/or infrared observatories[1]; these use mirrors to collect and focus visible and infrared light. The MKSR also hosts three submillimeter observatories and a radio antenna (the VLBA) that is part of a larger system.[2] All except the VLBA Antenna are located within the 525-acre area at the summit that the University of Hawai‘i’s *Mauna Kea Science Reserve Master Plan* refers to as the “Astronomy Precinct”.

[1] This counts Keck I and Keck II separately.

[2] Submillimeter wave astronomy is a relatively new branch of astronomy that studies celestial objects using the submillimeter band of the electromagnetic spectrum (300 GHz to 3,000 GHz). Most of the radiation in this band is blocked by the earth’s atmosphere, and it is only with the development of high-altitude facilities such as those on Mauna Kea that scientists have been able to acquire the valuable information it contains.

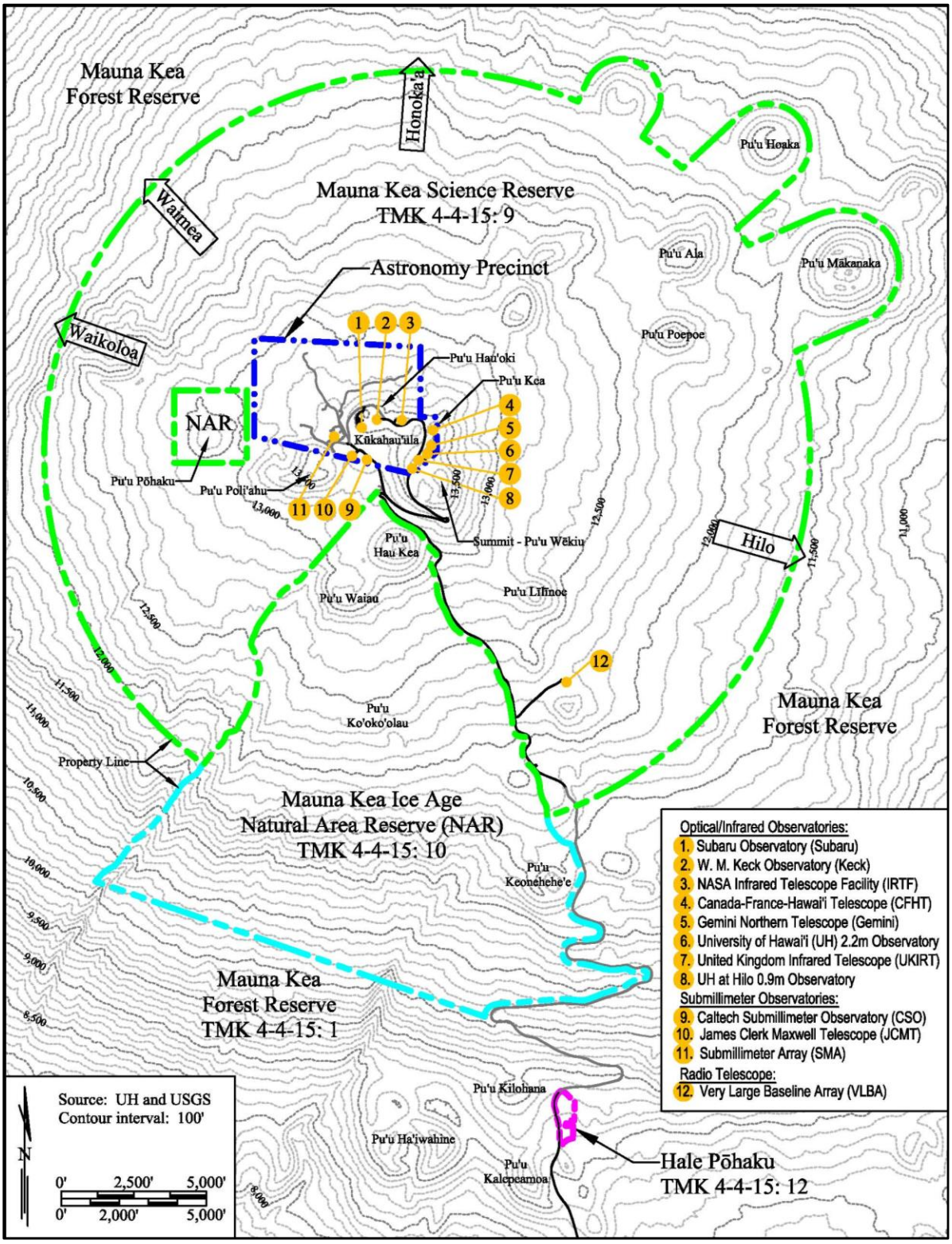
The Very Long Baseline Array (VLBA) radio antenna is a telescope but does not individually meet the definition of an observatory because it is only one part of a larger array, which stretches from the U.S. Virgin Islands to Mauna Kea.

Figure 1.1 Project Location



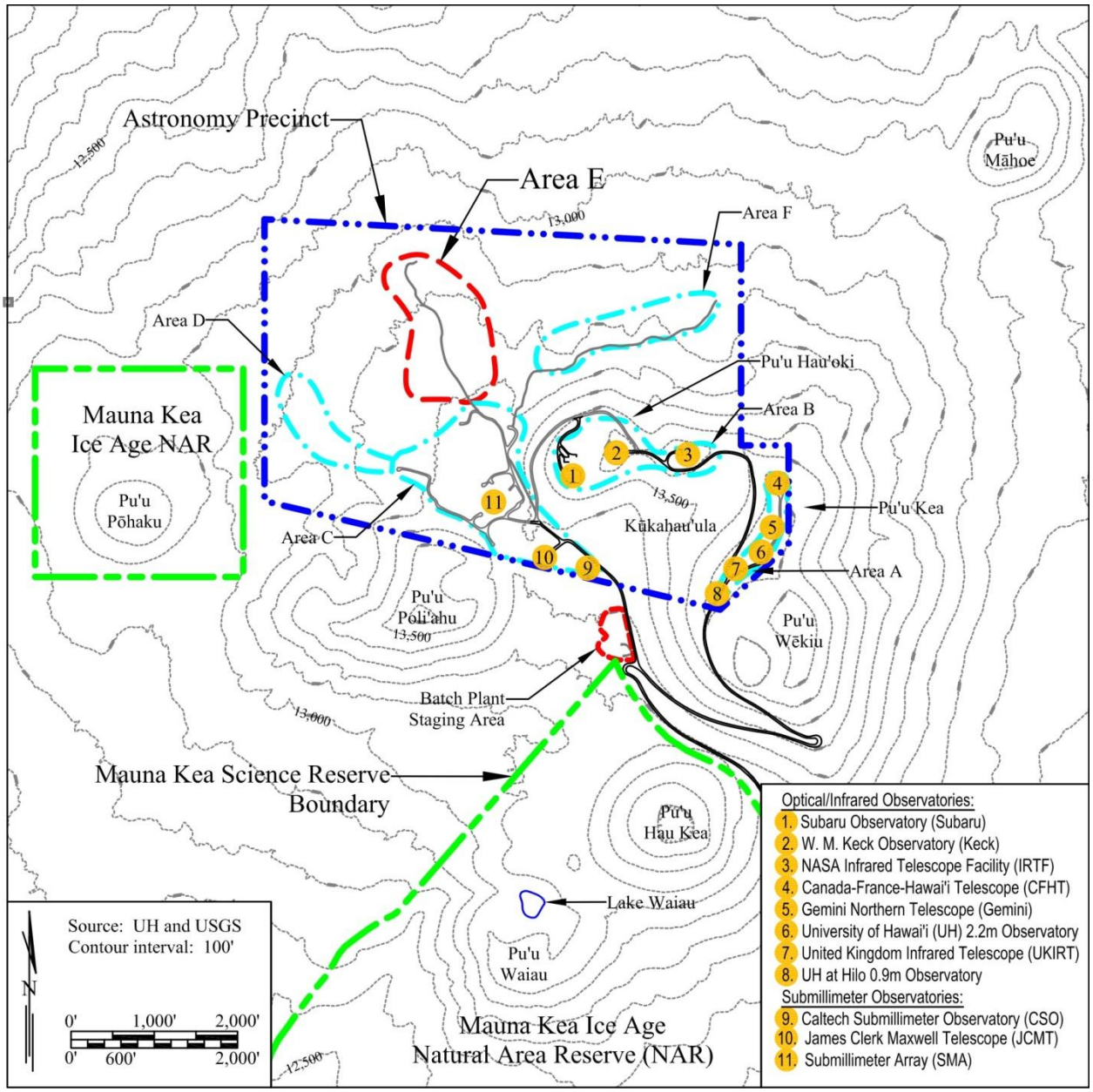
Source: Planning Solutions, Inc.

Figure 1.2: Overview of Mauna Kea



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

Figure 1.3: Mauna Kea Summit Region: Existing Facilities, Features, & Future Development Areas



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

Table 1.1. Mauna Kea Telescopes (as of 2010)

	Facility Name	Mirror Size (in meters)	Owner/Operator	Year Built
Optical/Infrared				
UH 2.2m	UH 2.2-m Telescope	2.2m	University of Hawai‘i	1970
IRTF	NASA Infrared Telescope Facility	3.0m	NASA	1979
CFHT	Canada-France-Hawai‘i Telescope	3.6m	Canada/France/UH	1979
UKIRT	United Kingdom Infrared Telescope	3.8m	United Kingdom	1979
Keck I	W. M. Keck Observatory	10m	Caltech/University of California	1992
Keck II	W. M. Keck Observatory	10m	Caltech/University of California	1996
Subaru	Subaru Telescope	8.3m	Japan	1999
Gemini	Gemini North Telescope	8.1m	USA/UK/Canada/Argentina/ Australia/Brazil/Chile	1999
UHH 0.9m[3]	UHH 0.9-m Telescope	0.9m	University of Hawai‘i, Hilo	2008
Radio				
CSO	Caltech Submillimeter Observatory	10.4m	Caltech/NSF	1987
JCMT	James Clerk Maxwell Telescope	15m	UK/Canada/Netherlands	1987
SMA	Submillimeter Array	8x6m	Smithsonian Astrophysical Observatory/Taiwan	2002
VLBA	Very Long Baseline Array	25m	NRAO/AUI/NSF	1992

Note: The California Institute of Technology (Caltech) has announced that it will begin decommissioning the Submillimeter Observatory (CSO) in 2016 with the return of the site to its natural state, consistent with the terms of the CSO sublease by 2018.

Source: http://www.ifa.hawaii.edu/mko/telescope_table.htm as reported in the *Decommissioning Plan for Mauna Kea Observatories*, dated January 2010.

These observatories have been attracted to the summit region of Mauna Kea principally because of the superb viewing conditions that its high-altitude/mid-oceanic location provides. The intellectual and physical support infrastructure that has been developed around the complex complements these natural assets. Combined, they have helped Hawai‘i become one of the most important centers for astronomical research in the world.

1.2 OVERVIEW OF THE PROPOSED USE

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[4] within an area below the summit of Mauna Kea that is known as “Area E”. The TMT Observatory Corporation is a private non-profit corporation that will be responsible for constructing the TMT project and for managing its operations. The TMT project is currently a partnership among the TMT Observatory Corporation (TMT), the University of California (UC), the California Institute of Technology

[3] In 2008 the UH 0.6-m telescope (built in 1968) was replaced by the UHH 0.9-m telescope.

[4] An observatory includes the telescope(s), the dome(s) that contain the telescope(s), and the instrumentation and support facilities for the telescope(s) that fall under a common ownership.

(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 in the TMT project.

Management Action FLU-1 in the recently adopted CMP states that future facility planning should follow the guidelines presented in the University of Hawai'i *Mauna Kea Science Reserve Master Plan*, referred to as the *2000 Master Plan* (University of Hawai'i, 2000). The *2000 Master Plan* limits future development to the Astronomy Precinct and identifies Areas A through F within it as preferred sites (Figure 1.3). It also lists criteria to assist in the selection of an appropriate site for a ground-based telescope with a primary mirror of 25 to 50 meters in diameter (generically referred to as a "Next Generation Large Telescope", or NGLT in the *2000 Master Plan*). The *2000 Master Plan* identifies Area E as the preferred location for an NGLT.[5] 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. Road access to the site will be provided by improving the existing four-wheel drive road from the point where it diverges from the existing Mauna Kea Loop Road. This includes one segment across the base of Pu'u Hau'oki and another that extends through the existing Submillimeter Array (SMA) 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 DETAILED DESCRIPTION OF TMT FACILITIES

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

- Section 1.3.1 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 1.3.2 describes the proposed TMT Access Way, which consists of an improved road and underground utilities (power and telecommunications) improvements that will be constructed to connect the TMT Observatory with existing roads and utilities.
- Section 1.3.3 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 CDUPs (e.g., those for the Subaru, Keck II, and SMA telescope facilities).

[5] It should be noted that the 2000 Master Plan limits future development to Areas A, B, C, D, E, and F within the Astronomy Precinct. By doing this, the Master Plan removed the possibility of developing an observatory on an undeveloped pu'u within the MKSR.

- Section 1.3.4 describes the upgrades that will 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 Mauna Kea Ice Age Natural Area Reserve (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.

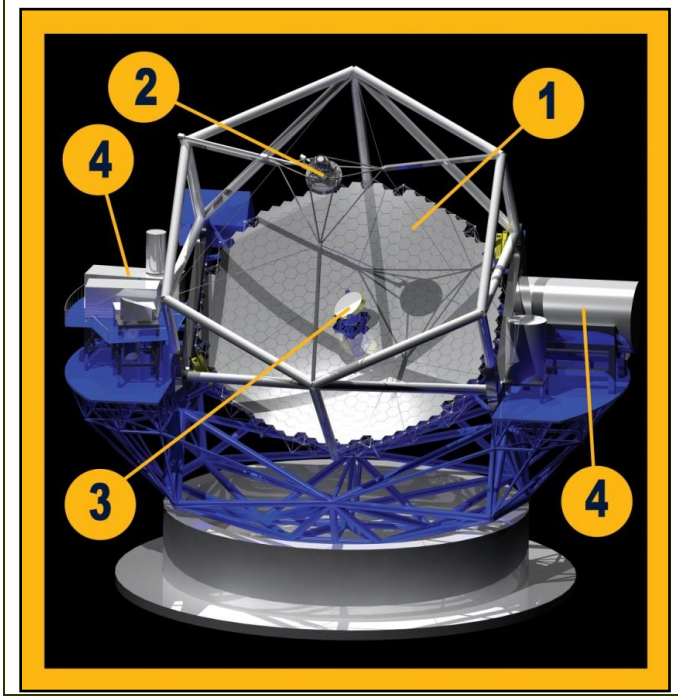
In addition to these facilities and activities, construction and operation of the TMT project will entail several other uses that do not require a new CDUP. These include the use of existing roadways to transport construction workers and materials from the place where they live/are landed on the island, 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*.

1.3.1 TMT OBSERVATORY

1.3.1.1 Telescope Design

The core of the TMT Observatory is the 30-meter aperture telescope, referred to as the TMT. Figure 1.4 illustrates the telescope assembly. The numbers correspond to the features listed to the right of the sketch.

Figure 1.4: Thirty Meter Telescope Overview



1. The primary mirror – the “eye” of telescope– will be 98 feet (30 meters) in diameter. This mirror will be comprised of 492 individual mirror segments operating as one.

2. The secondary mirror sits above the primary mirror and will direct the light collected by the primary mirror to the tertiary mirror.

3. The tertiary mirror sits in the middle of the primary mirror and will direct the collected light into different instruments for analysis.

4. Interchangeable instruments and sensors mounted to the side of the mirror will collect and process light from wide array of wave lengths.

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

1.3.1.2 TMT Observatory Design

Pursuant to the *2000 Master Plan*'s design review process, the TMT Observatory Corporation developed the design in consultation with OMKM with reviews by the Mauna Kea Management Board. 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.[6]

The proposed observatory includes the following:

- The telescope described in Section 1.3.1.1. The center of the surface of the primary mirror will be located approximately 66 feet above the ground surface.
- 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 1.4).
- The TMT adaptive optics (AO) system.[7] The TMT will be the first large optical/infrared observatory to integrate AO into its original design. AO systems correct for 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 Calotte[8] type enclosure with the following characteristics (as depicted in Figure 1.5 and Figure 1.6).
  - 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.

[6] 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.

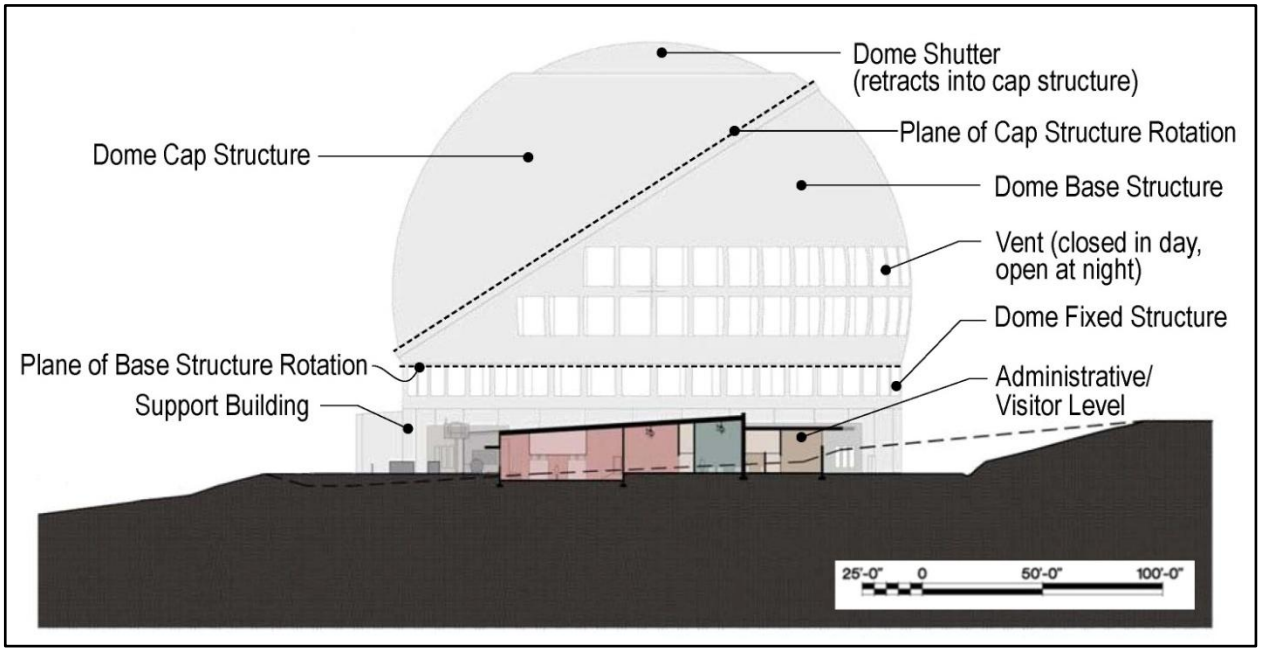
[7] "Adaptive optics" (AO) is a technology used to improve the performance of optical systems by reducing the effects of rapidly changing optical distortion. AO works by measuring the distortions in the wavefront that occur when it passes through the earth's atmosphere and compensating for them. When 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.

[8] 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.

- The fixed cylindrical structure below the rotating base will enclose 34,304 gross 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.

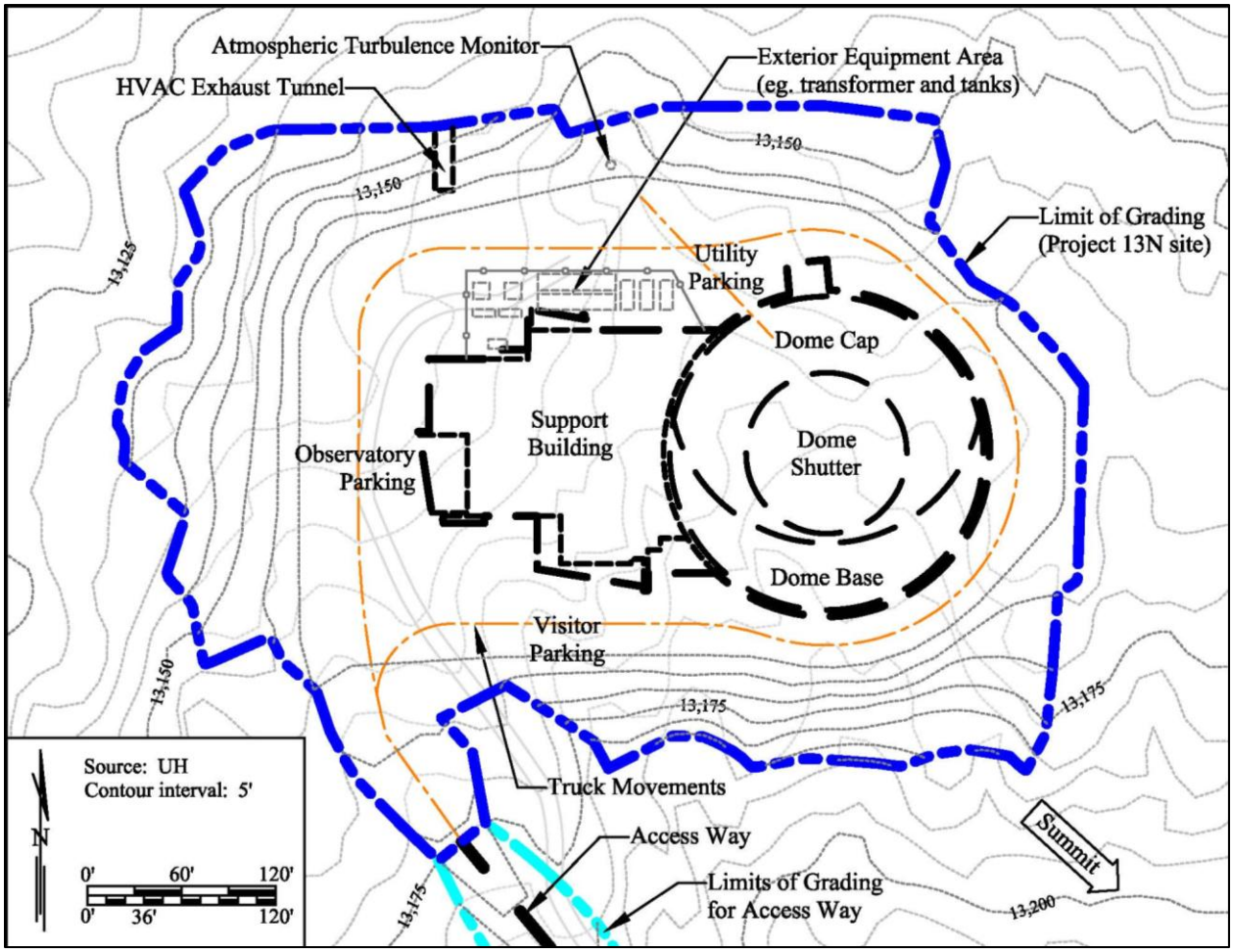
- The support building will be attached to the dome (see Figure 1.6). The building will have a roof area of approximately 21,000 square feet, a gross interior area of roughly 18,376 square feet, a primarily flat roof, and be lava-colored. The support building will include the following spaces:
  - Mirror coating and staging area.
  - Laboratory and shop spaces, including a computer room, engineering and electronics laboratories, and mechanical shop.
  - 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.

Figure 1.5: TMT Observatory Cross-Section



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

Figure 1.6: TMT Observatory Plan View and Grading Plan



Source: Figure 2-7, *Final EIS*: TMT Observatory

- 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.

1.3.2 TMT ACCESS WAY

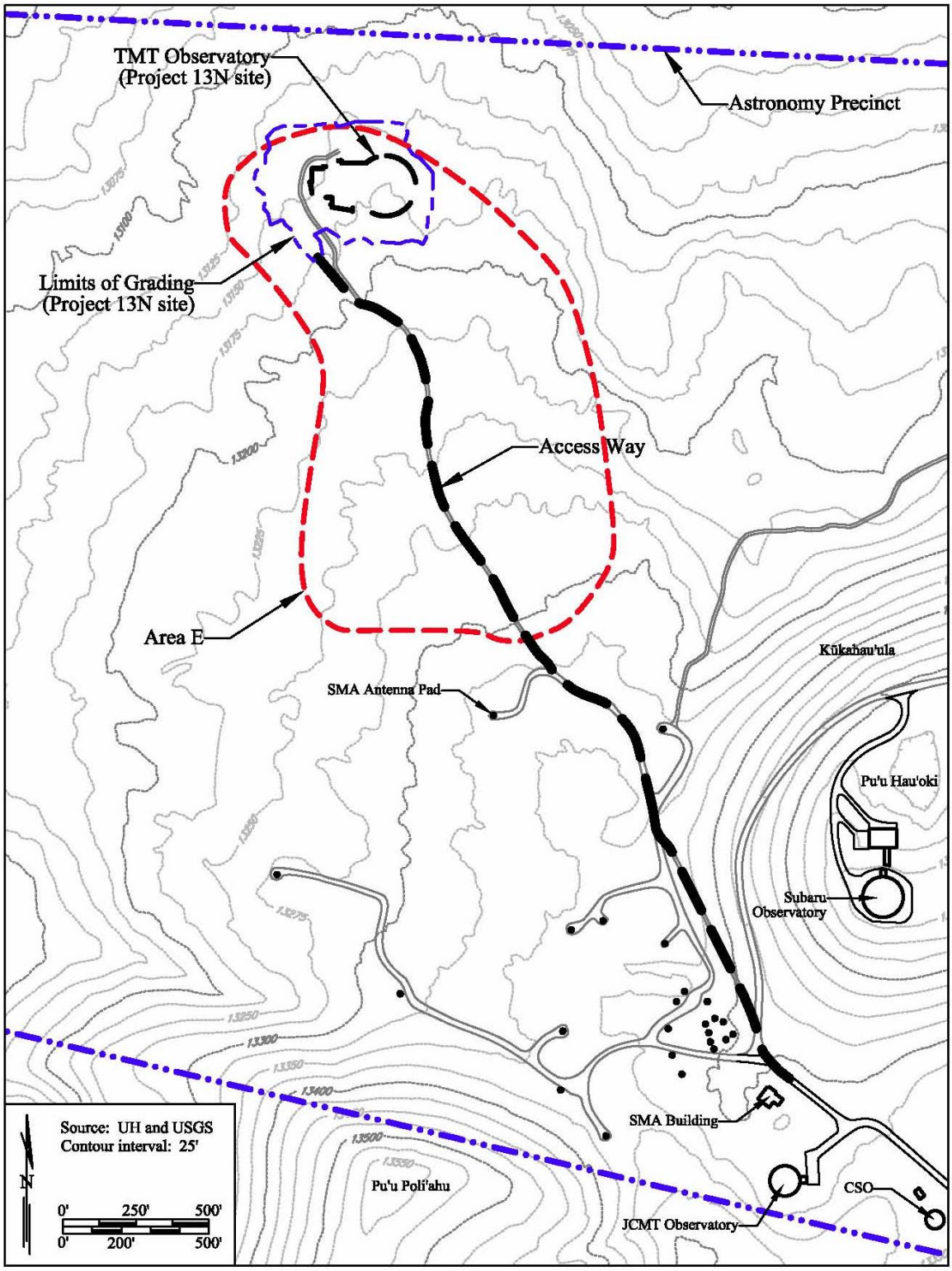
Currently, utility services exist along the Mauna Kea Access Road to a point near the intersection of the Mauna Kea Loop Road and the Submillimeter Array (SMA) roadway.[9] The proposed TMT Access Way will start at that point and extend to the TMT Observatory; for the most part it will follow either existing 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 Puʻu Hauʻoki); the remainder is two lanes (see Exhibit B for construction details). The vast majority of the Access Way route follows and goes over an existing 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 will 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, TMT consulted with the University in developing the Access Way design. Because the proposed Access Way route passes through areas of the SMA project, both parties are working 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 1.7 is being proposed.

[9] 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.

Figure 1.7. TMT Observatory Access Way



Source: UH and USGS

The acreage that will be disturbed by construction of the proposed TMT Access Way is shown in Table 1.2.[10] A portion of the area was previously disturbed by the existing 4-wheel drive and SMA roads as indicated in the table. The University believes that the proposed Access Way is also the best from the viewpoint of minimizing visual and physical impacts.

Table 1.2: Summary of Access Way Disturbances

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

Source: TMT provided design drawings by M3.

1.3.3 BATCH PLANT STAGING AREA

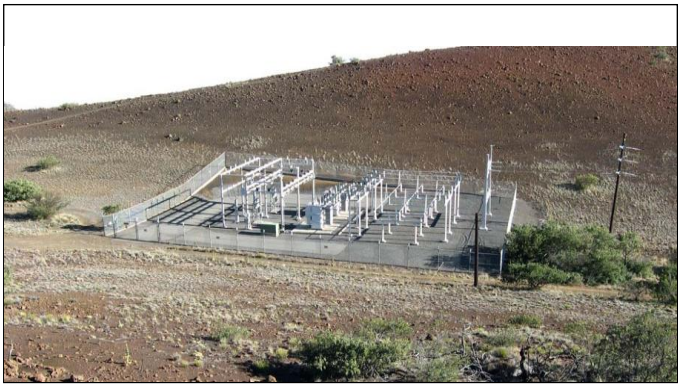
The Batch Plant Staging Area is a roughly 4-acre area northwest of where the Mauna Kea Access Road forks near the summit (see Figure 1.3. This area will be used primarily for storing bulk materials and a concrete Batch Plant, as it has been in the past during construction of other observatories and roads.



Batch Plant Staging Area

1.3.4 ELECTRICAL UPGRADES

HELCO will 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 will replace the existing transformers on a one-for-one basis, and the existing fenced compound will not be expanded.



HELCO compound near Hale Pōhaku.
Photo by CSH

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

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 (see Figure 1.8). 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 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 the DLNR to determine if there are any additional easement requirements in connection with these activities.

1.3.5 CONSTRUCTION ACTIVITIES

As discussed in Section 3.15 of the *Final EIS*, construction work details will be developed during the final design of the Project. However, in general construction of the proposed facilities will involve the same sorts of activities that have accompanied erection of the other telescope facilities on Mauna Kea. A description of TMT Observatory and Access Way construction activities and construction plan details are available in Exhibit B.

1.3.6 DECOMMISSIONING ACTIVITIES.

Decommissioning the TMT Observatory and the portion of the Access Way that the University asks it to re-naturalize will require activities similar to those required to build them, but the exact method that will be used is not known at this time.

1.4 BUILDING FOOTPRINTS

See Figure 1.6 and drawings in Exhibit A.

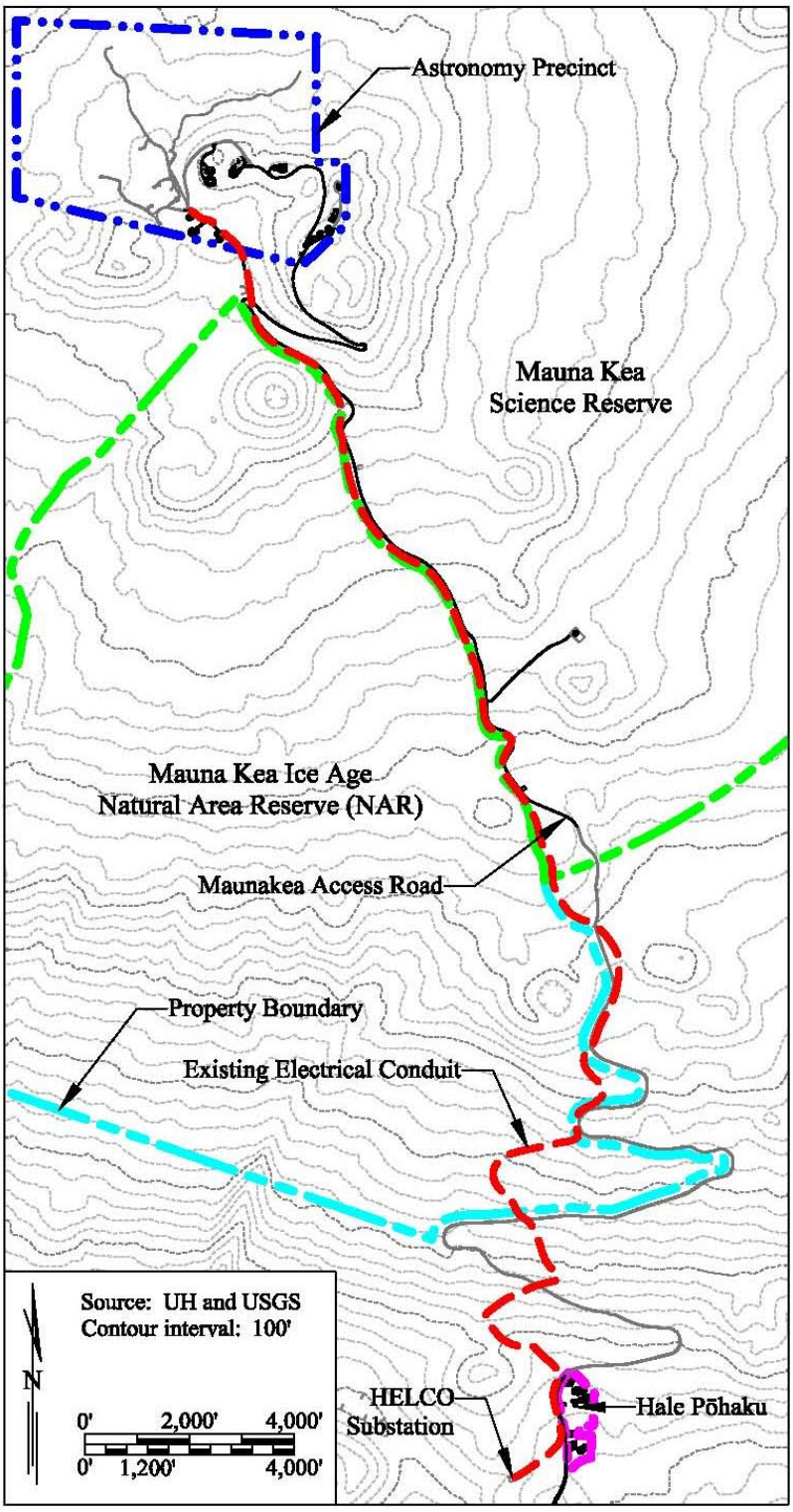
1.5 EXISTING (BEFORE) AND PROPOSED (AFTER) GRAPHICS

See photos in Exhibit A for existing views across the areas on which the TMT Observatory and Access Way will be constructed. See architectural renderings in Section 1.7 and visualizations in Section 7 for appearance with the proposed project.

1.6 RELATED USES OUTSIDE THE CONSERVATION DISTRICT

In addition to the facilities and activities for which a Conservation District Use Permit is being sought, construction and operation of the proposed TMT Observatory will entail some other activities as well. The most substantial of these, a headquarters facility and harbor construction materials staging area, are described below.

Figure 1.8. HELCO Hale Pōhaku Substation and Electrical Line

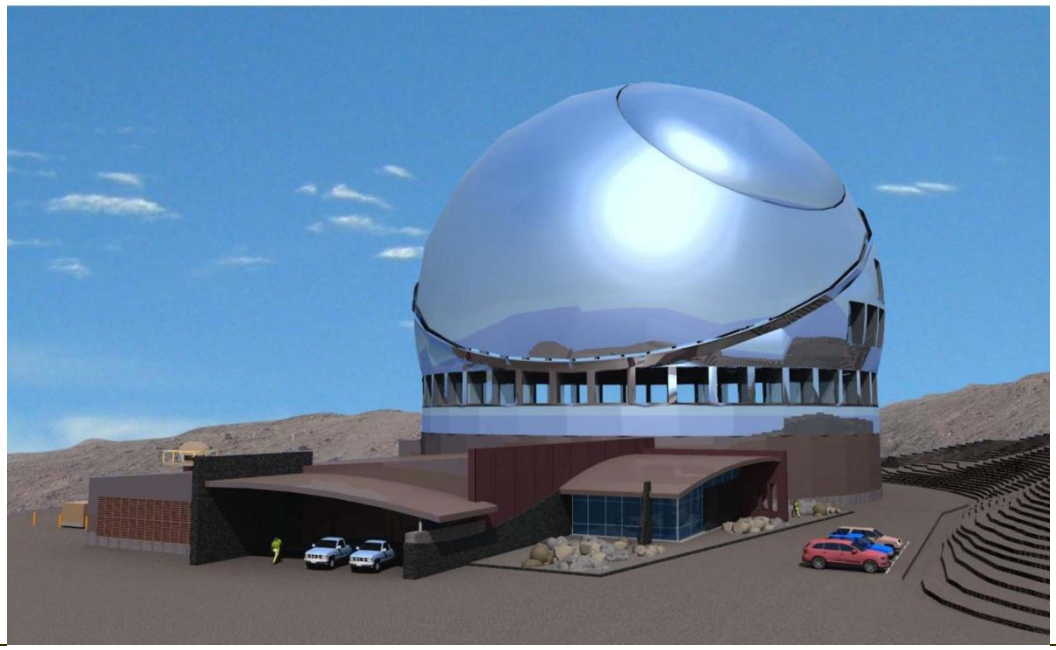


Source: UH and USGS

1.7 PRELIMINARY ARCHITECTURAL RENDERINGS

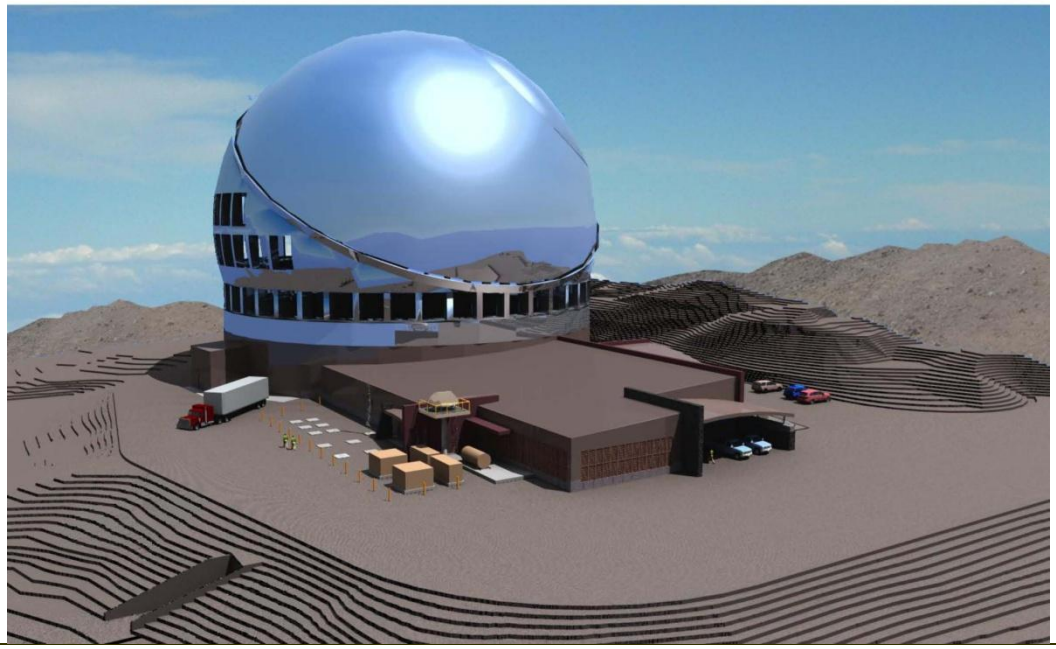
TMT
THIRTY METER TELESCOPE

Southwest View



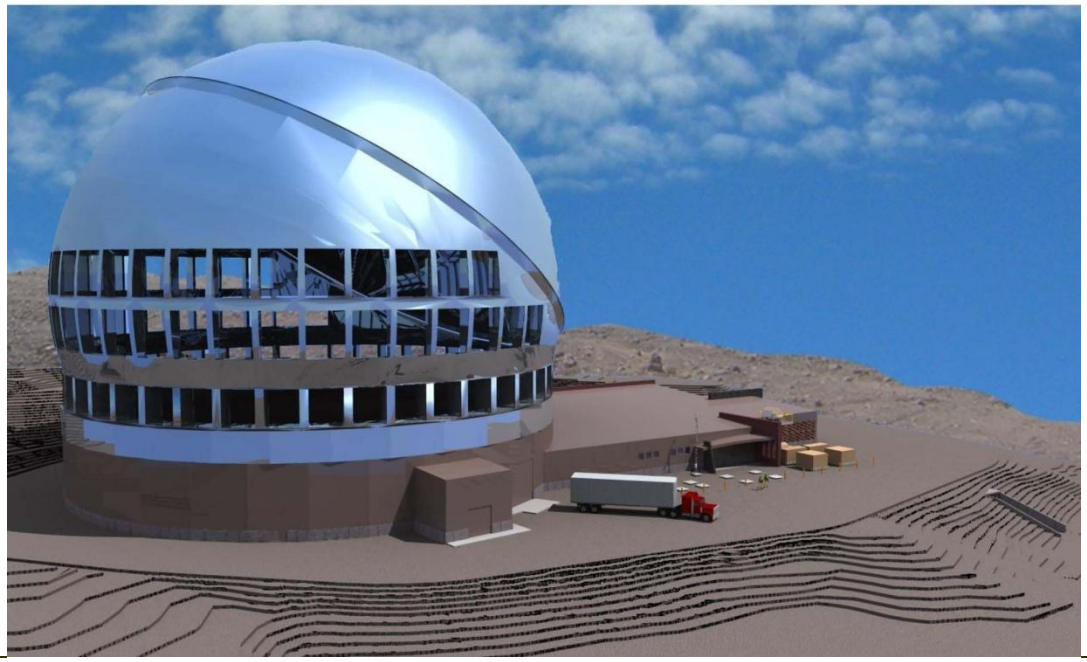
TMT
THIRTY METER TELESCOPE

Northwest View



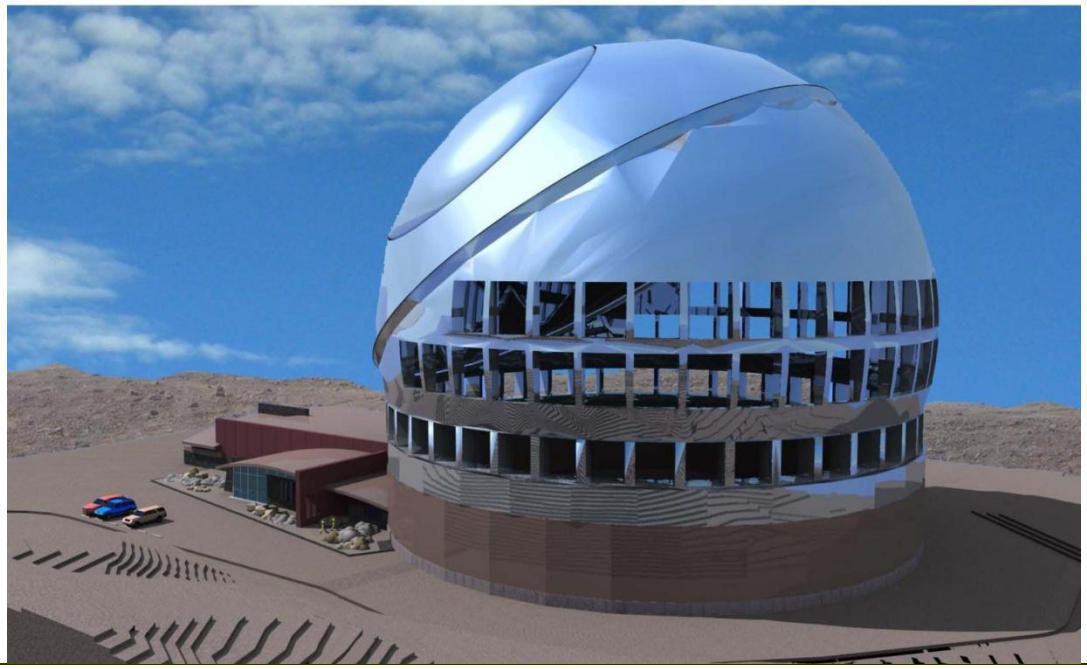
TMT
THIRTY METER TELESCOPE

Northeast View



TMT
THIRTY METER TELESCOPE

Southeast View



TMT Headquarters. Due to the rigors of living and working at a high elevation, observatories build headquarter facilities at lower elevations for the majority of their administrative and operations staff. Most of the staff members do not need to visit the telescope on a daily basis. TMT has planned its operation to minimize the number of activities needing to be done by staff at the TMT Observatory and plans to maintain and operate much of the equipment remotely from its Hilo Headquarters. This will limit the number of trips to and people at the TMT Observatory.

The Headquarters will be located in Hilo on the UH Hilo campus, within the University Park of Science and Technology (University Park) development. University Park consists of portions of TMK 2-4-1:7, all of TMK 2-4-1:41, and a mauka expansion on portions of TMK 2-4-1:122. Some existing observatories have their headquarters in University Park. TMT is considering two principal options for the Project Headquarters; all within either TMK 2-4-1:7 or 2-4-1:122. The Headquarters will be an approximately 20,000 to 35,000 square-foot office building; and it is planned to include solar hot water systems for domestic water use, photovoltaic power systems to supplement the electricity purchased from HELCO, use of natural lighting, and energy-efficient light fixtures controlled by occupancy sensors. The Headquarters will be designed with local knowledge to make maximum use of the climate and natural ventilation.

Port Staging Area. TMT will lease or make other arrangements for the use of an existing warehouse and/or yard near the port (Hilo and/or Kawaihae) where materials and project components are landed. This area will be used for receiving materials and assembly of those materials to the extent possible prior to transport to either another staging area or the construction site.

1.8 PROJECT SCHEDULE

The TMT Observatory Project involves four major phases: planning and design, construction and testing, operation, and decommissioning of the TMT Observatory after it reaches the end of its planned useful life. Table 1.3 presents the overall project schedule. Maintaining this schedule will require the timely completion of ongoing optical design tasks, equipment fabrication, and permit approvals. To the extent that these are delayed, the project development schedule could be extended.

Table 1.3: Project Schedule

Phase	Start	End
Planning and Design	**2003**	**2010**
CDUA Submission/Processing	August 2010	Q1 2011
Construction Plans	Q4 2010	Q2 2011
Construction and Testing	**2011**	**2018**
Grading and foundation	2011	2012
Observatory erection	2012	2016
Observatory finish	2016	2017
First light	September 2018	
Telescope/instrument testing	2017	2018
Operation	**2018**	**To be determined**
Decommissioning	**To be determined** (see note)	

Note 1: Notice of Intent (NOI) to decommission the telescope must be given at least 5 years prior to the lease end or the desired decommissioning date, whichever occurs first. This is followed by the environmental due diligence review and decommissioning and restoration planning. Decommissioning would occur over a 2-year period.

Note 2: Schedule does not account for additional time required if there should be a contested case hearing. Similarly, it does not account for delays that might result from legal challenges.

Note 3: Decommissioning will take place over approximately five years.

Construction. As indicated in the schedule, it will take approximately seven years from the time the first work is done on the mountain until the telescope is operational. TMT Observatory Corporation expects that construction activities will take place 12-15 hours a day, seven days a week; however, some special operations or construction phases will require longer work hours. Winter weather conditions at the TMT Observatory site will interrupt construction at times, until the dome is completed.

Operation. Once it is operational, the TMT Observatory will be occupied and used continuously. Most of the activity will be associated with maintaining the facilities and setting up observational experiments. During the night, the facility will be staffed by a small crew (a half-dozen) of system operators; others will observe remotely from the Headquarters.

Decommissioning. The TMT Observatory site and any portion of the Access Way that the University determines will no longer be needed will be decommissioned and restored at the end of the Observatory's life. Deconstruction and site restoration efforts will be managed by TMT with oversight by OMKM in accordance with the *Decommissioning Plan for the Mauna Kea Observatories – a Sub-Plan of the Mauna Kea Comprehensive Management Plan* (OMKM, 2010). TMT will document the condition of the observatory site, outline its approach to decommissioning, and propose a plan for site restoration. As described in the TMT Management Plan (see Exhibit B), a process similar to the Mauna Kea Management Board (MKMB)-approved Project Review Process will be established to review, guide, and recommend the disposition of a site, including site restoration. Reviewers will include OMKM, Kahu Kū Mauna, and the Environment Committee, with MKMB approval required.

1.9 VIOLATIONS ON PARCEL

The following sections provide a summary of the two past violations within the MKSR (TMK 4-4-15:9).

1.9.1 HA 05-08

On May 11 and 12, 2004, representatives of the Office of Conservation and Coastal Lands (OCCL) inspected facilities within the MKSR for compliance with existing CDUPs. During the site inspection potential discrepancies and/or non-compliance issues were identified at four observatory sites within the MKSR. The observatories listed in the May 19, 2004, letter from OCCL to UH include Caltech Submillimeter Observatory (CSO), James Clerk Maxwell Telescope (JCMT), Subaru, and SMA. UH worked with the observatories and OCCL to immediately address the discrepancies and/or non-compliance issues. UH also paid a $20,000 fine related to the non-compliance issues. In a letter dated October 20, 2004, OCCL indicated that all pending violations identified had been adequately resolved.

1.9.2 HA 09-53

On May 17, 2009, roughly 22.7 gallons of hydraulic fluid was released at the CSO. The spill was reported properly. Approximately 46.8 cubic yards of impacted soil was removed and the Department of Health issued a no further action letter for the spill case. A letter dated October 13, 2009, from OCCL indicated that the matter had been resolved and the case was closed.

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2 Conservation District Consistency

Demonstrate that the proposed use is consistent with the following criteria. Refer to HAR, Section 13-5-30. Attach additional sheets if necessary.

The proposed use is consistent with HAR, Section 13-5-30, the Conservation District requirements, as described below.

2.1 PURPOSE OF CONSERVATION DISTRICT

Is the proposed land use consistent with the purpose of the Conservation District?

For reasons outlined below, the proposed TMT project is fully consistent with the purpose of the Conservation District.

The State Land Use Law (Chapter 183C, Hawai‘i Revised Statutes) makes it the purpose of the Conservation District "…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 of Hawai‘i and TMT Observatory Corporation are both committed to management measures that will achieve these purposes.

As discussed elsewhere in this application, the Board of Land and Natural Resources has adopted the *Comprehensive Management Plan* and subplans (*Cultural Resources Management Plan*, *Natural Resources Management Plan*, *Public Access Plan*, and *Decommissioning Plan*) as the approved management documents for land use and activities in the UH Management Areas. The UH Management Areas include the 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 NAR. The CMP and subplans provide management strategies designed to preserve and protect the resources located in the UH Management Areas, and the University is committed to their implementation using the resources that are available to it. The TMT Observatory Corporation has also developed a TMT Management Plan (provided as Exhibit B) that adopts the approach, goals, objectives, findings, recommendations, and management strategies and actions of the CMP and subplans in their entirety. In addition, the TMT Management Plan fulfills the requirements of the Conservation District Rules, HAR § 13-5, particularly Exhibit 3 regarding management plan requirements, and therefore, this Plan together with the CMP and subplans fulfill the purpose of the Conservation District concerning the TMT project and the UH Management Areas.

The design of the TMT project itself is consistent with the CMP and subplans. Furthermore, the financial and other resources that the TMT project will make available will 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 will improve the University's ability to implement the measures in the CMP (and therefore to preserve, protect, and manage the resources in the UH Management Areas) by:

- Implementing the various mitigation measures outlined in the *Final EIS*;

- helping fund OMKM's implementation of the CMP by making future sublease payments that it anticipates will be required by BLNR[11]; and
- adhering to its proposed project-specific management plan (which is consistent with and implements the CMP and CMP subplans in the TMT project area).

2.2 OBJECTIVE OF SUBZONE

Is the proposed use consistent with the objectives of the subzone of the land in which the use will occur?

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 chapter describes the objective of the level of protection and management and identifies potentially permissible 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 when it is 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 can be allowed, 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 UH Management Areas in a way that fulfills the objective of the Resource subzone of the Conservation District. The proposed TMT project will help meet the objectives of the Resource subzone by using the excellent astronomical resources that Mauna Kea possesses to maintain Hawai‘i at the forefront of astronomical research while implementing and supporting overall management activities that will promote the sustained use of the natural and cultural resources in the subzone.

The proposed project will 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 applicable UH Management Area and site-specific management plans discussed in the following subsections. If approved, the TMT Observatory Corporation will implement the TMT Management Plan. Together with the CMP and its subplans, the TMT Management Plan will 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.

[11] 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.

[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.

2.2.1 MAUNA KEA COMPREHENSIVE MANAGEMENT PLAN

As noted above, the *(1) Mauna Kea Comprehensive Management Plan, (2) Cultural Resources Management Plan, (3) Natural Resources Management Plan, (4) Decommissioning Plan for the Mauna Kea Observatories, and (5) Public Access Plan for the UH Management Areas on Mauna Kea,* adopted by the Board of Land and Natural Resources on April 9, 2009 and March 25, 2010, are the approved management documents for land use and activities in the UH Management Areas on Mauna Kea, including the TMT project. The overarching goal of the CMP and subplans is to provide management strategies that protect, preserve and enhance Mauna Kea's resources within the UH Management Areas. The *CMP* and subplans are consistent with the purposes of the Conservation District lands and the objectives of the Resource subzone.

The activities that the TMT Observatory Corporation would carry out if the TMT project is approved and implemented are consistent with the management actions described in the CMP and subplans. This provides consistency and viability of management objectives, which include ensuring the sustained use of natural resources in the Resource subzone under HAR § 13-5-13. Additionally, the sublease which TMT Observatory Corporation would enter with the University of Hawai‘i, is almost certain to provide for rent that by law is deposited into a special fund and used for management of the Mauna Kea lands. These funds would be used as needed by the Office of Mauna Kea Management, the local management authority for the UH Management Areas, to implement the management actions called for in the CMP. This support includes funding appropriate management actions which are intended to mitigate the impacts of astronomy facilities on Mauna Kea as well as to ensure that Mauna Kea’s resources are protected, preserved and enhanced in the years to come. These management actions and how TMT intends to implement them are detailed in the TMT Management Plan in Exhibit B of this Application.

2.2.2 TMT MANAGEMENT PLAN

In addition to supporting the implementation of the CMP, the TMT project has also developed a project-specific management plan. The TMT Management Plan provides a general description of the proposal, the existing conditions on the parcel, proposed land uses on the parcel and reporting schedule; it also adopts the approach, goals, objectives and management strategies and actions of the CMP and subplans in their entirety. Specifically, the TMT Management Plan implements all relevant action items and plans of the CMP and subplans on a site-specific basis ensuring that the management actions called for in the CMP and subplans which are applicable to the TMT project are effectively and responsibly implemented. Additionally, the TMT Management Plan sets forth mitigation measures in the form of Best Management Practices and conservation methods intended to mitigate the impacts of the TMT project on Mauna Kea's varied resources.

The TMT Management Plan is intended to provide site-specific information and be an extension of the CMP and subplans and together (CMP, subplans and TMT Management Plan), these documents are intended to fulfill the purpose of the Conservation District concerning the TMT project. In addition to this and in conjunction with one another, these plans are intended to fulfill

the requirements for the Resource subzone, specifically management plan requirements under Exhibit 3 to the Conservation District Rules.[13]

In addition, the CMP and its subplans provide the primary framework for managing the development and operation of astronomy and other uses within the UH management areas on Mauna Kea. The TMT Management Plan, which includes a Draft Historic Preservation Mitigation Plan (included as an appendix in Exhibit B), sets forth specific measures intended to implement the CMP and subplans and mitigate the effects of the TMT project so that resources within the UH management areas are effectively and responsibly managed, preserved and protected.

2.3 COASTAL ZONE MANAGEMENT

Does the proposed land use comply with provisions and guidelines contained in Chapter 205A, Hawaii Revised Statutes (HRS), entitled "Coastal Zone Management", where applicable?

§205A Hawai‘i Revised Statutes defines Hawai‘i's Coastal Zone Management Area as consisting of all lands of the State (excluding those lands designated as state forest reserves) and the area extending seaward from the shoreline to the limit of the State's police power and management authority, including the United States territorial sea. It then establishes guidelines for their use. The areas covered by this application are outside the coastal areas (Special Management Area and Shoreline Setback Area) that are designated for more intensive regulation. The following subsections demonstrate the uses covered by this application compliance with the applicable provisions of Chapter 205A.

2.3.1 RECREATIONAL RESOURCES

Several trails traverse the Mauna Kea summit region. Among these are the Mauna Kea–Humu‘ula Trail and the Mauna Kea–‘Umikoa Trail. None of these trails are near the TMT Observatory or Access Way, and there is no snow play in the area.

The Mauna Kea – Humu‘ula Trail begins near Hale Pōhaku and ends at Lake Waiau. A modern trail around the western side of Pu‘u Haukea connects the Mauna Kea-Humu‘ula Trail with the Mauna Kea Access Road close to the existing Batch Plant Staging area (see Figure 5.1). Proposed TMT-related use of the Batch Plant Staging Area will be visible to trail users during the construction period (as it has been in the past), but the work will not entail lasting land disturbance and is consistent with the preservation and continued use of these resources. As the TMT Observatory plans call for the partial re-naturalization of the Batch Plant site following completion of construction, implementation of the proposed project is likely to improve conditions in the vicinity of the trail once construction is completed.

2.3.2 HISTORIC/CULTURAL RESOURCES

As discussed in detail elsewhere in this application, protection of historic and cultural resources has been a major objective in planning the proposed TMT project. This has resulted in locating

[13] It should be noted that the TMT Management Plan has been drafted to conform with the current Conservation District Rules (HAR § 13-5) as well as with the amendments to the Conservation District Rules which have been proposed and are currently being discussed.

the Project in Area E. Furthermore, the TMT project has committed to several mitigation measures to minimize the Project's impacts on historic/cultural resources as described in the TMT Management Plan (Exhibit B) and the Draft Historic Preservation Mitigation Plan attached to the TMT Management Plan as Appendix A.

2.3.3 SCENIC AND OPEN SPACE RESOURCES

As discussed in Section 7 of this CDUA, the proposed TMT project will be visible from the town of Waimea and locations along Highway 250, resulting in only 15.4 percent of the population of Hawai'i island potentially being able to view the TMT Observatory from their residence. In addition, the TMT project will be minimally visible from viewpoints within the summit area. For example, the Project will be visible from the northern ridge of Kūkahau'ula, but will not be visible from the summit of Kūkahau'ula as well as from Lake Waiau which are viewpoints of significant concern. There will be a less than significant effect on scenic and open space resources.

2.3.4 COASTAL ECOSYSTEMS

There are no streams, coastal wetlands or estuaries in the vicinity of this site and it is not located near a Marine Life Conservation District or within the Shoreline Setback Area. The high elevation, limited rainfall, and the porous nature of the cinder of the TMT project site essentially preclude the migration of effluents to coastal areas. Best Management Practices (BMPs) for the control of stormwater runoff from construction will be developed in conjunction with finalization of the site development plans. As construction involves the disturbance of more than 1 acre of land, the TMT Observatory Corporation will prepare an NPDES Stormwater Application (NOI-C) for submission to the Clean Water Branch of the State of Hawai'i Department of Health.

As described in detail in Section 3.8 of the *FEIS,* all potentially hazardous materials will be handled (i.e., transported, used, and disposed of) in accordance with all applicable rules, regulations, and requirements. These include the Resource Conservation and Recovery Act (RCRA), the Emergency Planning and Community Right-To-Know Act (EPCRA), HRS Chapter 342J, Hawai'i Hazardous Waste Law, HAR Title 11, Chapter 260, Hazardous Waste Management General Provisions, HAR Title 11, Chapter 262, Standards Applicable to Generators of Hazardous Waste, and the CMP. The Project will develop and implement a Waste Management Plan (WMP) and a Materials Storage/Waste Management Plan, which will include a Spill Prevention and Response Plan (SPRP). These plans will be overseen by a Safety and Health Officer (SHO). The duties of the SHO will include regular inspection of all Project facilities to evaluate compliance with guidance, rules, and regulations; inspection of equipment and storage areas to detect any inappropriate practices and items needing maintenance; and developing new policies and practices as new rules, regulations, and techniques are developed, including waste minimization practices that could eliminate or replace the use of chemicals in the Project's operation. These plans and policies will be used to manage hazardous materials, solid waste, and hazardous waste. Consequently, there is little likelihood that project-related use of these would affect coastal ecosystems.

2.3.5 ECONOMIC USES

The Hawai'i Coastal Zone Management Program has several provisions related to economic uses. These include attempting to concentrate coastal dependent development (such as harbors

and ports) in appropriate areas and seeing that these uses are conducted in a way that minimizes adverse social, visual, and environmental impacts in the coastal zone. The proposed project lies well away from the coastal areas that this objective seeks to protect.

2.3.6 COASTAL HAZARDS

The activities for which the CDUP is being sought would be conducted far inland. As a result, potential flooding, tsunamis and subsidence are not a concern in relation to the site.

2.3.7 MANAGING DEVELOPMENT

This objective of the Hawai‘i Coastal Zone Management Program is aimed at managing development in such a way as to support the other program objectives. The reviews and approvals that are being obtained for the proposed TMT Observatory Project are designed to ensure that development on Mauna Kea is carried out in accordance with this objective. On April 9, 2009, the BLNR adopted the *Comprehensive Management Plan*. On March 25, 2010, it adopted the four CMP subplans: *Cultural Resources Management Plan*, *Natural Resources Management Plan*, *Public Access Plan* and *Decommissioning Plan*. The CMP and subplans are the comprehensive management documents directing management of the UH Management Areas on Mauna Kea. In addition to these documents, the TMT project has developed the TMT Management Plan, which is included as Exhibit B. The TMT Management Plan is intended to implement the CMP and subplans and incorporates the management actions and strategies of the CMP and subplans. The TMT Management Plan will ensure that appropriate management actions required in the CMP and subplans will be effectively implemented by TMT and in the TMT project area. Collectively, all of these documents are intended to fully, comprehensively, and sustainably manage resources in the UH Management Areas.

2.4 SUBSTANTIAL ADVERSE IMPACT

Describe how the proposed land use will not cause substantial adverse impact to existing natural resources within the surrounding area, community or region.

The existing natural resources and potential impacts of the TMT project are detailed in the attached Final Environmental Impact Statement (*FEIS*) which was accepted by the Governor of the State of Hawai‘i on May 19, 2010. The potential Project impacts were evaluated within the framework of the Project’s compliance with all applicable rules, regulations and requirements; the evaluation assumed implementation of the mitigation measures that had been proposed and implementation of relevant CMP management actions. It should be noted that locating the TMT project within the Northern Plateau (Area E) will result in less than significant impact on wēkiu bug habitat, historic properties and viewplanes, including viewplanes of greatest concern from within the summit area, and existing facilities. The Observatory and Access Way, fall within the Mauna Kea Summit Region Historic District but would have minimal adverse impact on the character of the District. In addition, the portion of the Access Way which follows and goes over an existing single-lane, 4-wheel drive road on the flank of the Pu‘u Hau‘oki cinder cone will result in a minor disturbance of the Kūkahau‘ula Historic Property. It should be further noted that natural resources, such as habitat, species and geology located in the TMT project area are not unique or critical to the survival of any species in the Mauna Kea Science Reserve.

During the construction and decommissioning of the proposed project, there will be temporary adverse impacts due to noise, traffic, dust, visual intrusion, and the increase in human presence on the mountain; possible adverse impacts during construction and decommissioning also include potential disturbance beyond the project limits. Although there is the potential for accidents to occur, through compliance with all applicable rules, regulations, and requirements for the project type and location, these potential temporary impacts associated with construction and decommissioning will be less than significant.

The proposed project will operate in accordance with the TMT Management Plan, CMP and its subplans as well as other relevant rules, regulations and requirements. As documented in the *Final EIS* for the TMT project, the mitigation measures and management actions proposed in the TMT Management Plan found in Exhibit B of this CDUA and summarized in Table 2.1 below together with broader management and mitigation actions implemented in accordance with the CMP and subplans will prevent substantial adverse impact (see right-hand column of Table 2.1).

Table 2.1. Summary of Potential Effects and Mitigation Measures

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
Cultural Practices and Beliefs (*Final EIS* Section 3.2, page 3-8)	After considering the Project mitigation and implementation of CMP management actions, the Project is not anticipated to result in any substantial or significant adverse effect on the cultural practices of the surrounding community or State. The Project has been sited in an area removed from places of highest cultural concern including the Kūkahauʻula traditional cultural property (TCP) and Lake Waiau. The Project will have little impact on the following cultural practices: (1) pilgrimage, prayer, shrine erection and offerings; (2) collection of water from Lake Waiau; (3) piko deposition; (4) scattering of cremation ashes; and (5) burial blessing. In addition, as the Access Way will overlay existing roads, the Project will have little impact on the integrity of cinder cones, including Kūkahauʻula. Although the Project will have some visual impacts, the TMT Observatory and the Access Way will not be visible from areas of highest cultural concern including the summit of the Kūkahauʻula TCP, Pu'u Līlīnoe and Waiau.	CMP FLU-1: Follow design guidelines presented in the *2000 Master Plan*.	The proposed telescope is sited at the 13N site, within Area E, where it will not be visible from culturally sensitive locations, such as the summit of Kūkahauʻula, Lake Waiau, and Puʻu Līlīnoe.	In the context of the current summit region conditions and the view of those who believe cultural practices and astronomy can co-exist, compliance with applicable regulations and requirements together with the implementation of mitigation measures will lessen the potential Project impacts to ensure a level of impact that is less than significant.
		CMP FLU-1: Follow design guidelines presented in the *2000 Master Plan*.	The Access Way has been designed to limit its effect on cultural resources. This has been done by limiting it to one lane (versus the two lanes used elsewhere) and following the same alignment as the existing 4-wheel drive road on the flank of Puʻu Hauʻoki. In addition, coloring the pavement and guardrail to blend with the surroundings will reduce the potential effect on historic resources.	
		CMP CR-3: Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape.	A mandatory Cultural and Natural Resources Training Program will be implemented to educate employees to understand, respect, and honor Mauna Kea's cultural landscape and cultural practices.	
		CMP EO-1: Develop and implement education and outreach program.		
		CMP EO-2: 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.		

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Cultural Practices and Beliefs (*Final EIS* Section 3.2, page 3-8)	Same as on previous page.	CMP EO-3: Continue to develop, update, and distribute educational materials.	Same as on previous page	Same as on previous page.
		CMP EO-2: 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.	The TMT project facilities will be furnished with items to provide a sense of place and acknowledge the cultural sensitivity and spiritual attributes of Mauna Kea.	
		IM-2: Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	TMT project daytime activities will be minimized on up to four days per year identified by Kahu Kū Mauna.	
		CMP CR-3: Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape.	The TMT project's outreach staff will work with 'Imiloa and OMKM to develop exhibits for the Visitor Information Station (VIS) and 'Imiloa regarding the cultural and archaeological resources of Mauna Kea and support/fund programs specific to Hawaiian culture.	
		CMP EO-1: Develop and implement education and outreach program.		
		CMP EO-2: 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.		
		CMP EO-3: Continue to develop, update, and distribute educational materials.		

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Cultural Practices and Beliefs (*Final EIS* Section 3.2, page 3-8)	Same as on previous page.	CMP EO-6: 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.	Same as on previous page.	Same as on previous page.
		CMP EO-7: 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.		
		CMP EO-8: Provide opportunities for community members to participate in stewardship activities.		
		CMP OI-3: Maintain and expand regular interaction and dialogue with stakeholders, community members, surrounding landowners, and overseeing agencies to provide a coordinated approach to resource management.		

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
Historic Properties (*Final EIS* Section 3.3, page 3-40)	The Project will not have a substantial adverse effect on historic properties. The Project will not result in the loss of any historic properties within the Mauna Kea summit region. The physical impacts on the Kūkahauʻula TCP will be minimal and will not rise to the level of significant. Although the TMT project will add a new structure to the Mauna Kea Summit Region Historic District, this structure will be sited in the Northern Plateau, which will make it not visible from a majority of views in the summit including views of greatest cultural concern.	CMP FLU-1: Follow design guidelines presented in the *2000 Master Plan*.	The Access Way has been designed to limit its effect on historic resources. This has been done by limiting it to one lane (versus the two lanes used elsewhere) and following the same alignment as the existing 4-wheel drive road on the flank of Puʻu Hauʻoki. In addition, coloring the pavement and guardrail to blend with the surroundings will reduce the potential effect on historic resources.	The implementation of the treatment/mitigation measures will ensure Project will not result in significant impacts on any historic properties within the summit region.
		CMP FLU-1: Follow design guidelines presented in the *2000 Master Plan*.	The TMT project will be sited in Area E at the 13N site where it will not be visible from culturally sensitive locations, such as the summit of Kūkahauʻula, Lake Waiau, and Puʻu Līlīnoe.	
		CMP CR-3: Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape.	A mandatory Cultural and Natural Resources Training Program will be implemented to educate employees to understand, respect, and honor Mauna Kea's cultural landscape and cultural practices.	
		CMP EO-1: Develop and implement education and outreach program.		
		CMP EO-2: 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.		

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Historic Properties (*Final EIS* Section 3.3, page 3-40)	Same as on previous page.	CMP EO-3: Continue to develop, update, and distribute educational materials.	Same as on previous page.	Same as on previous page.
		IM-2: Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	TMT project daytime activities will be minimized on up to four days per year identified by Kahu Kū Mauna.	
		CMP CR-3: Conduct educational efforts to generate public awareness about the importance of preserving the cultural landscape.	The TMT project's outreach staff will work with 'Imiloa and OMKM to develop exhibits for the VIS and 'Imiloa regarding the cultural and archaeological resources of Mauna Kea and support/fund programs specific to Hawaiian culture.	
		CMP EO-1: Develop and implement education and outreach program.		
		CMP EO-2: 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.		
		CMP EO-3: Continue to develop, update, and distribute educational materials.		
		CMP EO-6: 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.		

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Historic Properties (*Final EIS* Section 3.3, page 3-40)	Same as on previous page.	CMP EO-7: 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. CMP EO-8: Provide opportunities for community members to participate in stewardship activities.	Same as on previous page.	Same as on previous page.

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
Biologic Resources (*Final EIS* Section 3.4, page 3-59)	Potential long-term impacts include displacement of existing species and habitat; dust generated by vehicle traffic along the unpaved Project areas; and paving approximately 1,600 feet of the Access Way. The Access Way will displace roughly 0.2 acre of wēkiu bug habitat on the lower slopes of Puʻu Hauʻoki. The TMT project will displace roughly 6 acres of alpine stone desert lava flow habitat. Other Project areas have previously been disturbed. These impacts are all expected to be less than significant.	CMP NR-1: Limit threats to natural resources through management of permitted activities and uses. CMP NR-3: Maintain native plant and animal populations and biological diversity.	The Access Way has been designed to limit its effect on wēkiu bug habitat. This has been done by limiting it to one lane (versus the two lanes used elsewhere) and following the same alignment as the existing 4-wheel drive road on the flank of Puʻu Hauʻoki. This limits the area of disturbance during construction and operation. In addition, paving this segment of the Access Way will reduce the potential effect on wēkiu bug habitat due to dust.	Implementation of the identified mitigation measures and CMP management actions will ensure that impacts will be less than significant.
		CMP NR-1: Limit threats to natural resources through management of permitted activities and uses. CMP NR-6: Reduce threats to natural resources by educating stakeholders and the public about Mauna Kea's unique natural resources. CMP EO-1: Develop and implement education and outreach program. CMP EO-2: 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. CMP EO-3: Continue to develop, update, and distribute educational materials.	A Cultural and Natural Resources Training Program and an Invasive Species Control Program will be implemented. These programs will educate employees regarding the status, condition, diversity, and protection afforded the natural resources present on the mountain.	

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Biologic Resources (*Final EIS* Section 3.4, page 3-59)	Same as on previous page.	CMP NR-6: Reduce threats to natural resources by educating stakeholders and the public about Mauna Kea's unique natural resources. CMP EO-1: Develop and implement education and outreach program. CMP EO-2: 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. CMP EO-3: Continue to develop, update, and distribute educational materials. CMP EO-6: 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 project staff will work with OMKM and 'Imiloa to develop exhibits regarding natural resources.	Same as on previous page.

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Biologic Resources (*Final EIS* Section 3.4, page 3-59)	Same as on previous page.	CMP EO-7: 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.	Same as on previous page.	Same as on previous page.
		CMP EO-8: Provide opportunities for community members to participate in stewardship activities.		
		CMP OI-3: Maintain and expand regular interaction and dialogue with stakeholders, community members, surrounding landowners, and overseeing agencies to provide a coordinated approach to resource management.		
		CMP NR-1: Limit threats to natural resources through management of permitted activities and uses.	A Ride-Sharing Program will be implemented to reduce traffic, dust, and noise in the summit region.	
		CMP NR-10: Incorporate mitigation plans into project planning and conduct mitigation following new development.	Arthropod monitoring will be performed prior to, during, and for two years following construction in the area of the Access Way on the alpine cinder cone habitat.	

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Biologic Resources (*Final EIS* Section 3.4, page 3-59)	Same as on previous page.	CMP NR-12: Create restoration plans and conduct habitat restoration activities, as needed. CMP NR-13: Increase communication, networking, and collaborative opportunities, to support management and protection of natural resources.	Work closely with OMKM to develop and implement a habitat restoration study.	Same as on previous page.
Visual and Aesthetic Resources (*Final EIS* Section 3.5, page 3-80)	The TMT project will be visible from 14 percent of the island area, restricted to the northern side of the island, including portions of Honokaʻa, Waimea, and Waikoloa. Currently, from approximately 43 percent of the island area, at least one existing observatory is visible, with the Project that will increase by less than 1.2 percent of the island area. Residents in the TMT viewshed represent approximately 15.4 percent of the island's population. Others, including visitors and island residents that reside outside the viewshed, will be able to see the TMT project when they travel through and visit locations within the viewshed. The Project will not block or substantially obstruct the identified views and viewplanes of the mountain, thus the Project's visual impact will be less than significant.	CMP FLU-1: Follow design guidelines presented in the *2000 Master Plan*.	The location of the TMT project is the primary impact avoidance measure, as it is north of and below the summit. The design of the observatory also mitigates the visual impact. The dome has been designed to fit very tightly around the telescope, and the telescope has been designed to be much shorter than usual. Also, the coating of the dome will be a reflective aluminum-like coating, which during the day reflects the sky and reduces the visibility of the structure.	Implementation of the identified mitigation measures and management actions will ensure that impacts will be less than significant.

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
Geology, Soils, and Slope Stability (*Final EIS* Section 3.6, page 3-105)	Hawai‘i is a seismically active area and the Project could be affected by earthquakes. Surface geologic structures present in the Project areas, such as lava flow morphology and glacial features, will unavoidably be removed. These geologic features are neither unique nor exceptional and better examples exist elsewhere on Mauna Kea. Associated impacts will be less than significant.	CMP NR-1: Limit threats to natural resources through management of permitted activities and uses. CMP NR-6: Reduce threats to natural resources by educating stakeholders and the public about Mauna Kea’s unique natural resources. CMP EO-1: Develop and implement education and outreach program. CMP EO-2: 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. CMP EO-3: Continue to develop, update, and distribute educational materials.	The Project will comply with all applicable seismic safety regulations and standards and will minimize the seismic risk to the telescope and equipment through extra design measures. Additional mitigation may include identifying noteworthy examples of glacial features near the Access Way, as well as working with OMKM and ‘Imiloa to develop exhibits to reflect the natural resources of the MKSR.	Mitigation will further reduce the level of impact which will be less than significant prior to any mitigation.
Water Resources and Wastewater (*Final EIS* Section 3.7, page 3-115)	Potential impacts could occur from new impervious surfaces, additional consumption of fresh (potable) water, and additional wastewater discharges. However, due to design features and mandatory compliance with existing requirements and regulations, those impacts are expected to be less than significant.	CMP FLU-1: Follow design guidelines presented in the *2000 Master Plan*. CMP 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.	Compliance measures will include collecting and transporting all wastewater down the mountain for treatment; no wastewater will be released to subsurface in the summit area. Water efficient fixtures will be used and the Waste Minimization Plan (WMP) will also include audits of water use to reduce potable water use.	Project impacts are expected to be less than significant.

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Water Resources and Wastewater (*Final EIS* Section 3.7, page 3-115)	Same as on previous page.	CMP IM-14: Encourage observatories to investigate options to reduce the use of hazardous materials in telescope operations.	Same as on previous page.	Same as on previous page.
Solid and Hazardous Waste and Material Management (*Final EIS* Section 3.8, page 3-124)	While the Project will result in additional generation of solid and hazardous wastes, the associated impacts are expected to be less than significant due to mandatory compliance with existing requirements and regulations.	CMP IM-1: Develop and implement an Operations Monitoring and Maintenance Plan. CMP IM-5: Develop and implement a Debris Removal, Monitoring and Prevention Plan. CMP 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. CMP IM-14: Encourage observatories to investigate options to reduce the use of hazardous materials in telescope operations.	Regulatory compliance will include the implementation of a WMP and a Materials Storage/Waste Management Plan, including a Spill Prevention and Response Plan. No additional mitigation will be required.	Less than significant impact.

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
Socioeconomic Conditions and Public Services Facilities (*Final EIS* Section 3.9, page 3-132)	The proposed TMT project effects in this area are expected to be beneficial and include job creation during Project construction, operation, and decommissioning. During operation, the Project will employ up to 140 full-time employees, and will create additional employment because the Project will contract with local companies for work and services. Project employees will purchase local goods and services, as well as pay local and state taxes, which would provide additional benefits to the community. TMT project employees' impacts on public services and facilities will be beneficial.		Employment opportunities will be filled locally to the greatest extent possible. In addition to its Public Information and Education Office, the TMT project will create a separate Community Outreach office with at least one full-time position dedicated to establishing and implementing the Workforce Pipeline Program and various mentoring and scholarship programs to maximize job opportunities for local residents. The TMT project operations budget will have funds specifically earmarked to provide financial support to workforce development programs, including curriculum and program development. The socioeconomic mitigation measures will ensure that the Project's future employees will include island residents.	Mitigation measures proposed will help maximize the level of beneficial impact.

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
Land Use Plans, Policies, and Controls (*Final EIS* Section 3.10, page 3-141)	The proposed TMT project will be in compliance with all applicable land use plans, policies, and controls for the project type and location. Impacts are expected to be less than significant.	CMP IM-2: Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources. CMP EO-1: Develop and implement education and outreach program. CMP EO-2: 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. CMP EO-3: Continue to develop, update, and distribute educational materials. CMP ACT-7: Confine University or other sponsored tours and star-gazing activities to previously disturbed ground surfaces and established parking areas.	Implementation of the Cultural and Natural Resources Training Plan is intended to reduce potential conflicts with current uses by cultural practitioners. The portion of the Access Way near or through the SMA area (approximately 1,600 feet) will be paved to reduce dust that could impact their operation. TMT project activities at Hale Pōhaku will not displace existing uses, including star-gazing tours.	The level of impact is expected to be less than significant prior to any mitigation. Implementation of mitigation measures will further reduce the TMT project's impact.
Roadways and Traffic (*Final EIS* Section 3.11, page 3-164)	Expected TMT project traffic will not result in the level-of-service on the Mauna Kea Access Road to drop below level C and will not warrant additional road improvements. Impacts are expected to be less than significant.	CMP IM-2: Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	Mandatory participation in a Ride-Sharing Program using Project vehicles for TMT Observatory employees traveling beyond Hale Pōhaku will be implemented.	The level of impact is expected to be less than significant prior to any mitigation. Implementation of mitigation measures will further reduce the TMT project's impact.

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
Power and Communications (*Final EIS* Section 3.12, page 3-169)	The proposed TMT project's electricity consumption will not significantly impact other facilities on the mountain or island-wide. HELCO has ample generation capacity to service the Project. The use of bandwidth for communications would not exceed the Project's allotment. Impacts are expected to be less than significant.	CMP 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. CMP IM-12: Conduct energy audits to identify energy use and system inefficiencies, and develop solutions to reduce energy usage.	Energy saving devices will be incorporated into TMT project facilities, plans including: solar hot water systems, solar panels on the Headquarters facility (photo voltaic power systems), energy efficient light fixtures, and efficient Energy Star rated appliances.	The level of impact is expected to be less than significant prior to any mitigation. Implementation of mitigation measures will further reduce the TMT project's impact.
Noise (*Final EIS* Section 3.13, page 3-173)	Noise associated with the TMT project will not detrimentally affect ambient noise levels or substantially degrade environmental quality in noise sensitive areas.	CMP FLU-1: Follow design guidelines presented in the *2000 Master Plan*.	The TMT project will place HVAC equipment indoors, significantly reducing noise levels associated with the equipment. In addition, façade acoustical louvers and duct silencers will be used to further reduce the level of HVAC noise outside of the observatory. Mandatory participation in a Ride-Sharing Program for TMT Observatory employees traveling beyond Hale Pōhaku will reduce transient vehicular noise.	The level of impact is expected to be less than significant prior to any mitigation. Implementation of mitigation measures will further reduce the TMT project's impact.
Climate, Meteorology, Air Quality, and Lighting (*Final EIS* Section 3.14, page 3-182)	Potential impacts related to dust and exhaust emissions from vehicular travel and emissions related to operation and maintenance activities will not substantially affect the existing air quality or climate. Sky illumination effects will be limited and not substantial. TMT project impacts are expected to be less than significant.	CMP IM-2: Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	Mandatory participation in a Ride-Sharing Program for TMT Observatory employees traveling beyond Hale Pōhaku and paving of a portion of the Access Way will reduce the generation of dust in the summit region.	The level of impact is expected to be less than significant prior to any mitigation. Implementation of mitigation measures will further reduce the TMT project's impact.

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
Construction and Decommissioning (*Final EIS* Section 3.15, page 3-188)	Through compliance with existing rules, regulations, and policies, TMT project construction is not expected to have a substantial adverse impact, as impacts will be temporary and less than significant.	CMP IM-2: Reduce impacts from operations and maintenance activities by educating personnel about Mauna Kea's unique resources.	A Ride-Sharing Program all workers at the TMT Observatory site	The level of impact is expected to be less than significant prior to any mitigation. Implementation of mitigation measures will further reduce the TMT project's impact.
		CMP C-7: Education regarding historical and cultural significance.	The Cultural and Natural Resources Training Program will require annual training of construction workers.	
		CMP C-8: Education regarding environment, ecology and natural resources.		
		CMP EO-2: 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.		
		CMP EO-3: Continue to develop, update, and distribute educational materials.		
		CMP C-2: Require use of Best Management Practices Plan for Construction Practices.	Cultural and Archaeological Monitoring Plan	
		CMP C-1: 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.		

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Construction and Decommissioning (*Final EIS* Section 3.15, page 3-188)	Same as on previous page.	CMP C-5: Require on-site monitors (e.g., archaeologist, cultural resources specialist, entomologist) during construction, as determined by the appropriate agency.	Same as on previous page.	Same as on previous page.
		CMP C-6: Conduct required archaeological monitoring during construction projects per SHPD approved plan.		
		CMP C-2: Require use of Best Management Practices Plan for Construction Practices.	An Invasive Species Prevention and Control Program will be implemented with plans that include materials control and reduction, washing/cleaning, inspections, monitoring, control, and education/training.	
		CMP C-9: Inspection of construction materials.		
		CMP C-2: Require use of Best Management Practices Plan for Construction Practices.	A Construction Best Management Practices (BMP) Plan will be implemented with measures to minimize land disturbance, appropriate manage materials and wastes, and respond to spills, among other measures.	

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Construction and Decommissioning (*Final EIS* Section 3.15, page 3-188)	Same as on previous page.	CMP C-2: Require use of Best Management Practices Plan for Construction Practices.	The TMT project will arrange for more frequent grading of the unpaved Mauna Kea Access Road in order to maintain it in good condition. The Project will endeavor to reduce noise in the vicinity of cultural practices. Connection to HELCO-supplied power will be sought early in the process to eliminate the need for generators, except for limited emergency use. 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.	Same as on previous page.
		CMP SR-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.	The Project will comply with the Decommissioning Plan for Mauna Kea Observatories and will plan for the eventual decommissioning, deconstruction and site restoration of the TMT Observatory and portion of Access Way used exclusively for the TMT Observatory. The plans for decommissioning the Project are described in the TMT Management Plan..	
		CMP SR-2: Require observatories to develop a restoration plan in association with decommissioning, to include an environmental cost-benefit analysis and a cultural assessment.		

FEIS Section	Impact Description	CMP Management Action	Project-Level Mitigation	Impact Level
(Cont'd) Construction and Decommissioning (*Final EIS* Section 3.15, page 176)	Same as on previous page.	CMP SR-3: Require any future observatories to consider site restoration during project planning and include provisions in subleases for funding of full restoration. CMP FLU-3: Require cataloguing of initial site conditions for use when conducting site restoration.	Same as on previous page.	Same as on previous page.

2.5 COMPATIBILITY WITH SURROUNDINGS

Describe how the proposed land use, including buildings, structures and facilities, will be compatible with the locality and surrounding areas, and to the physical conditions and capabilities of the specific parcel or parcels.

The proposed use is situated within the Astronomy Precinct and within the Mauna Kea Science Reserve on Hawai‘i Island. Specifically, the Project will be located in Area E (site 13N) in the Northern Plateau, which is outside of the Kūkahau‘ula summit area. As the Astronomy Precinct is the site of many existing astronomical observatories, the TMT project will be compatible with existing land uses.

As detailed in this CDUA, locating the TMT project in Area E will result in less than significant impact on historic properties, cultural practices and Native Hawaiian rights, as well as viewplanes, species habitat and existing facilities. In addition to this, locating the TMT project in Area E avoids any substantial impact to any cinder cone on Mauna Kea, including Kūkahau‘ula. The TMT project's observatory dome will also be coated with a reflective aluminum-like finish which reflects the colors of the sky and ground, helping the dome to blend in with the surrounding setting. This is intended to mitigate the Project's visual impacts. Based on all of this, the proposed TMT project is compatible with the locality and surrounding areas and to the physical conditions and capabilities of the area.

2.6 PRESERVATION OF ENVIRONMENT

Describe how the existing physical and environmental aspects of the land, such as natural beauty and open space characteristics, will be preserved or improved upon.

As detailed in this CDUA and the supporting documentation, the proposed TMT project will be sited in Area E and will have a minimal physical impact on the summit area cinder cones. The TMT project will not be visible from the summit of Mauna Kea or from Lake Waiau but will be visible from within the Northern Plateau as well as the northern ridge of Kūkahau‘ula, where other astronomical facilities are located and are visible. Views from the northern ridge of Kūkahau‘ula are presently dominated by other astronomical facilities including Subaru, Keck and the Canada-France-Hawaii observatory. It should be noted that, due to the TMT project’s design, the TMT will be at a lower elevation and various changes have been made to the dome and support structure to minimize the Project’s visibility. It will not block the view of Maui from the northern ridge. The Access Way for the Project incorporates design components that are intended to mitigate visual impacts, including the coloring of pavement (where used) to better blend with the surroundings. The Project, however, will still add a visual element to the Northern Plateau.

From outside of the Mauna Kea summit area, the TMT project will be visible to approximately 15 percent of the Hawai‘i island population. This includes views from the town of Waimea and along portions of Highway 250. The Project will not substantially block or obstruct existing views of Mauna Kea from around the Island of Hawai‘i. In the context of the existing observatories and the fact that the TMT project will not obstruct existing views, its visual impact is less than significant. A visual impact analysis may be found in Section 3.5 of the *Final EIS*.

Although the proposed TMT project will add a new element to the Northern Plateau, no substantial change to the natural topography will occur.

2.7 CHANGES IN INTENSITY OF LAND USE DUE TO SUBDIVISION

If applicable, describe how subdivision of land will not be utilized to increase the intensity of land uses in the Conservation District.

The proposed TMT project does not involve the subdivision of land.

2.8 PUBLIC HEALTH, SAFETY AND WELFARE

Describe how the proposed land use will not be materially detrimental to the public health, safety and welfare.

The proposed project has been designed/will be operated in a manner that will preserve public health, safety, and welfare. It does not entail substantial air emissions, but construction and operation of the proposed facilities will involve activities that produce sanitary wastewater and involve the storage/use/disposal of hazardous materials. Design and operational measures related to each aspect of the project that has the potential to affect these values are summarized below. Additional information is provided in the *FEIS.*

2.8.1 COLLECTION AND TREATMENT OF SANITARY WASTEWATER

The proposed TMT project will contain and properly dispose of all of the wastewater that it produces in a manner that will protect public health, safety, and welfare. In compliance with CMP Management Action FLU-7, the TMT project will not discharge any wastewater at the project site (see Section 3.7 of the *Final EIS* for more detail). The TMT Observatory will use a zero-discharge sanitary waste system at the project site. All sanitary wastewater will be collected, held in tanks designed for that purpose, and transported off the mountain for treatment and disposal at facilities approved by the State of Hawai‘i Department of Health.

2.8.2 COLLECTION, HANDLING, AND DISPOSAL OF SOLID WASTE

TMT Observatory Corporation and its contractors will comply with applicable Federal, State, and County health and safety-related rules and regulations, as well as with applicable provisions of the CMP.

Collection, Storage, and Disposal of Construction Waste. The great majority of the materials that will be used to construct the proposed project will be shipped in from off-island. A substantial proportion of the unpacking and preparation will occur near the port where the materials are landed on the island. The packing material in which they arrive will be collected, recyclable materials will be separated and sent to an approved recycling facility, and the remainder will be trucked to an approved landfill or other waste disposal facility selected by the construction contractor. Construction activities at the TMT site will also produce construction wastes, and these will be handled in a fashion similar to that described above. The construction contract will require the contractor to remove waste frequently so that there is no unnecessary build-up of waste materials. It will also direct the contractor to follow construction waste

minimization guidelines developed by the State of Hawai‘i Department of Business, Economic Development, and Tourism.[14]

Collection, Storage, and Disposal of Solid Waste from Operations. Based on data from the existing Keck Observatory, operation of the TMT project is expected to generate approximately 120 cubic feet (~4.5 cubic yards) of solid waste each week over the lifetime of the project.[15] This waste will consist principally of paper, spent containers, and limited amounts of garbage from eating areas and offices. To the extent possible, the Project intends to collect and recycle scrap metal, plastic, and glass; toward this end it will provide recycling containers at appropriate locations throughout the facility. Waste that cannot be re-used on-site will be transported off of Mauna Kea for disposal at recycling centers and/or approved landfills. In compliance with the CMP, all waste will be stored indoors in closed trash containers in order to prevent providing a potential food source for invasive fauna.

TMT Waste Minimization Plan: The TMT project will also develop a Waste Minimization Plan (WMP) and a Materials Storage/Waste Management Plan. The goal of the WMP will be to keep the level of solid waste generated by operation of the proposed TMT project at a level well below that of comparably sized facilities. These plans will be overseen by a Safety and Health Officer (SHO). The duties of the SHO will include regular inspection of TMT project facilities to ensure compliance with relevant rules and regulations, inspection of equipment and storage areas, and development of new policies including waste minimization practices.

The TMT project’s WMP will comply with the State of Hawai‘i WMP and will contain policies and procedures for efficient Project operation, handling of waste, annual audits, and the utilization of best practices and technologies concerning solid waste generation and management. The WMP will be regularly updated to ensure the WMP includes the most current methods and practices. The Materials Storage/Waste Management Plan will detail protocols for proper handling, storage, use and disposal of waste. Based on the above measures as well as the Project's compliance with existing rules and regulations, the TMT project will result in a negligible, adverse impact with regard to solid waste and waste management. Section 3.8 of the *Final EIS* discusses the TMT project's handling of solid waste in more detail.

2.8.3 HANDLING AND TRANSPORT OF HAZARDOUS MATERIALS

Similar to existing observatories on Mauna Kea, operation of the TMT Observatory will entail the controlled use of a variety of hazardous materials. These include vehicle and generator fuel, alcohols used for optics and general cleaning, liquid adhesives for optics bonding, various metals used for coating deposition materials, lubricants, hydraulic fluid, glycol coolants, and small quantities of acids, paints, and solvents. In handling these, it will comply with all applicable regulations, including the following:

- Resource Conservation and Recovery Act (RCRA);
- Emergency Planning and Community Right-To-Know Act (EPCRA);

[14] See *A Contractor’s Waste Management Guide Best Management Practices and Tools for Job Site Recycling and Waste Reduction in Hawai‘i*. Prepared by O’Brien & Company for The State of Hawai‘i, Department of Business, Economic Development, and Tourism’s Clean Hawaii Center.

[15] To put this into perspective, a typical home outside garbage can holds 32 gallons, or approximately 5 cubic feet; the larger containers now used for automated curbside pickup hold about 10 cubic feet.

- Hazardous Waste Operations and Emergency Response;
- HRS Chapter 342J, Hawai‘i Hazardous Waste Law;
- HAR Title 11, Chapter 260, Hazardous Waste Management General Provisions;
- HAR Title 11, Chapter 262, Standards Applicable to Generators of Hazardous Waste;
- Occupational Safety and Health Administration (OSHA), Title 29, Code of Federal Regulations, Section 1910.120; and
- HAR Title 12, Chapter 74.1, Hawai'i Occupational Safety and Health.

All hazardous materials will be stored in areas and/or containers with secondary containment that will capture any material that accidentally escapes from the primary storage unit. This will prevent a release to the surrounding environment in the event of an equipment malfunction or accident. Storage containers and containment areas will be inspected daily to insure that they are intact and functional. It should be noted that instead of toxic solutions, a non-toxic ethylene glycol solution of 35 to 40 percent by volume will be used for the chilled water system. The TMT Observatory's emergency generator will be served by a 2,000 gallon capacity diesel fuel tank in a double-containment system located outside and above-ground in a concrete-lined protected area. No mercury will be used by the Project.

To minimize the potential for an accidental spill of hazardous waste when it is being transported away from the project site to an approved disposal facility, the waste will be shipped in a closed container that will not be filled to the top of the container. Furthermore, the TMT project will utilize only EPA-permitted and licensed contractors to transport any hazardous wastes off the mountain for proper disposal. In addition to this, the TMT project will examine more frequent removal of wastes from the Project in order to reduce the amount of hazardous materials and waste stored on Mauna Kea. All of these measures will minimize the potential for the release of hazardous materials to the surrounding environment during transportation. In this regard, it is worth noting that no releases have occurred during transport of the hazardous materials used by existing observatory facilities on Mauna Kea.

Materials Storage/Waste Management Plan and Spill Prevention and Response Plan: As previously detailed, the TMT project will develop a Materials Storage/Waste Management Plan and component Spill Prevention and Response Plan that will establish protocols for proper handling, storage, use and disposal of hazardous materials/waste. Standard practices and emergency procedures will be outlined in compliance with applicable rules and regulations. The plan will outline steps to be taken to ensure that the accidental occurrence of a spill is minimized and, that if a spill did occur, that it will be quickly managed. Should a spill occur, observatory spill response procedures will include the notification of the Office of Mauna Kea Management, including all required authorities, of any release or spill of a reportable quantity of any hazardous material. Written safety procedures for both the handling and disposing of hazardous materials will be included in the plan along with emergency procedures for attending to spills of hazardous waste. All workers involved in the handling of hazardous materials will undergo specialized training, including proper implementation of all plan procedures and actions. Material Safety Data Sheets (MSDS) and warning and handling data will be collected and kept on file at the location of use and storage. The plans will also require inspections to ensure that systems are working properly, no leaks are occurring, and any necessary maintenance measures are taken.

Based on the above measures as well as the Project's compliance with existing rules and regulations, the TMT project will result in a negligible adverse impact concerning hazardous materials. Section 3.8 of the *Final EIS* discusses the TMT project's handling of hazardous materials in more detail.

2.8.4 COLLECTION AND TREATMENT OF MIRROR WASHING WASTEWATER

The TMT project design includes a separate mirror laboratory for mirror washing. The laboratory is designed to collect waste from the mirror washing and coating area floor drain and laboratory sinks into double-contained piping. The piping will drain by gravity to a double-walled holding tank sized to accommodate at least one week's worth of normal use plus the volume needed to allow for fire-suppression sprinkler discharge. Each point of exit from the mirror stripping area will have a trench drain that will drain to the storage tank. All exposed concrete in areas of chemical use will have a chemical resistant coating applied. A leak detection system will be installed and will monitor the double contained pipes and tank. A level control system will monitor the tank and be equipped with an overfill alarm and automatic cutoff that will be triggered in the event the level in the tank reaches 90 percent capacity. The waste collected from the mirror washing process will be collected, removed, and transported off site for treatment and disposal.

Mirror washing wastewater may possibly contain low concentrations of certain low-toxicity dissolved metallic compounds; it is not expected to be characterized as hazardous waste, but will be treated as such until test results confirm that it is not. Regardless of the outcome of the testing, the mirror washing wastewater will be handled, transported, and disposed of using procedures similar to those used for hazardous materials as detailed in Section 2.9.3 above. Section 3.8 of the *Final EIS* discusses the TMT project's handling of mirror washing wastewater in more detail.

2.8.5 SOUND LEVELS

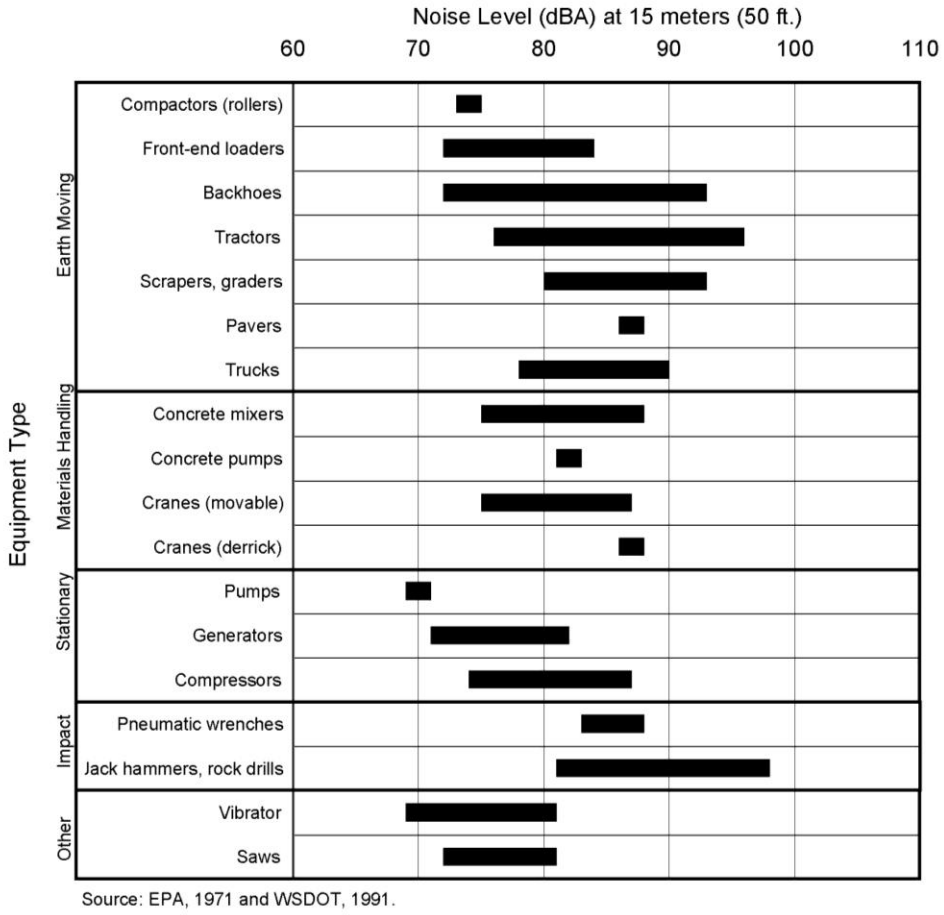
Construction Noise. Construction of the proposed facilities, particularly Observatory site and Access Way grading, will involve the use of heavy construction equipment, including that needed for excavation of relatively dense rock. It will also entail periodic operation of construction equipment on the concrete Batch Plant Staging Area site. Figure 2.1 shows the range of noise levels that can be expected from the different types of construction equipment. Short periods of blasting may also be necessary to dig foundations for the TMT Observatory. Noise during construction will be sufficiently loud to be audible for some distance from the construction work sites (Observatory, Access Way, and Batch Plant). The nature of the work that would be done at the existing Substation and within the electrical power line and communications corridor is such that only low levels of construction noise will result.

As illustrated in the tabulation to the right, construction noise decreases at a rate of 6 to 8 dBA per doubling of the distance from the source once more than 50 feet from the source. For example, as illustrated in the tabulation to the right, if the noise level is 90 dBA at 50 feet from a jackhammer, it would be reduced to approximately 83 dBA at 100 feet and 76 dBA at 200 feet. Doubling the number of noise sources would increase the noise level by 3 dBA. In the above

Distance from Source (feet)	Noise Level (dBA)
50	90 dBA
100	83 dBA
200	76 dBA
400	69 dBA
800	62 dBA
1,600	55 dBA
3,200	49 dBA

example, two jackhammers operating together would generate a noise level of 93 dBA at 50 feet. As the Subaru Observatory (the facility nearest to the TMT Observatory construction site) is roughly 2,500 feet away, even the loudest construction activity on the TMT Observatory site will produce noise levels of just over 50 dBA at the Subaru Observatory which is equivalent to the measured noise background levels in the summit region. Sound levels from other construction equipment would be substantially lower.

Figure 2.1: Typical Construction Equipment Noise Levels



Source: EPA, 1971 and WSDOT, 1991.

HAR §11-46 establishes noise standards for various zoning districts and time periods (see Table 2.2. These limits are applicable at the property line, which for the purpose of determining compliance is assumed to be the boundary of the area that TMT would lease. As some construction activities are expected to produce sound levels substantially above the property line limit, a noise permit will be sought from the State of Hawai‘i Department of Health in accordance with HAR §11-46-7 to allow noise levels to exceed those typically permitted. A noise variance will also be obtained under HAR §11-46-8 for construction of the TMT Observatory so that work could be performed beyond normal work hours. Noise impacts

associated with construction will be mitigated through compliance with conditions set forth in Noise Permits and the Noise Variance obtained by the Project for construction activities.

Table 2.2. HAR §11-46 Noise Standards (in dBA)

Zoning Districts	Daytime (7 a.m. to 10 p.m.)	Nighttime (10 p.m. to 7 a.m.)
Class A	55	45
Class B	60	50
Class C	70	70

Table Notes:

(1) Class A zoning districts include all areas equivalent to lands zoned residential, conservation, preservation, public space, open space, or similar type.

(2) Class B zoning districts include all areas equivalent to lands zoned for multi-family dwellings, apartment, business, commercial, hotel, resort, or similar type.

(3) Class C zoning districts include all areas equivalent to lands zoned agriculture, country, industrial, or similar type.

(4) The maximum permissible sound levels apply to any excessive noise source emanating within the specified zoning district, and at any point at or beyond (past) the property line of the premises. Noise levels may exceed the limit up to 10% of the time within any 20-minute period. Higher noise levels are allowed only by permit or variance issued under sections 11-46-7 and 11-46-8.

(5) For mixed zoning districts, the primary land use designation is used to determine the applicable zoning district class and the maximum permissible sound level.

(6) The maximum permissible sound level for impulsive noise is 10 dBA (as measured by the "Fast" meter response) above the maximum permissible sound levels shown.

Source: Hawaii Administrative Rules §11-46, "Community Noise Control"

Operational Noise. As discussed in more detail in Section 3.13 of the *Final EIS*, existing ambient sound levels on and immediately around the site of the proposed TMT Observatory facilities are highly variable, primarily as a function of wind speed and proximity to existing roadways. Measurements of sound levels in the summit region were recorded on October 21, 2009. The Puʻu Wēkiu/Kūkahauʻula Summit and Trailhead measurement locations experienced measured noise levels of 47 and 49 dBA Leq, and 50 and 53 dBA L_{10}. Sounds from existing observatory HVAC exhaust systems were not noticeable during the summit location field measurement. When the sound measurements were taken, the wind speed was 5 to 14 miles per hour, which is on the lower range of typical wind speeds in the summit region. Despite this, wind noise was generally the dominant noise source at the remote sites; this is typical for such locations.

Heating, ventilation, and air-conditioning (HVAC) equipment at the proposed facility will produce mechanical noise that is not now present. The TMT Observatory HVAC equipment (which would be used to cool the dome during the daytime so that heat from it does not degrade viewing conditions during the nighttime observing hours, among other needs) will be similar in function to the systems currently in use by existing observatories and will be no louder than the existing equipment.

To mitigate any impacts related to HVAC equipment and noise generation, the HVAC equipment will be placed indoors. By doing so, the noise levels outside the building associated

with HVAC equipment motors, evaporators and condensers will be significantly reduced. In addition to placing the equipment indoors, the exhaust for the HVAC equipment will be directed through a tunnel duct that exits on the northwest side of the observatory, which faces away from noise sensitive areas such as the Mauna Kea summit. Noise reduction measures such as acoustical louvers, tunnel duct wall treatments and duct silencers will be used to minimize sound emissions. Other openings such as air intake locations will also utilize these measures.

The sound level estimates in the *Final EIS* show that the proposed project will comply with the applicable State of Hawai‘i Department of Health noise standards (HAR §11-46). They also show that at a distance of less than approximately 500 feet from the HVAC tunnel outlet noise from the proposed facility is likely to be at or below existing background levels on days with moderate wind speeds. On days with low wind speed (and, therefore, lower background wind noise), sound from the HVAC equipment would not be audible at distances greater than approximately 1,000 feet. All identified noise sensitive areas in the summit region, including the trailhead and summit of Pu’u Wēkiu/Kūkahau‘ula, Lake Waiau, and Pu‘u Līlīnoe, will be more than 1,000 feet from the TMT Observatory HVAC system.

It should also be noted that the TMT project will institute a Ride-Sharing Program for TMT observatory staff in order to, among other things, mitigate transient noise generated by commuting TMT Observatory employees. Section 3.13 of the *Final EIS* discusses the TMT project's handling of noise generation in more detail.

3 Existing Site Information

3.1 DESCRIPTION OF EXISTING STRUCTURES

There are no existing structures on the TMT Observatory site, the Access Way right-of-way, or the Batch Plant site.

3.2 DESCRIPTION OF CURRENT LANDSCAPING/GRADING

No landscaping is present within any of the areas that would be used for the proposed project. More importantly, the lack of rain and high altitude, as well as the desire to protect the sparse native biota from introduced species, mean that the introduction of landscape features is best avoided.

The Batch Plant site was graded initially during the 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. Approximately one-third of the existing Access Way right-of-way has been graded during previous work in the area; this includes segments that were cleared as part of the SMA Observatory project and others that were graded to provide access for site investigations in Area E. Approximately one-tenth of the site proposed for the TMT Observatory has been previously disturbed. Existing topography on the proposed Observatory and Access Way sites is shown in Figure 3.1 and Figure 3.2, respectively.

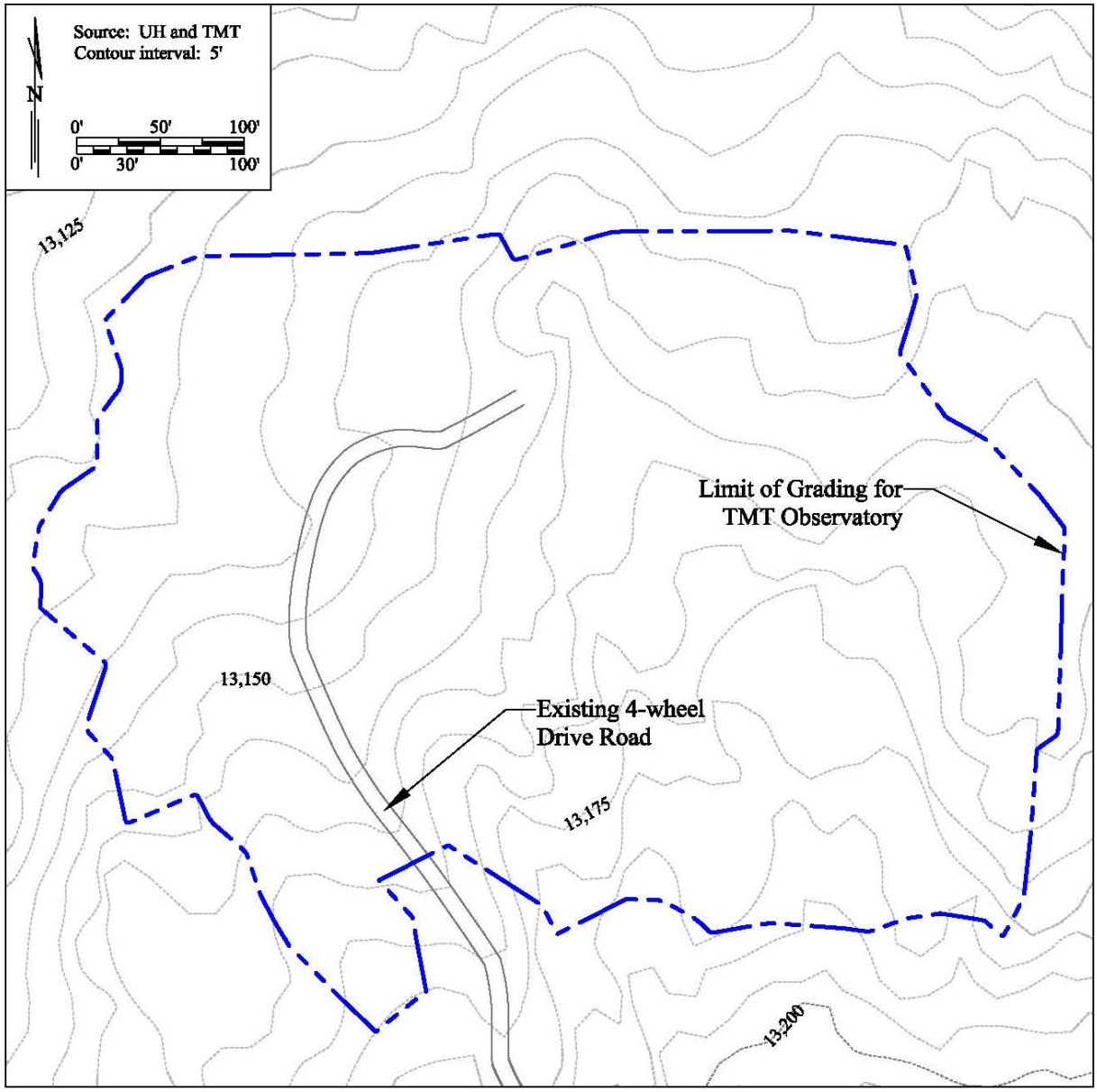
3.3 DESCRIPTION OF EXISTING UTILITIES

There is no existing utility service to the site of the proposed TMT Observatory. Hence, all service will require the installation of new facilities.

Electrical Power. As described in Section 1.3.4, the nearest electrical service originates at HELCO's Hale Pōhaku substation and terminates near the existing SMA Building as shown on Figure 1.8. The substation consists of two 3,000 kilovolt-ampere (kVA) transformers, with a total capacity of 6,000 kVA (or 5,400 kilowatts (kW) assuming a system power factor of 0.9). An underground 12.47 kV dual loop feed system from the substation services the observatory facilities, including the SMA, the closest facility to Area E. The existing peak demand load documented by HELCO at the substation, including all the observatories and the Hale Pōhaku facilities, is 2,230 kW, less than half of the capacity of the substation.

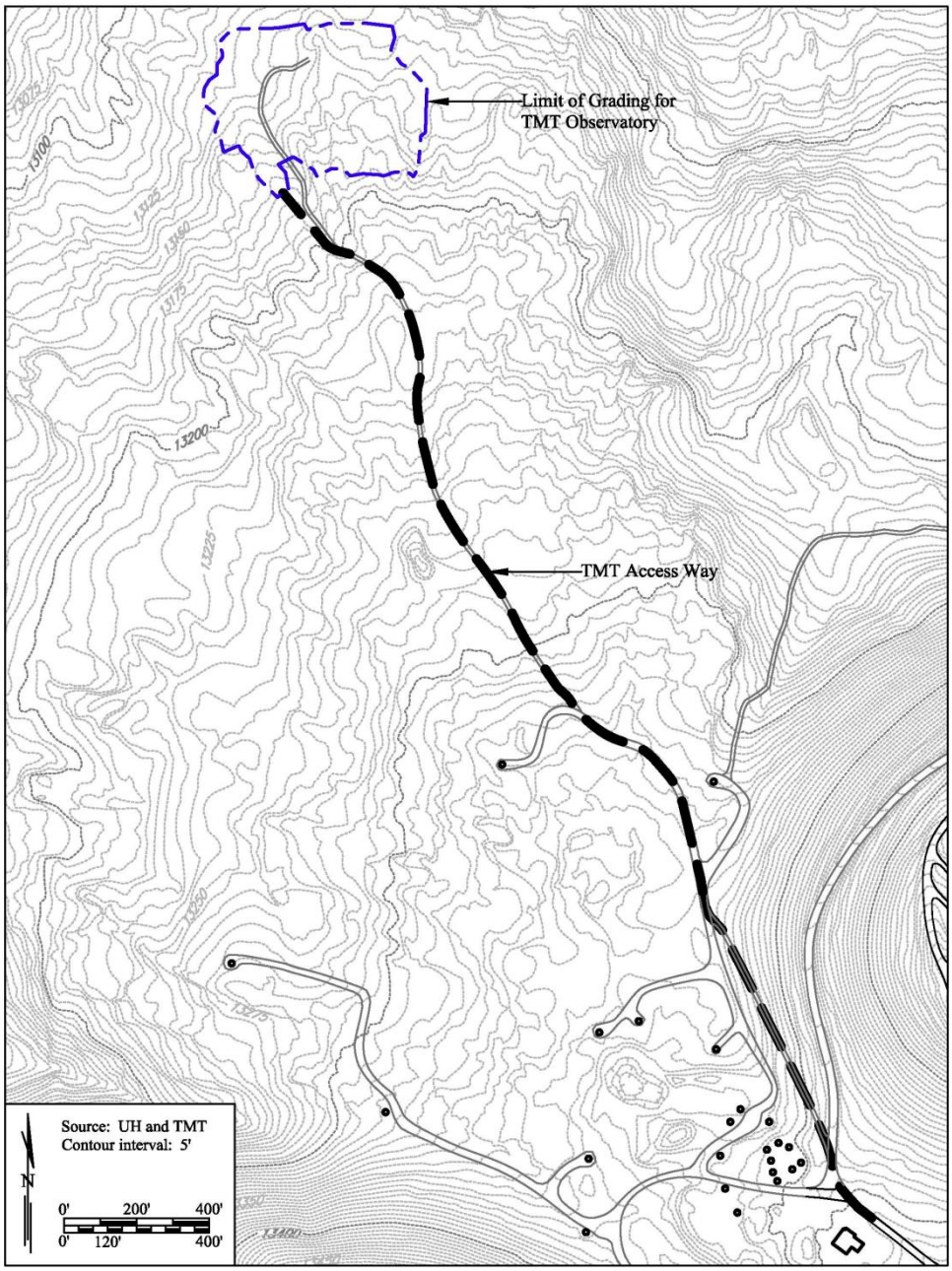
Communications. The first underground communications system was installed on the mountain at the same time the underground power distribution grid was installed. In the mid-1990s, the installation of underground fiber optic lines provided high speed communications capability to the observatories using a Hawaiian Telcom fiber cable. The fiber optic communications system services the same facilities as the power distribution system, and allows for data flow between the summit and off-mountain base facilities, thereby supporting remote observing.

Figure 3.1. Existing Topography on the Proposed TMT Observatory Site.



Source: TMT Observatory Corporation

Figure 3.2. Existing Topography Along the Proposed TMT Access Way.



Source: University of Hawai'i and TMT Corporation, 2010-06-30

Water. Mauna Kea Observatories Support Services (MKSS) contracts with a trucking company to deliver potable water from Hilo to the summit observatories in 5,000-gallon-capacity tank trailers that are owned by MKSS. Each observatory stores its own water and is responsible for the maintenance of its water tanks; observatories also use 5-gallon water jugs for drinking water. Water is trucked to the summit about twice a week for an annual average of approximately

502,500 gallons over the past three years, which indicates a combined daily use of roughly 1,400 gallons.

Domestic Wastewater. Each observatory operates its own wastewater system to collect and treat domestic wastewater, pursuant to the permits issued by the Hawai‘i State Department of Health (HDOH). Existing restroom facilities at the summit available for visitor use include four portable toilets and the restrooms located in the Keck Observatory. The portable toilets are located at two different parking areas and are moved between the sites as needed. Portable toilets are serviced weekly and pumping is done on-site.

3.4 EXISTING ACCESS (ROADWAYS/PUBLIC TRAILS)

This section describes the existing roadways and public trails on Mauna Kea. For a more thorough discussion of the project's potential impacts on roadways and traffic see Section 3.11 of the *Final EIS*. Additional details on the project's potential impacts on public trails may be found in Section 3.2 of the *Final EIS*.

3.4.1 ROADWAYS

Saddle Road, Route 200, connects Hilo to Māmalahoa Highway near Waimea and gets its name because it crosses the island through the saddle between Mauna Kea and Mauna Loa. Saddle Road reaches an elevation of 6,632 feet above mean sea level (msl) at its highest. Near that location 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 Pu‘u Kea, Pu‘u Hau‘oki, and an unnamed pu‘u cinder cone 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. The road is paved again above 11,600 feet. A portion of the loop is unpaved between the Keck Observatory and the SMA.

The existing observatories have mostly 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 trail extends into and runs through the middle of Area E to the 13N site on which the proposed TMT Observatory would be constructed, where it ends.

3.4.2 PUBLIC TRAILS

There are several trails that traverse the Mauna Kea summit region. Traditional accounts suggest that some ancient trails were present in that area. In some cases it is unknown if the current trails follow the same route as the ancient trails and in some cases it is known that current trails are on different alignments from ancient trails. Two of the trails in the summit region (see Figure 5.1) are:

- *Mauna Kea–Humu‘ula Trail*. This is probably the best known trail, and it apparently began in the Kalaieha area where the Humu‘ula Sheep Station is located and extended past Hale Pōhaku to Lake Waiau. The Mauna Kea-Humu‘ula Trail is historic in age and is a historic trail as

defined in the Highways Act of 1892. Today the trail begins near Hale Pōhaku and ends at Lake Waiau.

- *Mauna Kea–ʻUmikoa Trail*. This trail is not mentioned in early accounts, and it first appears on maps in the 1920s. The trail enters the MKSR between Puʻu Mākanaka and Puʻu Hoaka on the northeastern slope, passes below and west of Puʻu Līlīnoe, and intersects the Humuʻula Trail near Lake Waiau.

None of these trails are near the TMT Observatory or Access Way. Some people park at the Batch Plant Staging Area to walk along the trail to Lake Waiau.

3.5 FLORA AND FAUNA

This section describes the existing flora and fauna on Mauna Kea, summarizing the more detailed information contained in Section 3.4 of the *Final EIS*.

3.5.1 FLORA

There are two general vegetation types/ecosystems or habitats in the Mauna Kea summit region. Alpine Shrublands and Grasslands is generally the area from 9,500 feet (the tree line) to 12,800 feet. Alpine Stone Desert is the area above 12,800 feet. Vegetation generally decreases in diversity, density, and size towards the summit of the mountain, moving from alpine shrublands and grasslands above the tree line, at roughly 9,500 feet, to a stone desert above 12,800 feet. Area E, the Access Way, and the Batch Plant Staging Area are located in the alpine stone desert. The plant community in the alpine stone desert consists of several species of mosses and lichens, and a limited number of vascular plants.

- *Lichens*. The highest densities and diversity of the 21 known species of lichens tend to grow on north and west facing rocks in protected locations away from direct early morning sun exposure. A recent survey of Area E detected 10 species of lichens.[16] All of the species encountered also occur at somewhat lower elevations and none are unique to Hawaiʻi. The low diversity and extremely low cover (less than 1 percent) may be due to a lack of suitable habitat.
- *Mosses*. The 12 species of mosses reported to be present in the alpine stone desert occur in habitats partially protected by rock overhangs, or in deeply shaded pockets and crevices. Availability of water appears to be the most important factor determining the distribution of mosses. Two species of mosses were detected during the recent botanical survey of Area E. Both species are indigenous to Mauna Kea, and occur elsewhere Hawaiʻi and the world.
- *Vascular Plants*. Vascular plants that survive in the alpine stone desert occur mainly at the base of rock outcrops where there is an accumulation of soil and moisture, and some protection from wind. Six species are reported from the summit region: two Hawaiian endemic grasses, Hawaiian bentgrass (*Agrostis sandwicensis*) and pili uka (*Trisetum glomeratum*); two naturally occurring ferns, ʻiwaʻiwa (*Asplenium adiantum-nigrum*) and Douglas' bladderfern (*Cystopteris douglasii*); and two exotic daisies, Hairy cat's ear (*Hypochoeris radicata*) and

[16] This is relatively low for this elevation on Mauna Kea. This may be due to the fact that Area E is composed principally of solid lava flows rather than the mounds of rock that are more typical of other areas at approximately the same altitude.

common dandelion (*Taraxacum officinale*). Seven vascular plant species were detected in Area E during the recent botanical survey, all present in low abundance. The endemic spleenwort, ʻoāliʻi (*Asplenium trichomanes* subsp. *densum*) was uncommon in Area E, occurring in crevices of rocks. This species, not previously reported from the alpine stone desert, is locally abundant in full sunlight in open areas on lava fields and in kīpuka from 3,950 to 8,850 feet on East Maui and Hawaiʻi. The Hawaiian endemic Douglas' bladderfern was observed and is known to occur at high elevations on Haleakalā and Mauna Kea but also occurs in moist forests on Kauaʻi, Oʻahu, Lānaʻi, and Maui, and is a U.S. Fish and Wildlife Service (USFWS) species of concern. In the summit region, this fern is more common to the east, in the vicinity of Area F, near an existing unimproved dirt roadway, where several patches occur.

3.5.2 FAUNA

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 Hawaiʻi, 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.

The wēkiu bug lives only in loose cinder habitats on the cinder cones above 11,715 feet on Mauna Kea. The wēkiu bug is a small "true bug" that has made a remarkable adaptation in feeding behavior. Many true bugs, including most of those found elsewhere in Hawaiʻi, are herbivores and feed on seeds and plant juices. The wēkiu bug is a scavenger that uses its straw-like mouth to feed on insects blown up to the summit area from the surrounding lowlands. These aeolian insects accumulate in protected pockets on the cinder cones; they quickly become moribund in the cold and thus easy prey for foraging wēkiu bugs who have adapted to the harsh conditions of the summit area. Wēkiu bugs are generally concentrated on the cinder cones in the summit area, but also utilize other habitats.

Six arthropod habitat types have been identified in the alpine stone desert.

- *Type 1 – Snow patches*: Seasonal patches of snow accumulate insects that are blown up the mountain from lower elevations. Wēkiu bugs are thought to exploit the edges of these patches, feeding on aeolian insects as they emerge from the melting snow.
- *Type 2 – Tephra ridges and slopes*: On cinder cones, where tephra cinders are large enough (≥1 cm), wēkiu bugs, spiders, caterpillars (*Agrotis* sp.) and smaller arthropods are able to move within the interstitial spaces and utilize humid, protected microhabitats among the tephra. This is the habitat where wēkiu bugs are observed in greatest abundance. Smaller arthropods, like springtails (*Collembola*), and mites inhabit smaller (≤1cm) tephra cinders.

- *Type 3 – Loose, steep tephra slopes*: The unstable steep outside slopes of cinder cones where tephra cinders are smaller and subject to downward creep. Wēkiu bugs are present in low abundance in this habitat.
- *Type 4 – Lava flows*: ʻaʻa and pāhoehoe lava flows with large outcrops of andesitic rocks. This is the principal habitat for lichens and mosses, lycosid wolf spiders, and centipedes. Wēkiu bugs are uncommon in this habitat, presumably because of the lack of suitable microhabitat.
- *Type 5 – Talus slopes and highly fractured rock outcrops*: Usually found as islands within Type 4 habitat, these are areas of talus slopes, highly fractured rock outcrops, and depressions between lava flows with glacially deposited, rounded cobbles and rocks lie on fine loess. Small voids provide suitable microhabitats for wēkiu bugs which can occur in moderate abundance during times of high population outbreaks.
- *Type 6 – Compacted ash, silt, and mud*: Found on roadways, disturbed areas, and where fine aeolian loess accumulates. The interstitial spaces are mostly filled with fine-grained material and therefore not suitable for wēkiu bugs and lycosid spiders. Springtails and mites are the most abundant arthropods in this habitat type.

The great majority (greater than 95 percent) of the area that would be disturbed by construction of the proposed Observatory and Access Way consists of Type 4, 5, and 6 habitats. Surveys conducted in 2008 and 2009 show these to be free of wēkiu bugs. Only one percent of the area that would be disturbed consists of Type 3 habitat, which the spring 2009 survey showed had a few members of this species. No wēkiu bugs were identified in the affected Type 3 habitat in the summer of 2008.

3.5.3 THREATENED AND ENDANGERED SPECIES

No currently-listed threatened or endangered species are known to occur in the Astronomy Precinct.[17] 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 listing and is known to occur on a number of cinder cones above an elevation of 11,700 feet; they are most common in Type 2 habitat but are also known to frequent Type 3 habitat. As discussed above, a few wēkiu bugs were found in the Type 3 habitat at the southern end of the proposed Access Way during a survey conducted in the Spring of 2009.

One species currently considered a species of concern by the 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 and is more common to the east, in the vicinity of Area F. Area E is not considered critical habitat for the Douglas' bladderfern.

[17] An individual commenting on the Draft EIS reported that an ʻio (*Buteo solitaries*), the endangered Hawaiian Hawk, has been observed circling above the summit region on occasion. ʻIo 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.

The ʻuaʻu (*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.

3.6 TOPOGRAPHY DESCRIPTION

As noted in Section 1.2, the *2000 Master Plan* designates Area E (which includes the TMT site) as a location for future development of astronomical facilities. 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 is not believed that significant lava tubes exist; however, geotechnical borings need to be completed to confirm subsurface conditions.

Approximately one-tenth of the 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 Observatory project and others that were graded in the 1960s for site testing at the 13N site. The Batch Plant Staging Area 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.

3.7 DESCRIPTION OF EXISTING ENCUMBRANCES

Through General Lease No. S-4191, the University of Hawaiʻi 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 University of Hawaiʻi 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".

4 Cultural Resources

4.1 DESCRIPTION OF HISTORIC PROPERTIES AND TRADITIONAL & CUSTOMARY PRACTICES

This section describes the historic properties found in the areas of the Proposed Action. Section 3.2 of the *Final EIS* for the TMT project provided information on traditional and customary practices carried out at or associated with Mauna Kea. Section 3.3 of the *Final EIS* provided data on currently known historic and cultural resources on Mauna Kea, including the areas of the Proposed Action. Additional information has been drawn from the recently completed report documenting the archaeological inventory survey of the Mauna Kea Science Reserve (McCoy & Nees 2010).[18]

4.1.1 DESCRIPTION OF HISTORIC PROPERTIES IN THE VICINITY OF THE TMT OBSERVATORY SITE AND THE ACCESS WAY

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 SHPD's *Mauna Kea Historic Preservation Plan Management Components* (SHPD 2000).[19] 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 (McCoy & Nees 2010). 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 Hawaii Administrative Rules §13-275-6.

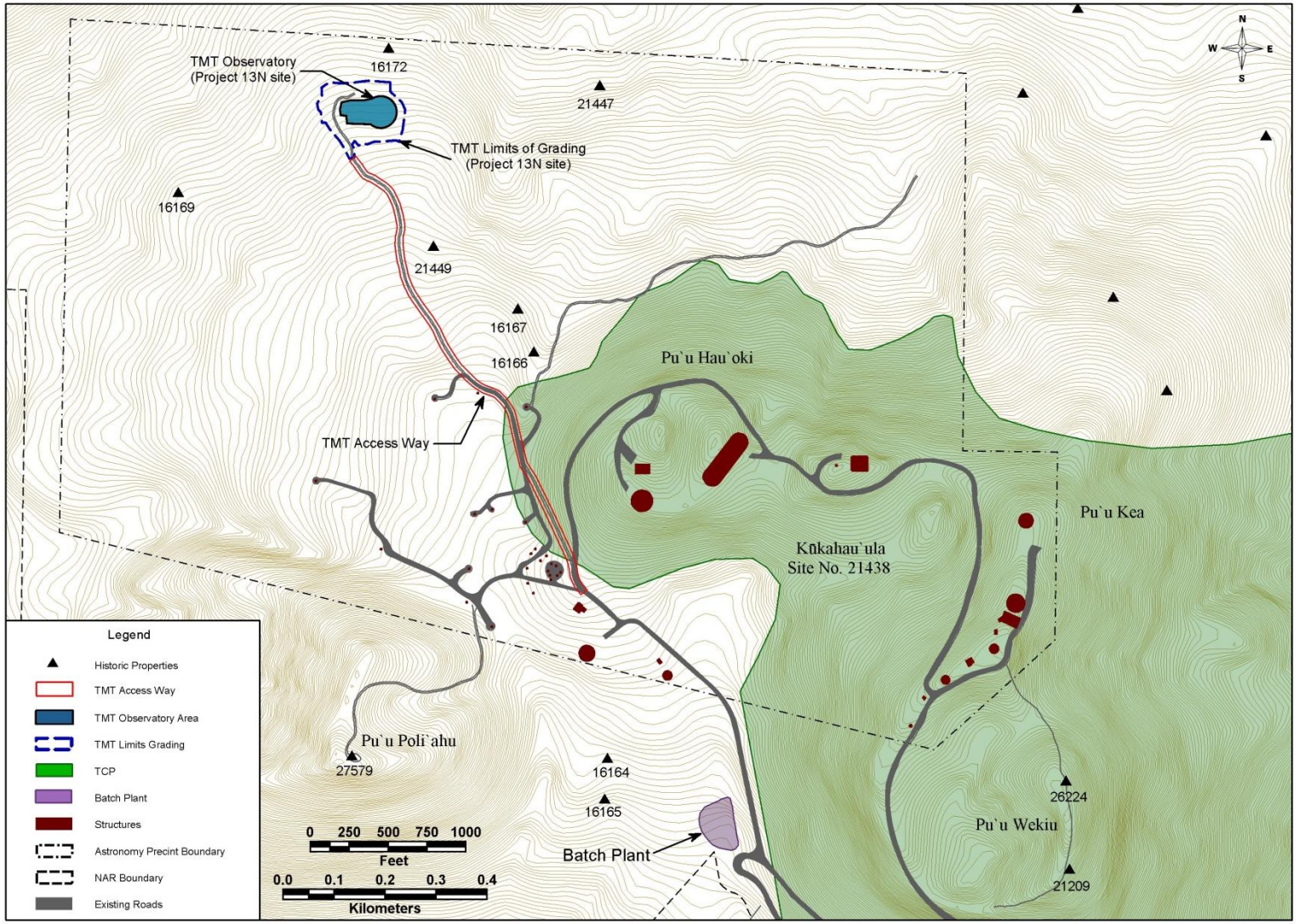
Figure 4.1 shows the historic properties that have been identified in the vicinity of the TMT project areas. There are several archaeological sites in the vicinity of Area E, where the TMT Observatory would be constructed, and where the Access Way for the Observatory would be located. Three historic shrines, first identified during a 1982 survey, are in the vicinity and are described as follows:

- SIHP No. -16172 is located about 225 feet north of the proposed TMT Observatory site and consists of a single upright with several support stones. A Bishop Museum entomologist also reported seeing a crude C-shaped structure and other walls in this general area in 1982. None of these walls were observed during the 1995 or 2005 field inspections of the site.
- SIHP No. -16167 is located approximately 500 feet east of the Access Road and about 1,300 feet southeast of the proposed TMT Observatory site and consists of one, possibly two, uprights placed in a bedrock crack. In 1995, the site was revisited and both stones were found in a vertical position.

[18] McCoy, Patrick, Nees, Richard, et.al., (August 2010) Final Report, *Archaeological Inventory Survey of the Mauna Kea Science Reserve*.

[19] Historic Preservation Division, Department of Land and Natural Resources, State of Hawai'i (2000) *Mauna Kea Historic Preservation Plan Management Components,* (Appendix F).

Figure 4.1. Historic Properties in the Vicinity of the TMT Project Areas



Source: Pacific Consulting Services Inc., (2010)

- SIHP No. -16166 is approximately 350 feet east of the Access Road and 1,600 feet southeast of the proposed TMT Observatory site and is a multi-feature shrine with a total of eight, possibly nine uprights arranged in two groups. When the site was revisited in 1999 it was noted that several of the uprights had been reset in a vertical position along the edge of the outcrop.

In addition to the shrines, a terrace of unknown function (SIHP No. -21449) was documented in 2005; it is located in Area E approximately 200 feet east of the Access Road and 700 feet south of the proposed TMT Observatory site.

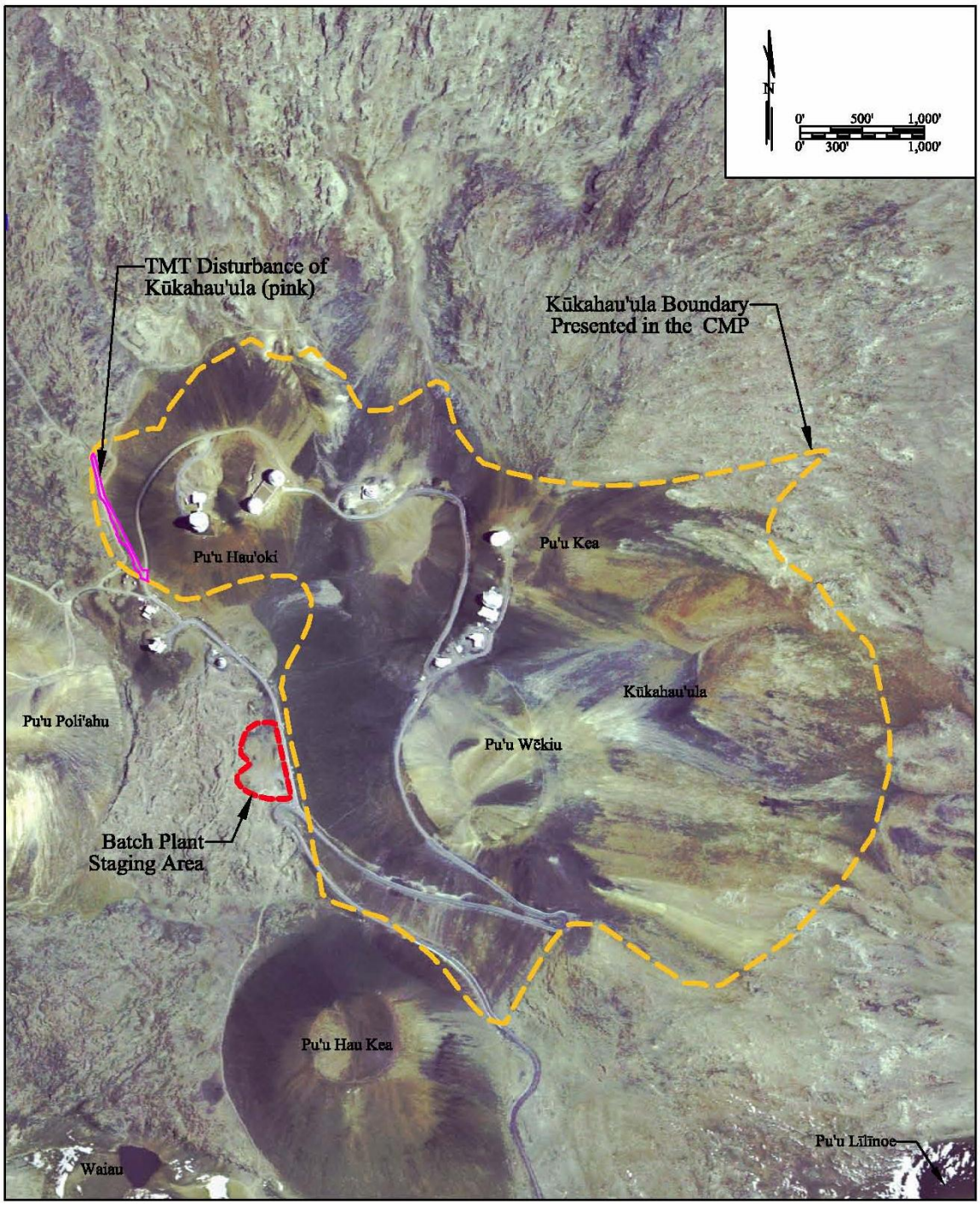
The site proposed for the TMT Observatory is nearly one-half mile northwest of Kūkahauʻula, and the Access Way leading to the observatory would intersect the northwestern edge of Kūkahauʻula for approximately 800 feet. Kūkahauʻula (SIHP No. -21438) includes the summit cinder cones (referred to separately as Puʻu Wēkiu, Puʻu Kea, and Puʻu Hauʻoki) and covers roughly 463 acres, of which nearly one third is within the Astronomy Precinct. SHPD has described and referred to it as a TCP. The Kūkahauʻula TCP is associated with the activities of Native Hawaiian deities as identified in numerous legends and oral histories, and plays an important role in ongoing traditional and religious practices carried out by modern-day Native Hawaiians.[20] Although Kūkahauʻula has neither been nominated nor placed on the National Register of Historic Places, SHPD has previously stated that this historic property and the entire summit region of Mauna Kea may be eligible for inclusion on the National Register as a historic district. Kūkahauʻula is a contributing property to the Mauna Kea Summit Region Historic District. Figure 4.2 provides an aerial photograph showing the Kūkahauʻula TCP and identifying the areas to be developed as part of this project.

4.1.2 Description of Historic Properties in the Vicinity of the Batch Plant Staging Area

The Batch Plant Staging Area is adjacent to the southwestern boundary of the Kūkahauʻula TCP, across the Mauna Kea Access Road. It has undergone considerable ground disturbance over the years due to a series of construction-related activities. No historic properties are known to be present in this area and none has been recorded during various surveys. The locations of two traditional shrines, SIHP Nos. -16164 and -16165 originally recorded in 1982 were verified during the survey for the TMT project. Both shrines are more than 500 feet west of the Batch Plant Staging Area.

[20] In conformance with SHPD's practice, Kūkahauʻula is referred to as the Kūkahauʻula TCP.

Figure 4.2. Aerial Photograph Showing the Kūkahauʻula TCP & Identifying Areas to be Developed



Source: TMT Observatory Corporation

4.1.3 DESCRIPTION OF HISTORIC PROPERTIES IN THE VICINITY OF HELCO'S HALE PŌHAKU SUBSTATION

In 1985, two lithic scatters were identified in the Hale Pōhaku area and determined to be part of the Puʻu Kalepeamoa Site Complex, which includes two shrines and a stone tool quarry and workshop complex. Two workshop areas – designated as SIHP Nos. 50-10-23-10310 and 50-10-23-10311 -- subsequently underwent archaeological data recovery after increased erosion in the site area made preservation of the sites difficult. The data recovery field work demonstrated the presence of both lithic workshops and manufacturing areas for octopus lure sinkers. The two shrines (SIHP Nos. 50-10-23-10313 and 50-10-23-10315) are located across the four-wheel drive access road and to the south about 190 feet away from Hale Pōhaku.[21] They are over 1,200 feet from the HELCO substation and from the nearest electrical pull box that will be accessed when the conductors in the existing conduits are replaced. None of the actions required to implement the proposed project will affect these historic properties.

Only one known historic site is present near HELCO's Hale Pōhaku Substation, where transformer swaps will occur. SIHP No. 50-10-23-10320 (also part of the Puʻu Kalepeamoa Site Complex) is a lithic scatter that lies about 200 feet west of the existing substation. None of the potential TMT activities in this area will be carried out near this site.

In addition to these archaeological sites, the original buildings of Hale Pōhaku – the "stone cabins" – are historic in age. Two rest houses date to the 1930s and were constructed by participants in the Civilian Conservation Corps; one comfort station dates to 1950. They are over a thousand feet from the work that would be done within the existing HELCO Hale Pōhaku Substation, and will not be used or otherwise affected by the subject Project.

4.1.4 CULTURAL PRACTICES RELEVANT TO THE PROPOSED PROJECT

The CMP and the Cultural Impact Assessment prepared in support of the environmental impact statement for the TMT project as well as earlier studies (e.g., Maly & Maly 2005) have identified a range of ongoing cultural practices and beliefs involving Mauna Kea that have origins in the past. Such practices range from the socio-religious in nature to more pragmatic actions.

Practices identified as having religious associations include:

- Recognition of the summit area as a sacred place and the abode of divinities.
- Continued worship practices, including the constructing of ahu or leaving of offerings.
- Umbilical cord deposition (Kanu piko), particularly at Lake Waiau.
- Scattering of cremation remains.
- Collecting water from Lake Waiau and snow from the summit area.
- Calendrical rites carried out at the summit of Kūkahauʻula.

Practices identified as having economic or subsistence associations include:

- Traversing the summit region from area of Hawaiʻi Island to another, via the trail system.

[21] Note that the work within Hale Pōhaku itself that was discussed as a possibility in the *Final EIS* for TMT has been determined to be unnecessary and is not a part of the Conservation District Use Application.

- Hunting birds and, in modern times, feral ungulates.

For the most part, none of these activities has been associated with a specific historic property such as a shrine or workshop that has been identified in or near the areas of the Proposed Action. The exceptions to this include the Kūkahaʻula TCP and the Mauna Kea Summit Region Historic District. A number of the cultural practices listed above are integrally related to the traditional histories surrounding the landscape forms of the Kūkahaʻula TCP and the Historic District, the legendary accounts of the deities who made their homes in the area, and to family practices that extend back in time for some generations.

4.2 IMPACT ON RESOURCES USED FOR TRADITIONAL AND CUSTOMARY NATIVE HAWAIIAN RIGHTS

This section describes the impacts associated with the Proposed Action on the resources used for traditional and customary Native Hawaiian rights on Mauna Kea. Sections 3.2 and 3.3 of the *Final EIS* for the TMT provide considerable detailed discussion concerning those potential impacts.

Several cultural practices involving Mauna Kea may be considered traditional and customary. Other practices observed by Native Hawaiians have some basis in traditional and customary practices and are also included in this discussion of potential impacts. The ongoing cultural practices associated with Mauna Kea addressed here are:

- Pilgrimage, prayer, shrine construction and offerings.
- Collection of water from Lake Waiau.
- Piko deposition.
- Scattering of cremation ashes.
- Burial blessing.

Potential impacts on the resources associated with these practices are described individually in this section, followed by a description of the impacts of the Project on historic properties that are associated with traditional and customary Native Hawaiian practices and rights.

There are diverse opinions concerning the Project's potential impact on cultural resources. For those of the opinion that any use, development, or disturbance of Mauna Kea by someone other than a Native Hawaiian is significant and unmitigable, the Project's impact to the cultural, spiritual, and sacred quality of the summit region will be significant. For those who believe that Native Hawaiian cultural practices can co-exist with astronomy through (a) compliance with all applicable governmental laws, codes, ordinances, rules, regulations, requirements and procedures, (b) conformance with UH planning and management documents and policies (including the 1983 and 2000 Master Plans and the CMP, including all its associated subplans), and (c) implementation of the identified mitigation measures and management procedures, the Project's potentially harmful effects on Mauna Kea's historic properties and associated Native Hawaiian cultural practices will be significantly reduced. Any remaining effects on these cultural practices and historic properties will be further mitigated by the mitigation commitments proposed in Section 4 of the TMT Management Plan attached hereto as Exhibit B and the mitigation actions described in the draft Historic Preservation Mitigation Plan for the TMT.

The Project is not anticipated to result in any substantial or significant adverse effect on the cultural practices of the community or State. The Project's impact on Mauna Kea's historic properties and associated cultural practices or beliefs, after considering compliance as described above and the identified mitigation measures, should not be significant based on the significance criteria set out in HRS Chapter 343 and the applicable conservation district and historic preservation regulations of the State of Hawai'i.

4.2.1 IMPACTS ON PILGRIMAGE, PRAYER, SHRINE CONSTRUCTION AND OFFERINGS

The summit region, which includes the Mauna Kea Summit Region Historic District and the Kūkahau'ula TCP, is a sacred area in Hawaiian culture and serves as a site for individual and group ceremonial and spiritual practices. These practices include prayer, shrine erection and the placement of offerings. The approximately 5-acre area to be occupied by the TMT Observatory structure would not be available for future cultural practices of this nature. In addition, for some individuals, the introduction of new elements associated with the Project in the area of the northern plateau would adversely affect the setting in which such practices could take place. The shoulders of the existing 4-wheel drive road whose route the proposed Access Way would generally follow would be similarly affected. However, as they are already disturbed and close to a vehicular travelway, the effect would be, at most, a muted one.

Data collected during a series of archaeological surveys indicate that modern shrine construction occurs primarily in areas outside of the Astronomy Precinct. Approximately 90 percent of the over 300 find spots that have been interpreted to be modern shrines occur outside the Astronomy Precinct. Although the Project may decrease the desirability of the northern plateau area for shrine construction, this is not anticipated to result in a substantial effect on shrine construction within the MKSR. The majority of the areas within the MKSR currently used for shrine construction would not be affected by the Project.

To some individuals, the Project could represent a significant impact on the suitability of the northern plateau area for spiritual observances and offerings. However, it would not result in any adverse impact on Native Hawaiian rights. The majority of the areas within the MKSR where observances and rituals are believed to occur would not be affected by the Project. Further, while the introduced elements associated with existing observatories may have had an effect on the perceived quality of the observances conducted, or may have caused some practitioners to conduct their observances further away from the vicinity of the observatories, there is no evidence suggesting that the presence of the existing observatories has prevented or impacted those practices. Therefore, the Project is not anticipated to significantly impact the resources available on Mauna Kea used for traditional and customary Native Hawaiian rights involving pilgrimage, prayer, shrine construction and offerings.

4.2.2 IMPACTS ON COLLECTION OF WATER FROM LAKE WAIAU

Water from Lake Waiau is collected by some cultural practitioners for use in healing and ritual practices. The Project would not affect that practice, nor would it affect the quality of the water in Lake Waiau. There will be no adverse effect associated with the Project on this traditional and customary Native Hawaiian right.

4.2.3 IMPACTS ON PIKO DEPOSITION

Historically, *piko* (umbilical cord) deposition on Mauna Kea has been associated primarily with the Lake Waiau area of the summit region. The Project would not affect cultural practices at or near Lake Waiau.

Some ethnographic studies also indicate that *piko* deposition may be occurring in other areas of the summit region. The area that would be occupied by the proposed TMT Observatory would not be available for future deposition of *piko*. In addition, individuals may be unwilling to deposit *piko* in the immediate vicinity of the TMT Observatory due to the new elements that it would introduce. This would not impact traditional and customary Native Hawaiian rights. The vast majority of the MKSR as well as the Mauna Kea Ice Age NAR, including Lake Waiau, would remain unaffected by the Project. Substantial undisturbed areas will remain within the summit region that could continue to be used for *piko* deposition. Therefore, the Project is not anticipated to significantly impact the resources available on Mauna Kea used for traditional and customary Native Hawaiian rights involving *piko* deposition.

4.2.4 IMPACTS ON SCATTERING OF CREMATION REMAINS

The scattering of cremation ashes in the summit area of Mauna Kea is considered an ongoing contemporary cultural practice that has its roots in traditional and customary Native Hawaiian practices. The area occupied by the TMT Observatory would not be available for the scattering of cremation remains in the future, and the new elements introduced by the Project could adversely affect the setting for some individuals wishing to scatter ashes on and immediately around the area where the TMT Observatory and Access Way would be constructed. This would not result in an impact on the traditional and customary Native Hawaiian rights. Significant undeveloped natural areas that could be used for scattering ashes would remain unaffected by the Project throughout the MKSR. Therefore, the Project is not anticipated to significantly impact the resources available on Mauna Kea used for scattering cremation remains.

4.2.5 IMPACTS ON BURIAL BLESSING

Archaeological studies have identified 29 burials and possible burials within the MKSR. Ethnographic studies indicate that there may be additional undocumented burials on Mauna Kea, primarily associated with various *puʻu*. Although human burials can no longer occur on Mauna Kea under State law, some descendants currently take part in blessing ceremonies within the MKSR to honor their ancestors.

The site of the proposed TMT Observatory is over one mile from the nearest known or possible burial identified during past archaeological studies. No specific sites have been documented as associated with burial blessing ceremonies within the northern plateau. As a result, the Project is not anticipated to have substantial adverse effects on any burial blessing practices occurring on Mauna Kea and would not impact this traditional and customary Native Hawaiian right.

4.2.6 IMPACTS ON KŪKAHAUʻULA HISTORIC PROPERTY

The proposed Access Way leading to the TMT Observatory has been designed to minimize its effect on the Kūkahauʻula TCP. This includes following the path of existing roadways to the maximum extent possible; limiting the proposed Access Way to a single lane; and avoiding the use of a retaining wall or other slope treatment. As a result, it will only be necessary to widen

and pave roughly 1,100 feet of the existing 4-wheel drive road at the western side of Puʻu Hauʻoki (i.e., the outermost edge of the Kūkahauʻula TCP).

Figure 4.2 shows the area within Kūkahauʻula that would be impacted by the Proposed Action. As shown in this photograph, the impact within Kūkahauʻula would occur in an area that has been extensively altered by previous observatory construction. The Access Way would not result in any significant degradation of the Kūkahauʻula TCP, nor would it affect Native Hawaiian practices or rights associated with Kūkahauʻula. While the construction of telescope facilities and related infrastructure over the past 40 years has clearly had a cumulative impact on Kūkahauʻula, the CMP and its subplans approved in 2009 and 2010 by BLNR provides the primary framework for addressing those impacts which includes the implementation of the management actions discussed in Exhibit B (TMT Management Plan). In addition, as proposed in the Draft Historic Preservation Mitigation Plan that accompanies the TMT Management Plan, some of the measures that TMT will support are intended to address issues related to broader astronomy-related development on Mauna Kea.

4.3 BLNR ACTION

What feasible action, if any, could be taken by the BLNR in regards to your application to reasonably protect native Hawaiian rights?

The TMT project has been developed to achieve full compliance with all existing State requirements that protect resources on Mauna Kea associated with traditional and customary Native Hawaiian rights. In approving the Mauna Kea CMP and its four component sub-plans, BLNR has adopted a rigorous set of requirements that safeguard Native Hawaiian rights. As detailed in the TMT Management Plan and this CDUA, TMT commits to following those requirements during the construction, operation and decommissioning of the TMT Observatory.

As stated in Section 7.1.1 of the CMP, access to UH Management Areas for Native Hawaiian traditional and customary practices may not be restricted, except where safety, resource management, cultural appropriateness, and legal compliance considerations may require reasonable restrictions. The CMP specifically identifies the following as being among those rights for which access will be maintained insofar as is consistent with those other requirements:

- Access for traditional and customary practices, including the gathering of cultural resources, including but not limited to mamake, koʻokoʻolau, māmane, ʻawa, and ōwī.
- Access for families to visit *na iwi kupuna* (the bones of their ancestors).
- Access to scatter *ʻohana* ashes.
- Access through the trails located within the UH Management Areas for subsistence gathering and hunting.
- Access for families to continue to deposit their ʻ*ohana piko*.
- Access for traditional and customary practices, including religious and spiritual observances.
- Pilgrimage, offerings, and prayers.
- Access for families to gather water from Lake Waiau for religious and spiritual purposes.

As provided for in Section 5 of the Public Access Plan, the traditional and customary rights of Native Hawaiians will be preserved and protected. More specifically, the University will:

- Develop guidelines for Native Hawaiian cultural practices on Mauna Kea in consultation with cultural practitioners and the Native Hawaiian community.
- Provide for the exercise of Native Hawaiian cultural practices, safely accommodating individuals and groups wishing to exercise such traditional practices or customs, subject to the reasonable regulation of such rights as permitted by law.

For safety reasons, the TMT project would necessarily restrict access to construction areas during the construction of the observatory and associated infrastructure improvements. Such restrictions would be temporary in nature and limited to the immediate vicinity of the construction work. After completion of construction, access to the interior of the TMT Observatory would be restricted for safety considerations. These restrictions would not prevent or preclude access to any resources available within the UH Management Areas of Mauna Kea for the practice of traditional and customary Native Hawaiian rights.

BLNR can continue to ensure unrestricted access by Native Hawaiians to the resources present on Mauna Kea by incorporating a condition in the CDUP requiring that the TMT project adhere to aspects of the CMP and its sub-plans as they relate to TMT. BLNR can also help ensure the preservation and protection of Mauna Kea's resources within the UH management areas by incorporating a condition in the CDUP that the TMT project implement the management actions set forth in the CMP and subplans as described in the TMT Management Plan (see Exhibit B).

5 Public Access

Does the proposed land use have an effect (positive/negative) on public access to and along the shoreline or along any public trail?

5.1 DIRECT EFFECTS ON PUBLIC ACCESS

Shoreline Access. The TMT Observatory, Access Way, and other temporary and permanent facilities on Mauna Kea that comprise the proposed TMT project are all situated at high elevation and are far from the nearest shoreline (the TMT Observatory, for example, is more than 17 miles from the nearest coastal area). Consequently, they have no potential to affect public access to and along the shoreline. The other components of the project that are within the Conservation District are equally far removed from the shoreline and also lack any ability to interfere with public access to or along the ocean shoreline.

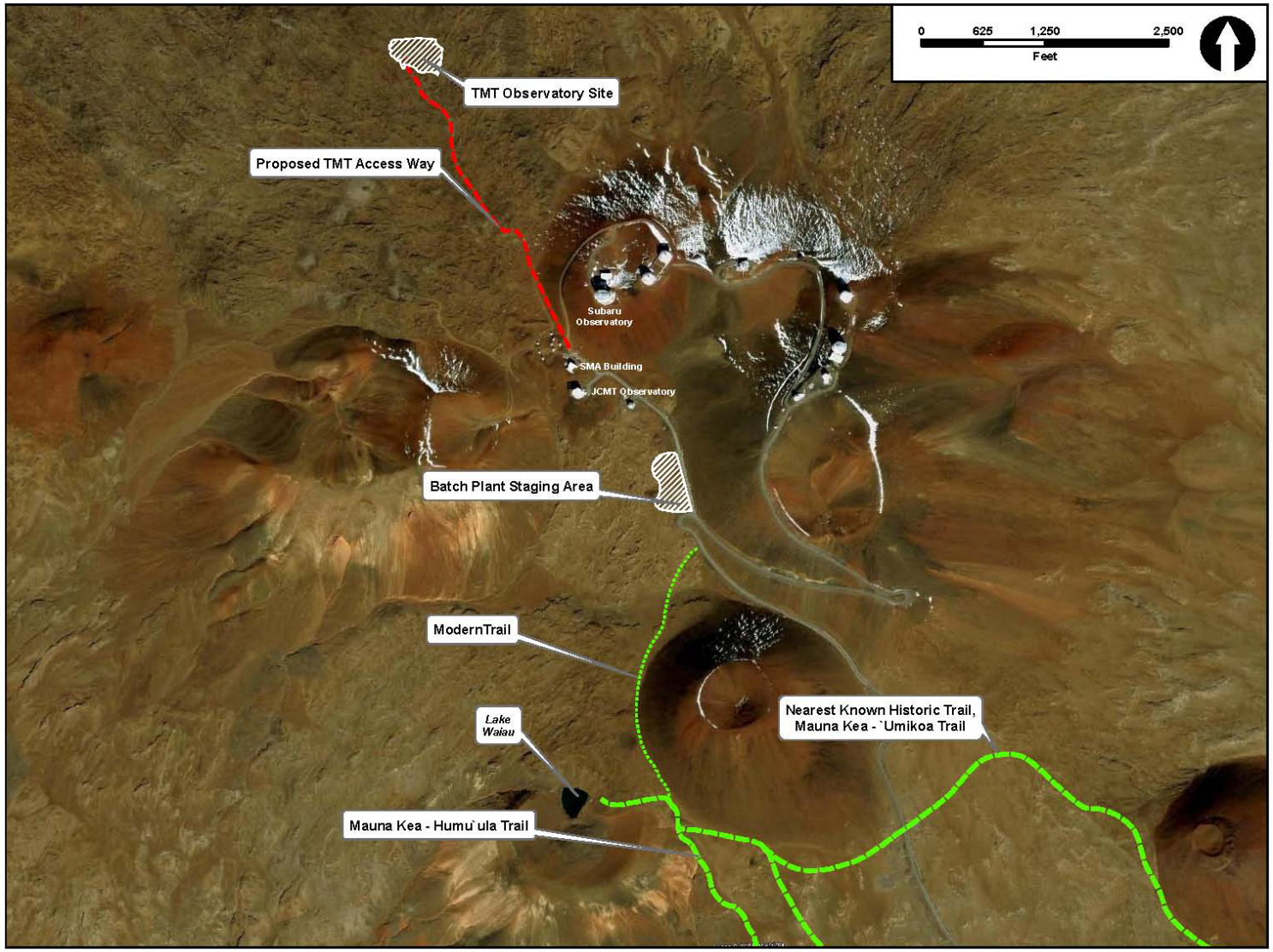
Trail Access. As shown in Figure 5.1, there are no trails in the vicinity of the proposed TMT Observatory site. The nearest known customary trail (Mauna Kea – ʻUmikoa Trail) is approximately a mile to the south-southeast. The limited amount of road construction that is required for the TMT project would pass closer to the Mauna Kea – ʻUmikoa Trail, but at its closest point they would be over two-fifths of a mile apart. The distance, and the fact that existing topography blocks views from the trails toward these proposed new facilities means that there is no potential for project-related work at those locations to adversely affect public access.

The only location where project-related activities within the Conservation District (other than the use of existing roads) would come close to existing trails is the point where the modern trail around the western side of Puʻu Haukea intersects the Mauna Kea Access Road. At that point, it is a short distance south of the Batch Plant site that would be used during construction of the proposed project. While the Batch Plant site is utilized for the TMT project construction, it will be visible to trail users, just as it has been during the construction of some existing Mauna Kea telescopes. While this is not a direct effect that would deny individuals access to the trail, it does have the potential to alter trail users' experience slightly for the period of time the Batch Plant site is in operation.

5.2 INDIRECT EFFECTS ON PUBLIC ACCESS

The small, temporary direct effect on trail users' experience that is noted above will be more than offset by the long-term indirect benefits from the public education and cultural awareness efforts that the University of Hawaiʻi Office of Mauna Kea Management would be able to undertake using the sublease rent derived from the proposed lease to TMT. A Public Access Plan (PAP) for the UH Management Areas on Mauna Kea was prepared as part of the CMP that addresses overall access to the summit area. With existing programs and the implementation of the concepts presented in the CMP and PAP sub plan, including the ranger program and increased education programs, the impact to cultural resources by visitors and employees is likely to be reduced relative to current conditions.

Figure 5.1 TMT Access Way and Nearest Trails



Source: Planning Solutions, Inc. (2010)

6 Runoff

Will the proposed use cause increased runoff or sedimentation?

Annual precipitation in the summit region ranges from approximately 20 inches at the Very Long Baseline Array (VLBA) at an altitude of 12,600 feet to approximately 15.5 inches (including snowfall) at the Subaru Observatory at an altitude of 13,575 feet. Most of the rainfall either evaporates or percolates through the cinder and broken rock substrates to recharge groundwater. Occasionally, rainfall of sufficient intensity to cause runoff from the least permeable areas does occurs, but even under these circumstances it generally infiltrates into the ground as soon as it reaches more permeable zones.[22] There are no regularly flowing or perennial streams in the Mauna Kea Science Reserve.

Paved areas and buildings are impervious surfaces that prevent rainwater from directly percolating into the subsurface, and they may also increase the volume of storm water runoff. The proposed use will create new impervious surfaces at the TMT Observatory and along portions of the Access Way. The new impervious area at the TMT Observatory will be roughly 1.3 acres, which accounts for the dome and support building. The parking areas will not be paved and will remain pervious allowing rain to percolate naturally. A roughly 1,600-foot long portion of the Access Way will be paved, generating up to 0.66-acre of new impervious surface.

The impact due to new impervious surfaces will be limited due to the permeability of the surrounding ground surface and the area of natural land down slope from the TMT Observatory and Access Way. Also, in compliance with existing regulations and requirements, TMT facilities will be designed to maximize groundwater recharge to the extent possible. Site grading and landscaping will be designed to direct storm water to pervious areas so that it may percolate into the ground. These measures would result in all precipitation ultimately recharging underlying aquifers because runoff would be directed to nearby areas where it would percolate into the ground rather than enter streams that discharge to the ocean.

[22] The 24-hour rainfall event with a probability of occurring once in every 100 years is less than 8 inches, one of the lowest amounts on the island for such an event. The 1-hour/100-year rainfall event is less than 2 inches, again one of the very lowest on the island.

7 Visual Impact

This section, which is derived from the *FEIS* for the TMT project, describes the existing visual conditions on the Island of Hawai‘i and Mauna Kea, discusses the visual impacts the proposed project may have, and identifies how the potential visual impacts would be mitigated. Section 3.5 of the *Final EIS* and the Visual Impact Assessment Technical Report (Appendix M of the *Final EIS* contain a more detailed discussion of the Project’s potential impacts on visual and aesthetic resources.

7.1 ENVIRONMENTAL SETTING

7.1.1 RELEVANT PLANNING DOCUMENTS

The Hawai‘i County General Plan (County of Hawai‘i, 2005) recognizes the importance of preserving the island’s natural and scenic beauty. It establishes goals, policies and standards to identify and protect scenic vistas and viewplanes. One goal is to “Protect scenic vistas and view planes from becoming obstructed.” The General Plan also provides guidelines for designating sites and vistas of extraordinary natural beauty to be protected, and includes the standard “Distinctive and identifiable landforms distinguished as landmarks, e.g. Mauna Kea, Waipio Valley.” The General Plan identifies the following natural beauty sites 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

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.”

7.1.2 VISIBILITY OF EXISTING OBSERVATORIES

The attributes that affect the visibility of the existing observatories within the Astronomy Precinct on Mauna Kea are listed in Table 7.1. The table also lists the percent of the island’s land area from which each observatory is potentially visible.[23] Figure 7.1 depicts the primary viewpoints and view directions relevant to the discussion. Figure 7.2 illustrates the viewshed from which at least one of these observatories can be seen. According to 2000 U.S. Census data, over 70 percent of the population of the Island of Hawai‘i reside within view of at least one of the existing observatories.

[23] The term “potentially visible” is based on the absence of intervening trees, buildings, or other solid material. As views from many locations are blocked by one or more of these, the areas from which they are actually visible is much less.

Table 7.1: Existing Observatory Visual and Aesthetic Attributes

Observatory	2000 Master Plan Siting Area	Ground Elevation (feet)	Dome Height (feet)	Dome Color	Viewshed (%)
Subaru	B	13,578	141	Metallic	20
Keck	B	13,603	111	White	17
IRTF	B	13,652	53	Aluminum	14
CFHT	A	13,726	125	White	35
Gemini	A	13,764	151	Aluminum	39
UH 2.2m	A	13,784	80	White	36
UKIRT	A	13,762	61	White	26
UH Hilo 0.9m	A	13,727	20.25	White	15
CSO	C	13,362	63	Metallic	5
JCMT	C	13,390	100	White	7
SMA	C	13,279 – 13,400	45	NA	2

Source: *Final EIS for the Thirty Meter Telescope*, Table 3-7.

The existing observatories are most visible from the west coast of the island at sunset, when they are lit by the setting sun. They are most visible from the east coast at sunrise. Considering all existing observatories together, at least one observatory is visible from roughly 43 percent of the island's land area.[24]

7.1.3 VISUAL CONSIDERATIONS FOR SITING A NEW OBSERVATORY

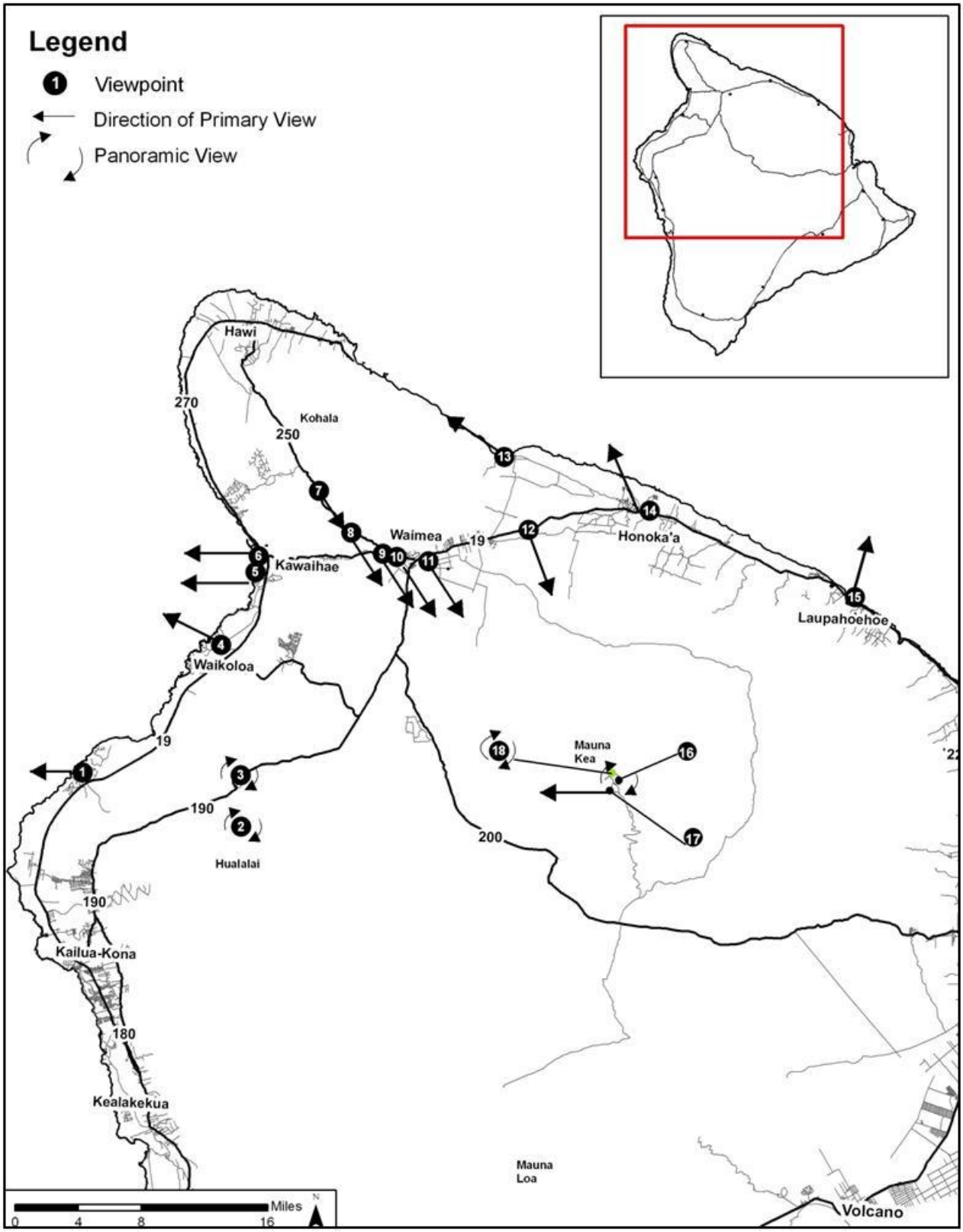
The *2000 Master Plan* includes a discussion of a large "Next Generation Large Telescope (NGLT) telescope such as the TMT. The *2000 Master Plan* recognizes that the size of such facilities makes the visual considerations very important to siting and design, and recommends siting such a facility within Area E of the Astronomy Precinct because it would "minimize its visibility." The proposed TMT site is in accord with this recommendation.

Different categories of people that view Mauna Kea (e.g., residents, sightseers and cultural practitioners) have different expectations, and these differences greatly affect their perception of the observatories. During preparation of the *Final EIS*, planners identified eighteen representative viewpoints within the northern portion of the island as places that are of visual significance to members of one or more of these viewer groups.[25] Table 7.2 provides the viewpoint name, description, the viewer group expected, and the primary view direction.

[24] Some of these observatories also use laser guide stars as part of their AO system, similar to the TMT AO system. The laser guide stars may be visible within some portions of the MKSR. They are not visible from more distant locations.

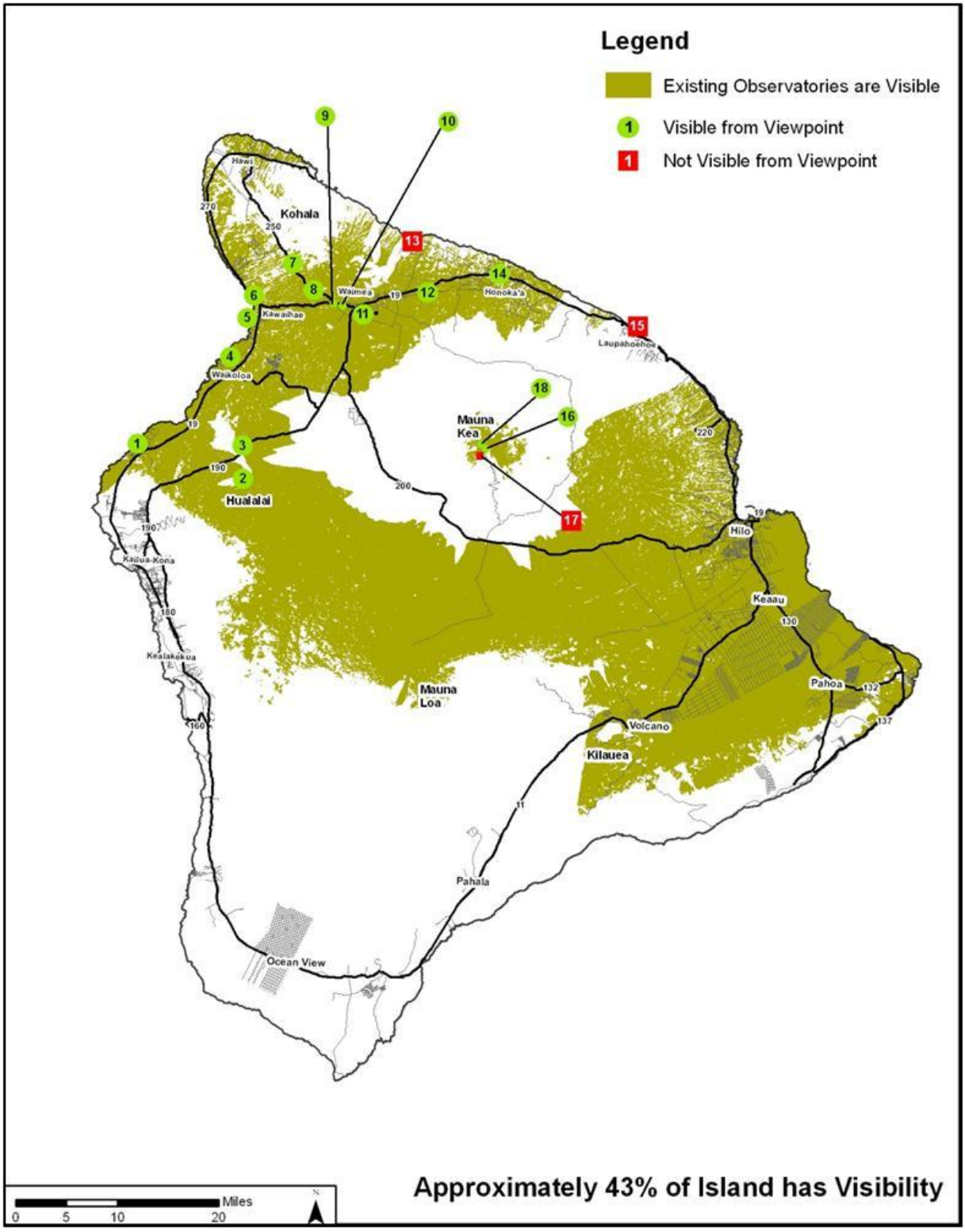
[25] The viewpoints are all located in the northern portion of the island because the location of the TMT Observatory is such that it will not be visible from the southern portion.

Figure 7.1: Viewpoints and Primary View Direction from Viewpoints



Source: Figure 3-7, *Final EIS for the Thirty Meter Telescope*.

Figure 7.2: Viewshed of Existing Observatories on Mauna Kea



Source: Figure 3-8, *Final EIS for the Thirty Meter Telescope*.

Table 7.2: Description of Viewpoint, Viewer Group and Primary View Direction

View-point	Location	Description	Viewer Group	Primary View
1	Hualālai Resort	Exclusive, luxury residential community and hotel.	Residents / Sightseers	West toward the ocean
2	Puʻu Waawaa	Summit of cinder cone that is of cultural importance to Native Hawaiians.	Cultural Practitioners	Panoramic
3	Big Island Country Club	Independent (non-resort affiliated) daily-fee golf course. The club includes views of the coastline and of Mauna Kea.	Residents / Sightseers	Panoramic
4	Waikoloa/Mauna Lani	Resort development.	Sightseers	West makai
5	Hāpuna Beach	Public beach near a resort.	Sightseers / Residents	West makai
6	Puukohola Heiau	National historic site & Spencer Beach Park, which includes camping & picnic areas along a beach.	Residents / Sightseers	West makai
7	DHHL Kawaihae at Route 250	Summit of Highway 250 between Waimea and Hāwī.	Residents	Southeast toward Mauna Kea (mauka)
8	Route 250 Puʻu Overlook	Gravel shoulder where cars pull off of the highway and view Mauna Kea and N. Kona/S. Kohala.	Sightseers	Southeast mauka
9	DHHL Lalamilo	Waimea residential neighborhoods.	Residents	Southeast mauka
10	Waimea Park	Athletic facilities for sports such as baseball and tennis; near a school.	Residents	Southeast mauka
11	DHHL Puʻu Kapu	Waimea residential neighborhoods.	Residents	Southeast mauka
12	DHHL Waikoloa-Waialeale	Along Old Māmalahoa Highway through ranch lands.	Residents	South mauka
13	Waipio Valley Lookout	Formal lookout with parking lot and trail to scenic view.	Sightseers	Northwest along the coast
14	Honokaʻa	Main road into town.	Residents	Northwest up the coast
15	Laupāhoehoe Point	State park with parking lot and picnic facilities along the coast.	Sightseers	Northeast makai
16	Mauna Kea Summit (Kūkahauʻula)	Highest point on Mauna Kea. Recognized as a sacred place to Native Hawaiians.	Cultural Practitioners	Panoramic
17	Lake Waiau	Small lake near the summit of Mauna Kea, accessible by a trail. Waters used for healing & worship practices in Hawaiian culture.	Cultural Practitioners	West over the lake
18	North ridge of Mauna Kea summit cinder cone (Kūkahauʻula)	North ridge of Kūkahauʻula, near Keck, Subaru, IRTF, or CFHT observatories.	Sightseers	Panoramic / toward Maui

Source: Table 3-7, *Final EIS for the Thirty Meter Telescope*.

7.2 POTENTIAL ENVIRONMENTAL IMPACT

7.2.1 SCENIC VISTAS AND VIEWPLANES

For reasons discussed in detail in the *FEIS*, locating the TMT Observatory on Mauna Kea will not substantially affect scenic vistas and viewplanes identified in the Hawai‘i County General Plan or the South Kohala Development Plan. The TMT Observatory will not be visible in the view of Mauna Kea from Pāhoa-Kea‘au, Volcano-Kea‘au Roads, or various Puna subdivisions. Neither will it be visible from locations where Hilo Bay is visible with Mauna Kea in the background. Although the TMT Observatory will 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.

7.2.2 VISIBILITY OF THE TMT OBSERVATORY

The results of the viewshed analysis conducted for the proposed project concluded that it would be potentially visible from roughly 14 percent of the island area, as summarized in Table 7.3 and depicted in Figure 7.3. One or more of the existing observatories is visible from nearly all of this area. According to 2000 U.S. Census data, approximately 15 percent of Hawai‘i’s population, or 23,000 people, live within the viewshed of the TMT Observatory. Others, including visitors and island residents that reside outside the viewshed, would be able to see the TMT Observatory when they travel through and visit locations within the viewshed when conditions are favorable (i.e., when clouds, darkness, vegetation, structures, and other factors do not obscure the view).

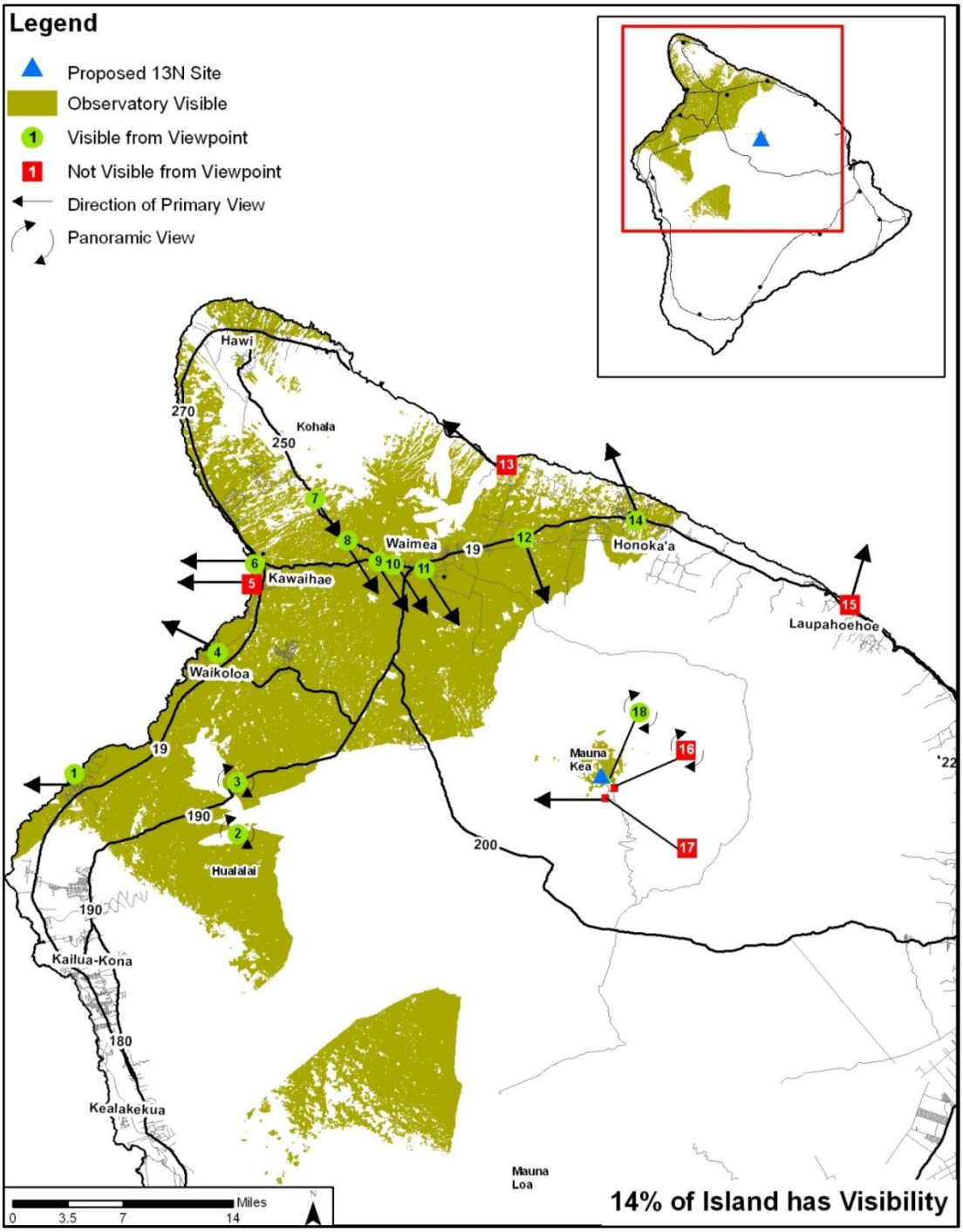
Table 7.3: Visibility of the TMT Observatory

Visibility	Area of Island (%)	Hawai‘i’s Population	
		%	People
Visible	14%	15.4%	23,000
Not Visible	86%	84.6%	125,000
Source: Table 3-8, *Final EIS for the Thirty Meter Telescope*.			

Of the 13 viewpoints depicted on Figure 7.3 from which the TMT Observatory may be visible, it will not be within the primary view from four (the Hualālai Resort, Waikoloa/Mauna Lani, Pu‘ukohola Heiau, and Honoka‘a). This is because the primary view from these coastal locations is *makai*.

The TMT Observatory is potentially visible and in the primary view direction from six viewpoints along Highway 250 (#7 and #8) and around the town of Waimea (#9, #10, #11 and #12). The TMT Observatory could also be visible from the Big Island Country Club (#3), from the summit of Pu‘u Wa‘awa‘a (#2), and from the north ridge of the Mauna Kea summit cinder cone (#18), where the panoramic view will be important to the viewer.

Figure 7.3: Viewshed and Primary View Analysis



Note: "Primary View" as depicted in the figure represents the direction that people generally look toward to see the most important attraction visible from that location. For example, the view toward the ocean is generally the "primary view" from shoreline lookouts.

Source: *FEIS* Figure 3-8.

Table 7.4 divides the viewshed, and the population within the viewshed, into five areas: Waimea, Honokaʻa, Hāwī, Waikoloa and Kawaihae, and Hualālai. Of these, the TMT Observatory will be

visible in the primary view direction only from the area around Waimea. Of the island's population, 5.5 percent, or 8,100 people reside within the area around Waimea and may be able to see the TMT Observatory.

Table 7.4: Visibility of the TMT Observatory within the Primary View Direction

Location	Hawai'i's Population		Primary View Direction?
	%	People	
Waimea	5.5%	8,100	Yes
Honoka'a	2.8%	4,200	No
Hāwī	2.6%	3,900	No
Waikoloa and Kawaihae	4.3%	6,400	No
Hualālai	0.2%	303	No
Source: Table 3-9, *Final EIS for the Thirty Meter Telescope*.			

Table 7.5 summarizes the results of the silhouette analysis for 13 representative viewpoints where the TMT Observatory may be visible. The purpose of the analysis was to determine whether the view of the facility will be a full or partial silhouette against the sky, or whether it will be seen against the backdrop of Mauna Kea.

Table 7.5: TMT Observatory - Summary of Potential Visual Impacts

View-point	Location	Visual Impact				
		Is the TMT visible?	Visible in primary view?	Visible in silhouette?		
				No	Partial	Full
1	Hualālai Resort	Yes	No	--	164 feet (50 m)	--
2	Pu'u Waawaa	Yes	N/A[1]	--	58 feet (17 m)	--
3	Big Island Country Club	Yes	N/A[1]	--	82 feet (25 m)	--
4	Waikoloa/Mauna Lani	Yes	No	--	164 feet (50 m)	--
5	Hāpuna Beach	No	No	N/A		
6	Puukohola Heiau	Yes	No	--	164 feet (50 m)	--
7	DHHL Kawaihae at Route 250	Yes	Yes	X	--	--
8	Route 250 Pu'u Overlook	Yes	Yes	X	--	--
9	DHHL Lalamilo	Yes	Yes	--	49 feet (15 m)	--
10	Waimea Park	Yes	Yes	--	89 feet (27 m)	--
11	DHHL Pu'u Kapu	Yes	Yes	--	98 feet (30 m)	--
12	DHHL Waikoloa-Waialeale	Yes	Yes	--	164 feet (50 m)	--
13	Waipio Valley Lookout	No	N/A	N/A		
14	Honoka'a	Yes	No	--	82 feet (25 m)	--
15	Laupāhoehoe Point	No	N/A	N/A		
16	Mauna Kea Summit	No	N/A	N/A		
17	Lake Waiau	No	N/A	N/A		
18	North ridge of Kūkahau'ula	Yes	N/A	X	--	--
[1] The primary view criterion is not applicable because at these viewpoints the panoramic view is important.						
Source: Table 3-10, *Final EIS for the Thirty Meter Telescope*.						

7.2.3 TMT OBSERVATORY DOME FINISH

The finish for the TMT Observatory dome will be a reflective aluminum-like finish, similar to that of the Subaru observatory. The use of a reflective aluminum-like finish was based on the following considerations (1) visibility of the dome, (2) optimum performance of the observatory, and (3) reduced need of cooling air within the dome during the day. When considering the visibility of the dome, the aluminum-like exterior finish was selected over white and brown because the aluminum-like finish reflects the colors of the sky and ground, which helps the dome blend into its setting and reduces the visual impact whether the summit is bare or covered in snow.

7.2.4 PHOTO SIMULATIONS

Photo-simulations provided show the TMT Observatory with an aluminum-like finish. Additional simulations, showing the TMT Observatory with white and brown finishes, are provided in Section 3.5.3 of the *Final EIS*. Important conclusions related to visual effects are summarized below.

7.2.4.1 Visual Effects on Lower-Elevation Developed Areas

An example of the naked eye view of Mauna Kea from Waimea is shown in Figure 7.4. In compliance with CMP Management Action FLU-4, TMT Observatory Corp. has prepared a series of visual renderings of the Project. Photo simulations of the TMT Observatory were created using photographs of the summit of Mauna Kea that were taken with a 600 mm/5.6 telephoto lens resulting in a "binocular view." For comparison purposes a "naked eye view", without the aid of binoculars or a telephoto lens, photo is also provided. The naked eye view has been sized so that if the page is held at arm's length the size and spacing of the existing observatories appears as it would when standing at the location the photo was taken.

Figure 7.5 contains a binocular view simulation of the TMT Observatory as seen from Waimea with the proposed aluminum-like finish when there is no snow present. Figure 7.6 shows its appearance when snow is present on Mauna Kea. Note that this photograph was taken from another location within Waimea so the perspective is slightly different. These simulations from Waimea illustrate that the lower portion of the TMT Observatory will be obscured behind a rise of Mauna Kea and located in front of one of the domes of the existing Keck or Subaru Observatory. Roughly the top 90 feet of the observatory dome will be visible from the Waimea area, as listed for viewpoints #9, #10, and #11 as shown in Figure 7.3 and listed in Table 7.4.

7.2.4.2 Visual Effects within the Summit Region

Although the TMT Observatory will not be visible from the summit of Mauna Kea (#16) or from Lake Waiau (#17) as shown on Figure 7.1, it will be visible from other locations within the summit region, primarily the northern plateau and the northern ridge of Kūkahauʻula where the Subaru, Keck, IRTF, and CFHT observatories are located, viewpoint 18. Figure 7.7 shows the current view from near the Keck Observatory, viewpoint 18, looking to the northwest, looking over the northern plateau and TMT Observatory 13N site. Figure 7.8 is a simulation of the TMT Observatory with an aluminum-like finish from the same view point.

Figure 7.4: Naked Eye View of Mauna Kea from Waimea



Photo Credit: CFHT

Source: Figure 3-10, *Final EIS for the Thirty Meter Telescope*.

Figure 7.5: TMT Observatory, Aluminum-Like Finish – "Binocular" View from Waimea w/o Snow



Photo Credit: Charles R. West Photography

Source: Figure 3-11, *Final EIS for the Thirty Meter Telescope*.

Figure 7.6: TMT Observatory, Aluminum-Like Finish – "Binocular" View from Waimea w/ Snow



Photo Credit: Charles R. West Photography

Source: Figure 3-11, *Final EIS for the Thirty Meter Telescope*.

Figure 7.8 shows that the TMT Observatory will add a new visual element to a relatively undeveloped portion of the summit region. That element will be visible from viewpoints along the northern ridge of Kūkahauʻula and from roadways within the northern portion of the summit region. Views from the northern ridge of Kūkahauʻula are now dominated by views of observatories, including Subaru, Keck, IRTF, and CFHT observatories, which are located on this ridge. The majority of visitors to the summit region and cultural practitioners visit the Kūkahauʻula summit, not the northern ridge of Kūkahauʻula. In addition, due to TMT's lower site elevation and moderate bulk and height, it will not block the view of Maui from the ridge.

As described in detail in Section 3.5.3 of the *FEIS*, the TMT Observatory will not be visible from the summit of Kūkahauʻula, referred to as Puʻu Wēkiu in modern times. This is due to the presence of the northern ridge of Kūkahauʻula blocking the view from the summit peak. The TMT Observatory will also be hidden from Puʻu Līlīnoe and Lake Waiau, culturally important areas from which a number of the existing observatories are visible. However, the TMT Observatory will be visible within the northern portion of the summit region, including the northwestern portion of Kūkahauʻula, referred to as Puʻu Hauʻoki, Puʻu Pōhaku, and Puʻu Poliʻahu. Many of the existing observatories are also visible from these areas.

Figure 7.7: Naked Eye View from Near Keck Observatory Viewing Northwest



Figure 7.8: Simulation of the TMT Observatory from Near Keck Observatory Viewing North

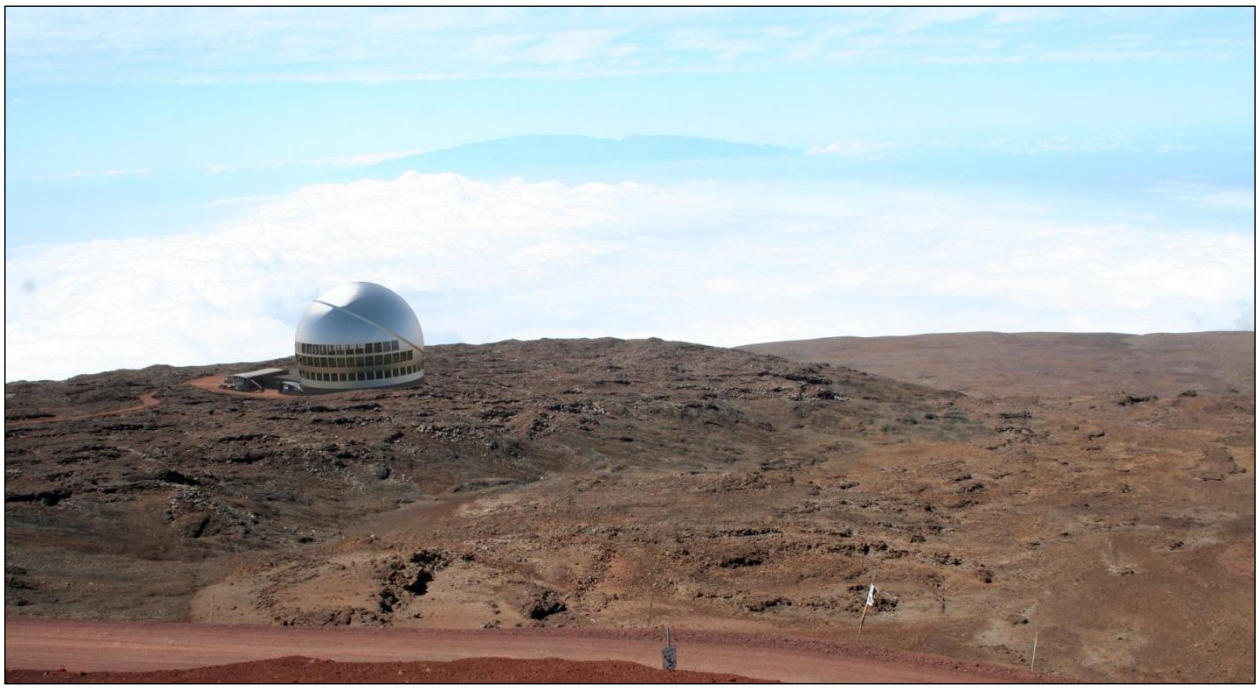


Photo Credit: Charles R. West Photography

Source: Figure 3-24, *Final EIS for the Thirty Meter Telescope*.

Currently there are roads and portions of the SMA observatory in the northern plateau area. The TMT Observatory will add a new visual element to the northern plateau area that will be visible to varying degrees from the shrines along the northern slopes of Mauna Kea. The TMT Observatory will appear in the view directly toward the summit from only a few of the shrines on the northern plateau.

The proposed Access Way will also result in a visual effect (particularly from a cultural perspective) as it passes within the Kūkahauʻula Historic Property. However, as it would follow an existing route, project-related work will simply modify an existing visual feature rather than introduce an entirely new one. The paving of the Access Way for a distance of roughly 1,600 feet (1,100 feet on Kūkahauʻula) and the addition of a guard rail and slight embankment immediately below the pavement will result in a slight change to the character of the road.

7.3 PROTECTION OF VISUAL RESOURCES

The selection of the site for the proposed TMT Observatory was strongly influenced by the desire to minimize adverse effects to the Conservation District's visual resources. Its location north of and below the summit makes the facility substantially less visible than if it were to be placed on the summit ridge or puʻu. The low focal ratio[26] (f/1.0) of the telescope itself is as short as possible for one with the required light-gathering power and allows the smallest possible dome. In addition, the enclosure has been designed to fit very tightly around the telescope, leaving only 20 inches (the minimum space needed to accommodate a person), between the telescope and the dome (see Figure 7.9). If the TMT Observatory designers had used the same ratio of mirror-to-dome size as that in the existing Keck Observatory, the TMT dome would have had a diameter of 364 feet, almost twice the size that is proposed for the TMT facility (see Figure 7.10).

In addition to minimizing its size, designers have also taken visual concerns into account when selecting the coating (and, therefore, the color) for the dome enclosure. Their choice of an aluminum-like coating similar to that used on the Subaru Observatory reduces the visibility of the observatory during most of the day (when the coating reflects the sky). Only during the morning sunrise and evening sunset does the choice make the dome more visible than the alternatives.

The support building is much smaller than the observatory dome to which it is attached and would only be visible from viewpoints relatively close to the project site. The ongoing refinements in the design process continue to incorporate features that will further reduce its visibility from Kūkahauʻula, 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 Kūkahauʻula, except the visitor parking area.

As a result of the intense effort that has gone into minimizing the instrument and dome size, the proposed TMT Observatory will only slightly increase the part of the island from which observatories can be seen. Other observatories remain higher above sea level, tempering the extent of its effect. Hence, while some individuals object to the addition of this new visual element to the summit area, the change does not appear to be significant, particularly when

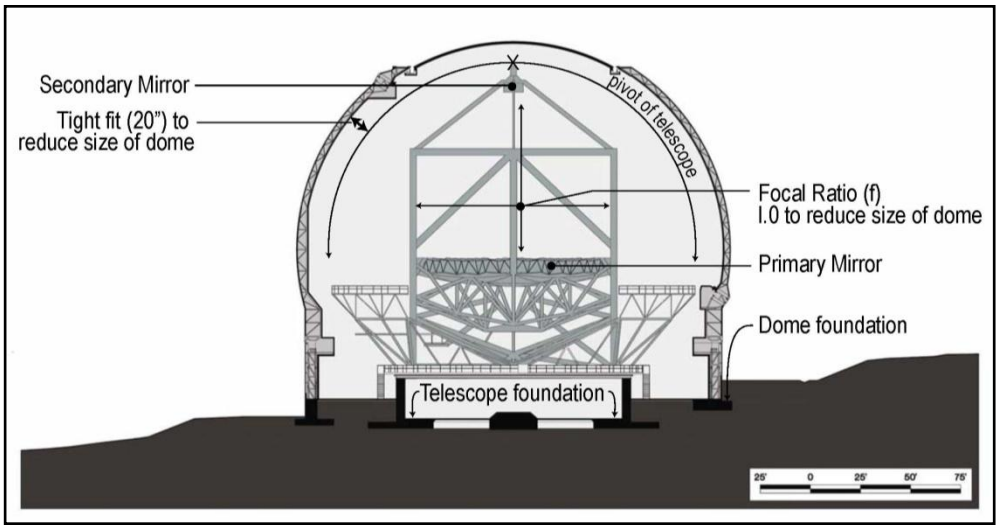
[26] Focal ratio (f/) is defined as the ratio of the focal length of the mirror to its diameter.

considered in the light of the removal of other telescopes that are part of the University's management plan for Mauna Kea.

The Access Way also incorporates design components to mitigate its visual impact. These measures include coloring the pavement a reddish color to better blend with the surroundings, using a wire type guardrail that would be painted a reddish color to blend with the surroundings to reduce its visibility. In addition, the Batch Plant site will be partially re-naturalized following the completion of construction.

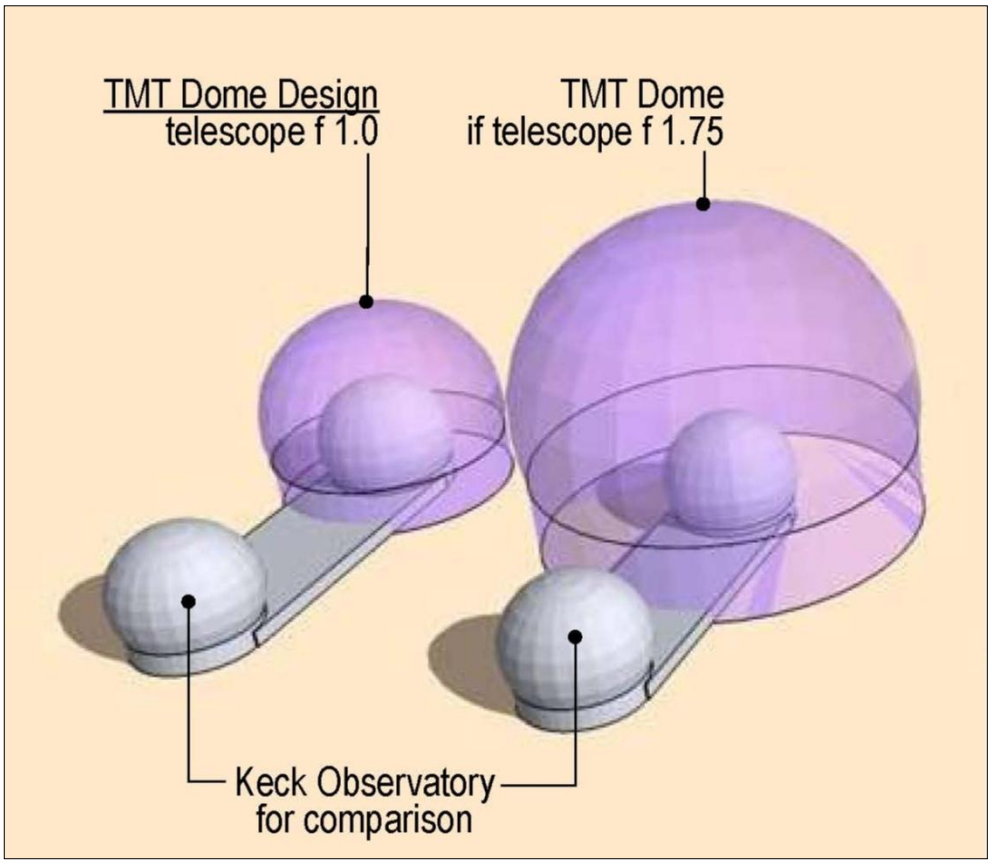
Finally, in addition to the measures implemented above, as detailed in the Draft Historic Preservation Mitigation Plan attached to the TMT Management Plan (Exhibit B), the TMT Observatory Corporation will implement the following measures to mitigate the visual impacts of the TMT project: (1) fund an effort to re-naturalize the road corridor on Pu'u Poliahu; (2) partially re-naturalize the Batch Plant site following the completion of construction; and (3) camouflaging the utility pull boxes in key locations so as to reduce the amount of visual distraction on the summit of Mauna Kea.

Figure 7.9: Overview of TMT and Dome Design



Source: Figure 3-25, *Final EIS for the Thirty Meter Telescope*.

Figure 7.10: Comparison of Observatory Dome Sizes to Telescope Focal Ratios

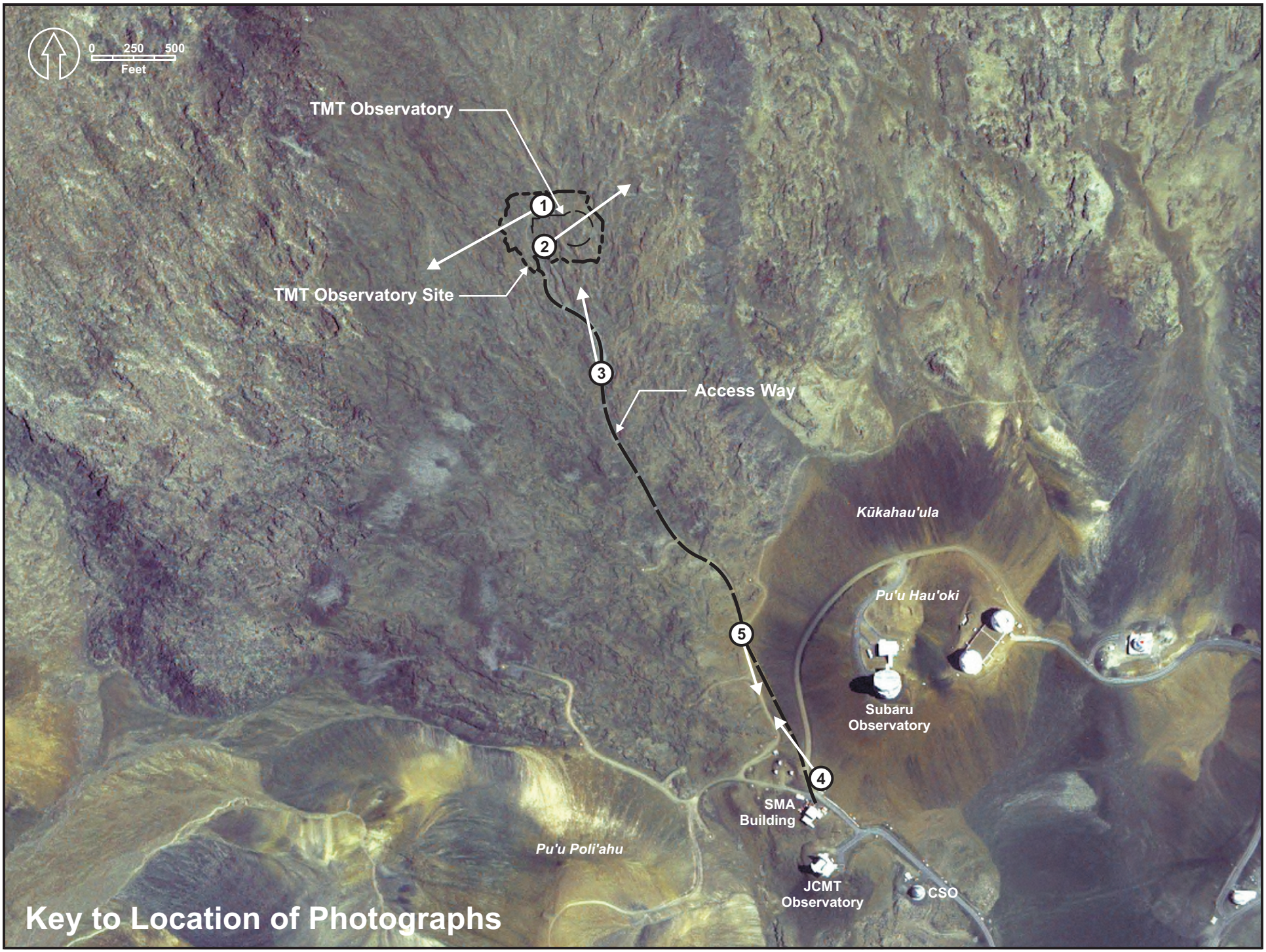


Source: Figure 3-26, Final EIS for the Thirty Meter Telescope.

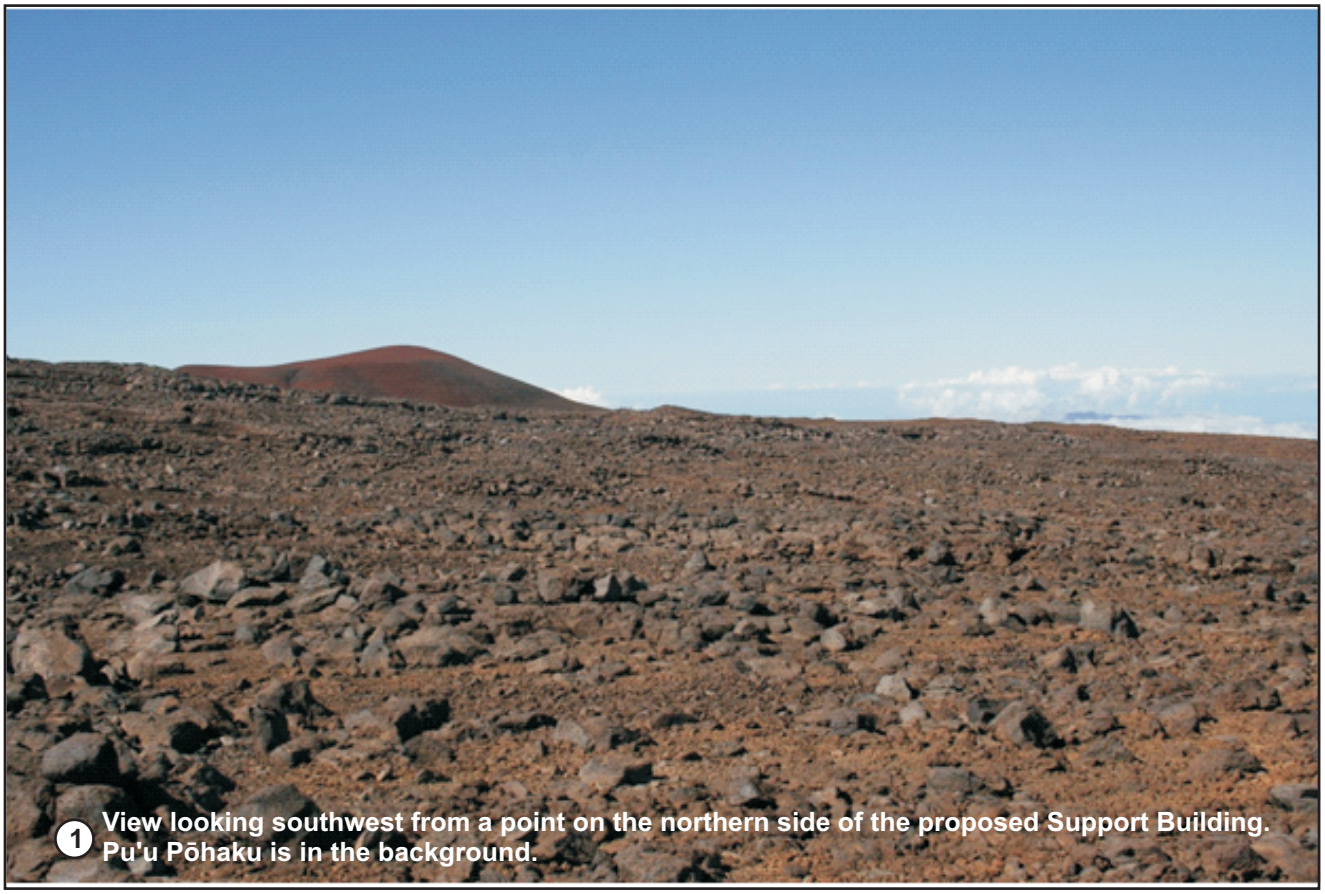
Exhibit A. Photographs/Maps/Plans

This exhibit contains the following:

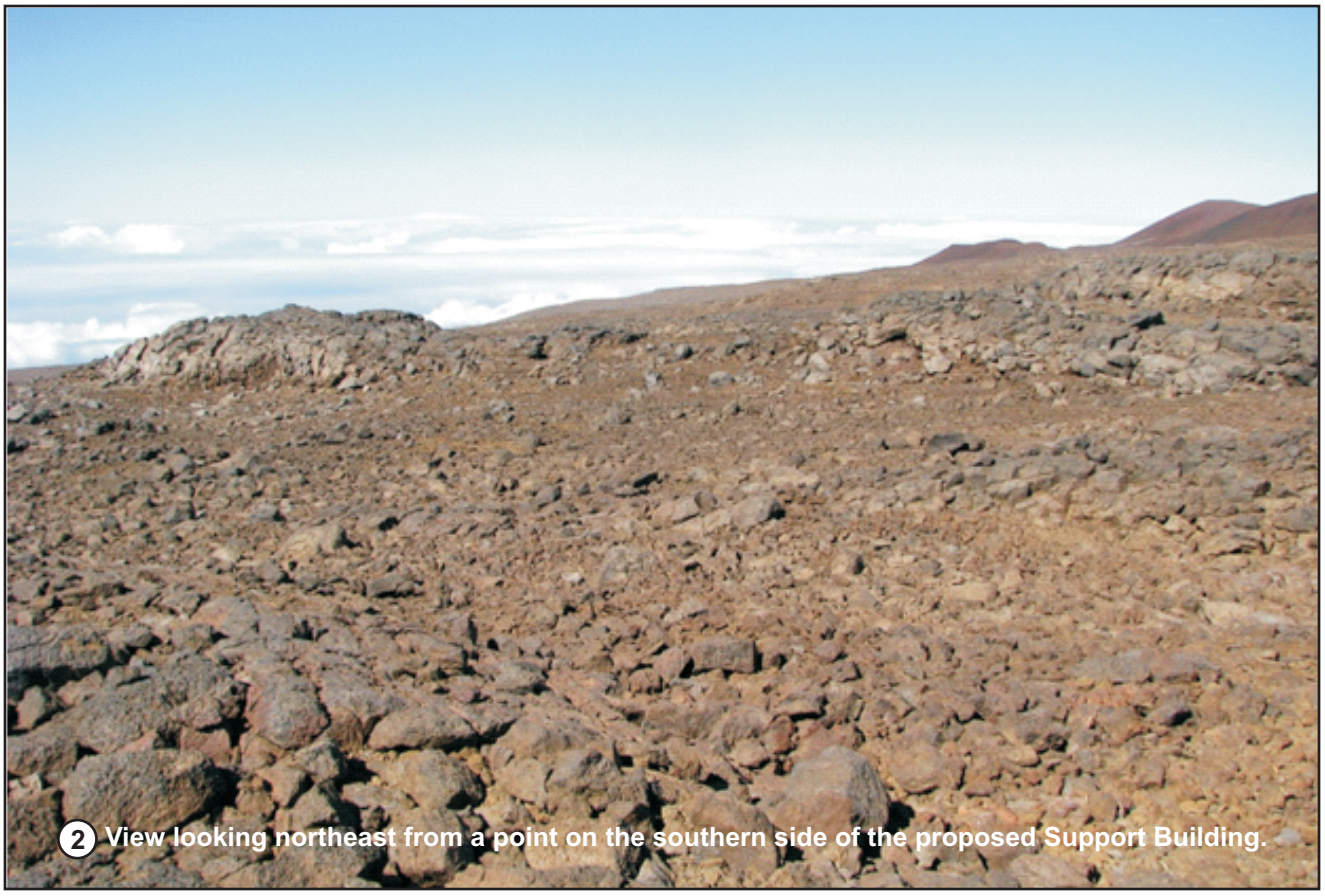
- Key to Location of Photographs
    - 13N Site
    - Access Way
    - Hale Pōhaku Substation
    - Batch Plant Staging Area
- Plans & Renderings of TMT Observatory
- TMT Access Way Plans


0 250 500
Feet
TMT Observatory
TMT Observatory Site
1
2
3
Access Way
Kūkahau'ula
Pu'u Hau'oki
5
Subaru
Observatory
4
SMA
Building
Pu'u Poli'ahu
JCMT
Observatory
CSO
Key to Location of Photographs

Photographs of the 13N Site



1 View looking southwest from a point on the northern side of the proposed Support Building. Pu'u Pōhaku is in the background.



2 View looking northeast from a point on the southern side of the proposed Support Building.

Photographs of the Access Way



3 View looking north from a point midway along the proposed Access Way route.



4 View looking north (i.e. downhill) from a point on the southern end of the proposed Access Way route.

Photographs of the Access Way and Hale Pohaku Substation



5 View looking south (i.e. uphill) along the portion of the proposed Access Way and crosses the base of Kūkahau'ula.



Hale Pohaku Substation
(not shown on map, see Figure 1.8)

Photograph of the Batch Plant Staging Area



View South across the Batch Plant Staging Area.
(Not shown on map, see Figure 1.3)

THIRTY METER TELESCOPE

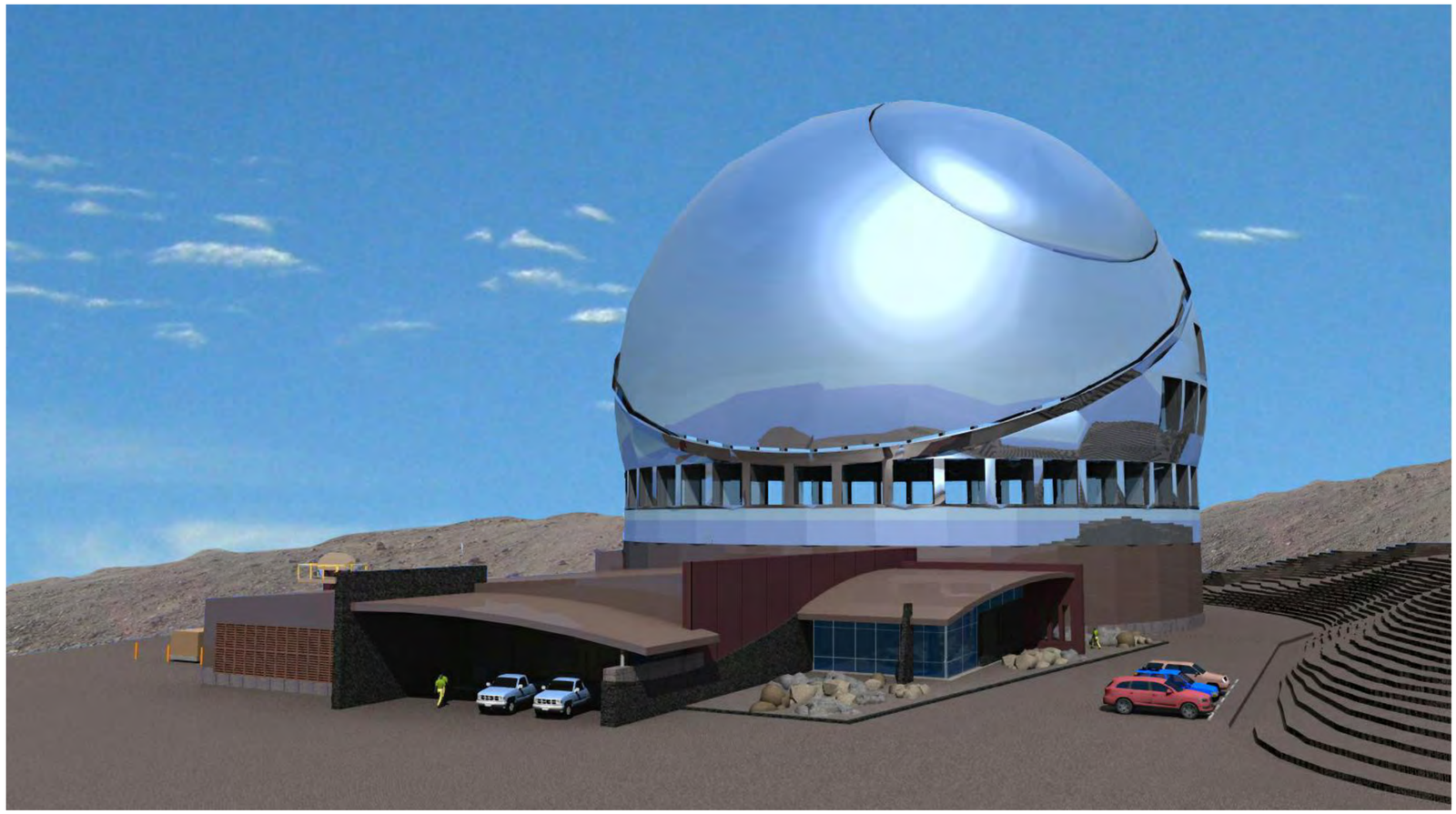
PHASE III - DESIGN DEVELOPMENT SUBMITTAL FOR THE OFFICE OF MAUNA KEA MANAGEMENT

ASSOCIATION OF CANADIAN UNIVERSITIES FOR RESEARCH IN ASTRONOMY - CALIFORNIA INSTITUTE OF TECHNOLOGY - UNIVERSITY OF CALIFORNIA

MAUNA KEA, HAWAII

APRIL 5, 2010

TMT.SUM.PDD.10.009.DRF01



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE
DESIGN DEVELOPMENT SUBMITTAL
FOR THE OFFICE OF MAUNA KEA MANAGEMENT
MAUNA KEA, HAWAII

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ARCHITECTURE
CONSTRUCTION MANAGEMENT

Revisions

	Description	Date
1		
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Drawn: E.J.G.
Checked: -
Issue Date: 4-5-10

Drawing Title

COVER SHEET

Sheet Number

GI001

M3PN 07131

Last Update: 3.26.2010

ABBREVIATIONS (NOT ALL ABBREVIATIONS SHOWN BELOW ARE USED IN THIS SET OF DRAWINGS)

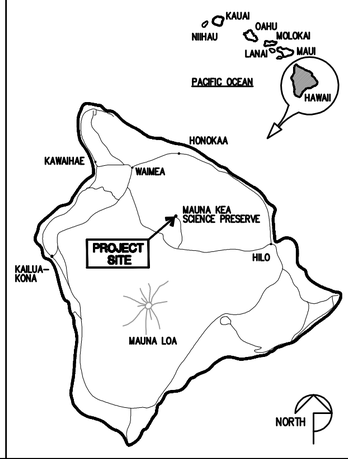
&	AND	F	FAHRENHEIT	OH	OVERHEAD
A.B.	ANCHOR BOLT	FD	FLOOR DRAIN	OPNG	OPENING
ABUT	ABUTMENT	FDN	FOUNDATION	OPP	OPPOSITE
ABC	AGGREGATE BASE COURSE	F.E.	FIRE EXTINGUISHER	ORN	ORNAMENTAL
ABV	ABOVE	FF	FINISH FLOOR		
AC	ACOUSTICAL SPRAY ON CEILING	FFE	FINISH FLOOR ELEVATION	PL	PLATE
ACI	AMERICAN CONCRETE INSTITUTE	F.G.	FINISHED GRADE	P.L., P	PROPERTY LINE
L	ANGLE (STRUCTURAL)	FIN	FINISH(ED)	PLF	POUNDS PER LINEAL FOOT
AFF	ABOVE FINISHED FLOOR	FLR	FLOOR	PLMB	PLUMBING
ALT	ALTERNATE	FLUOR	FLUORESCENT	PLS.LAM	PLASTIC LAMINATE
ALUM	ALUMINUM	FLG	FLANGE	PLYWD	PLYWOOD
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE	FLASH	FLASHING	PM	PRESSED METAL
		FOS	FACE OF STUD	PNL	PANEL
AP	ACOUSTICAL WALL PANEL	FT	FOOT, FEET	POLYISO	POLYISOCYANURATE
APPROX	APPROXIMATE	FTG	FOOTING		
ARCH	ARCHITECT(URAL)	FTR	FLUE THROUGH ROOF	REQ'D	REQUIRED
ARS	ARIZONA REVISED STATUTES	FURN	FURNITURE	REQ'MENT	REQUIREMENT
ASPH	ASPHALT			R	RESILIENT BASE
ASTM	AMERICAN SOCIETY FOR TESTING MATERIALS	G	GYPSUM BOARD	RA	REPAIR
		GALV	GALVANIZED	R	RADIUS
AVG	AVERAGE	G.B.	GRAB BAR	RE	REPLACE
AWG	AMERICAN WIRE GAGE	G.I.	GALVANIZED IRON	RR	RESTROOM(S)
AZ	AZIMUTH	GL	GLASS, GLAZING	ROW	RIGHT OF WAY
B	BRICK	GWB	GYPSUM WALL BOARD	S	STUCCO
B.BD	BULLETIN BOARD	GYP	GYPSUM	SC	SOLID CORE
BD	BOARD			SCHD	SCHEDULE
B.L.	BUILDING LINE	H	HEIGHT	S.D.	SOAP DISPENSER
BLDG	BUILDING	H.B.	HOSE BIBB	SECT	SECTION
BLK(G)	BLOCK(ING)	HC	HANDICAPPED	SF	SQUARE FOOT (FEET)
BLT	BOLT	HGT	HEIGHT	SHT	SHEET
BLW	BELOW	H.M.	HOLLOW METAL	SIM	SIMILAR
BM	BEAM	HORIZ	HORIZONTAL	SND	SANITARY NAPKIN DISPOSER
B.M.	BENCH MARK	H.P.S.	HIGH PRESSURE SODIUM		
BOF	BOTTOM OF FOOTING	HVAC	HEATING/VENTILATING/ AIR CONDITIONING	SNV	SANITARY NAPKIN VENDOR
BOT	BOTTOM				
BRG	BEARING			SOV	SHUT OFF VALVE
BUR	BUILT UP ROOFING	I.D.	INSIDE DIAMETER	SPECS	SPECIFICATIONS
		INCL	INCLUDE(D, ING)	SQ.	SQUARE
CAB	CABINET	INFO	INFORMATION	S.S.	SERVICE SINK
C/C	CENTER TO CENTER	INV. EL.	INVERT ELEVATION	STA	STATION
CF	CUBIC FOOT	INSUL	INSULATION	STD	STANDARD
CFCI	CONTRACTOR FURNISHED/ CONTRACTOR INSTALLED	INT	INTERIOR	STR	STORAGE
		IRRIG	IRRIGATION	STL	STEEL
CFM	CUBIC FEET PER MINUTE			STRUC	STRUCTURAL
CIP	CAST-IN-PLACE	JB	JUNCTION BOX	SURF	SURFACE
CJ	CONTROL JOINT	JCT	JUNCTION	SUSP	SUSPEND(ED)
CL	CENTER LINE	JT	JOINT	SYM	SYMMETRY(ICAL)
CLG	CEILING			SYS	SYSTEM
CLOS	CLOSET	L	LENGTH	SW	SWITCH
CLR	CLEAR(ANCE)	LAM	LAMINATE(D)	T&B	TOP AND BOTTOM
CO	CLEAN OUT	LAV	LAVATORY	TEL	TELEPHONE
COL	COLUMN	LB	POUND	T.O.	TOP OF
CONC	CONCRETE	LH	LEFT HAND	T.O.BM.	TOP OF BEAM
CONF	CONFERENCE	LT(G)	LIGHT(ING)	T.O.FTG	TOP OF FOOTING
CONN	CONNECTION	LT.WT	LIGHT WEIGHT	T.O.M.	TOP OF MASONRY
CONST	CONSTRUCTION	LVR	LOUVER	T.O.P.	TOP OF PARAPET
CONT	CONTINUOUS			T.O.S.	TOP OF STEEL
CONTR	CONTRACT(OR)	M	MOVABLE PARTITION	T.O.W.	TOP OF WALL
COT	CITY OF TUCSON	MACH	MACHINE	TPD	TOILET PAPER DISPENSER
CP	CARPET	MAINT	MAINTENANCE	TS	TUBE STEEL
CR	STAGE CURTAIN	MAS	MASONRY, MASON	TV	TELEVISION
CT	CERAMIC TILE	MATL	MATERIAL(S)	TYP	TYPICAL
CTR	CENTER	MAX	MAXIMUM		
CW	COLD WATER	MB	MACHINE BOLTS		
		MCJ	MASONRY CONTROL JOINT	UBC	UNIFORM BUILDING CODE
d	PENNY (NAIL SIZE)	MEAS	MEASURE	UG	UNDERGROUND
DBL	DOUBLE	MECH	MECHANICAL	UMC	UNIFORM MECHANICAL CODE
DEG	DEGREE	MED	MEDIUM	UNF	UNFINISHED
DEM	DEMOLISH, DEMOLITION	MEMB	MEMBRANE	UNG	UNDERGROUNDED
DESC.	DESCRIPTION	MFD	MANUFACTURED	UNO	UNLESS NOTED OTHERWISE
D.F.	DRINKING FOUNTAIN	MFG	MANUFACTURING	UPC	UNIFORM PLUMBING CODE
DIAG	DIAGONAL	MFR	MANUFACTURER	UR	URINAL
DIA.	DIAMETER	MH	MANHOLE	UTIL	UTILITY(TIES)
DIM	DIMENSION	MIN	MINIMUM, MINUTES		
DISP	DISPENSER	MIR	MIRROR	VAR	VARIES
DL	DEAD LOAD	MISC	MISCELLANEOUS	VGB	VERTICAL GRAB BAR
DN	DOWN	M.O.	MASONRY OPENING	VCR	VIDEO CASSETTE RECORDER
DO	DITTO	MT	MOSAIC TILE	VCT	VINYL COMPOSITION TILE
DR	DOOR	MTL	METAL	VER	VERIFY
D.S.	DOWNSPOUT			VERT	VERTICAL
DTR	DUCT THROUGH ROOF	#	NUMBER	VOL	VOLUME
DTW	DUCT THROUGH WALL	N	NEW	VTR	VENT THROUGH ROOF
DWG(S)	DRAWING(S)	N/A	NOT APPLICABLE		
		NAT	NATURAL	W	WIDTH
E, (E)	EXISTING TO REMAIN	NEC	NATIONAL ELECTRIC CODE	W/	WITH
EA	EACH	NEUT	NEUTRAL	WD	WOOD
ELEV	ELEVATION	NFPA	NATIONAL FIRE PROTECTION ASSOCIATION	WH	WALL HUNG
EIFS	EXTERIOR INSULATION FINISH SYSTEM			W/O	WITHOUT
		N.I.C.	NOT IN CONTRACT	WSCT	WAINSCOT
EOM	EDGE OF MASONRY	NOM	NOMINAL	WS	WAFFLE SLAB
EOS	EDGE OF STEM WALL	NTS	NOT TO SCALE	W/W	WALL TO WALL
EP	EPOXY PAINT			WWF	WELDED WIRE FABRIC
EQ	EQUAL	OA	OVERALL		
EQUIP	EQUIPMENT	O.C.	ON CENTER(S)	YD	YARD
ESMT	EASEMENT	O.D.	OUTSIDE DIAMETER		
EWC	ELECTRIC WATER COOLER	OFCI	OWNER FURNISHED/ CONTRACTOR INSTALLED	Z	GLAZING
EXIST	EXISTING				
EXP	EXPANSION, EXPOSED	OFOI	OWNER FURNISHED/ OWNER INSTALLED		
EXT	EXTERIOR				

SCOPE OF WORK

THE SCOPE OF WORK CONSISTS OF, BUT NOT LIMITED TO, THE CONSTRUCTION OF THE THIRTY METER TELESCOPE FIXED ENCLOSURE AND SUMMIT FACILITY WHICH INCLUDES ALL SITE WORK, ARCHITECTURAL, STRUCTURAL, PLUMBING, MECHANICAL, AND ELECTRICAL SYSTEMS AS NOTED IN THE DRAWINGS AND WRITTEN SPECIFICATIONS.

GENERAL NOTES

ISLAND MAP



DRAWING INDEX

GENERAL
- GI001 COVER SHEET
- GI002 DRAWING INDEX, ABBREVIATIONS, & SYMBOLS
- GI003 3-D MODEL RENDERINGS

ARCHITECTURAL
- AS101 ARCHITECTURAL SITE PLAN
- AR101 OVERALL FLOOR PLAN
- AR102 ENLARGED FLOOR PLAN
- AR103 ENLARGED FLOOR PLAN
- AR201 ELEVATIONS
- AR202 ELEVATIONS
- AR301 SECTIONS

OUTLINE OF WRITTEN SPECIFICATIONS

AIA MASTERSPEC – 16 DIVISION FORMAT

Division 1 – General Requirements
- 01000 – Special Provisions
- 01002 – Fire Plan
- 01010 – Summary of Work
- 01027 – Applications for Payment
- 01035 – Modification Procedures
- 01040 – Coordination
- 01045 – Cutting and Patching
- 01200 – Project Meetings
- 01300 – Submittals
- 01400 – Quality Control
- 01421 – Reference Standards and Definitions
- 01500 – Construction Facilities and Temporary Controls
- 01600 – Materials and Equipment
- 01631 – Substitutions
- 01700 – Contract Closeout
- 01740 – Warranties

Division 2 – Site Construction
- 02080 – Piped Utilities
- 02230 – Site Clearing
- 02300 – Earthwork
- 02361 – Termite Control
- 02510 – Water Distribution

Division 3 – Concrete
- 03300 – Cast-in-Place Concrete

Division 4 – Masonry
- 04200 – Unit Masonry

Division 5 – Metals
- 05120 – Structural Steel
- 05310 – Steel Deck
- 05400 – Cold-Formed Metal Framing
- 05510 – Metals Stairs and Handrails
- 05530 – Gratings
- 05550 – Corrugated Metal Pipe Exhaust Ducts

Division 6 – Woods & Plastics
- 06402 – Interior Architectural Woodwork

Division 7 – Thermal & Moisture Protection
- 07210 – Building Insulation
- 07412 – Manufactured Wall, Roof, and Soffit Systems
- 07620 – Sheet Metal Flashing and Trim
- 07841 – Through Penetration Firestop Systems
- 07920 – Joint Sealants

Division 8 – Doors and Windows
- 08110 – Steel Doors and Frames
- 08163 – Sliding Aluminum – Framed Glass Door
- 08211 – Flush Wood Doors
- 08305 – Access Doors
- 08331 – Overhead Coiling Doors
- 08410 – Aluminum Entrances
- 08420 – Aluminum Windows
- 08711 – Door Hardware
- 08800 – Glazing
- 08920 – Glazed Aluminum Curtain Walls

Division 9 – Finishes
- 09255 – Gypsum Board Assemblies
- 09511 – Acoustical Panel Ceilings
- 09651 – Resilient Tile Flooring
- 09652 – Sheet Vinyl Floor Coverings
- 09653 – Resilient Wall Base and Accessories
- 09680 – Carpet
- 09900 – Painting

Division 10 – Specialties
- 10155 – Toilet Compartments
- 10200 – Louvers and Vents
- 10505 – Metal Lockers
- 10520 – Fire-Protection Specialties
- 10521 – Fire Suppression Systems
- 10523 – Fire Extinguishers
- 10801 – Toilet and Bath Accessories

Division 11 – Equipment
- 11160 – Loading Dock Equipment

Division 12 – Furnishings
- 12500 – Black-Out Shades

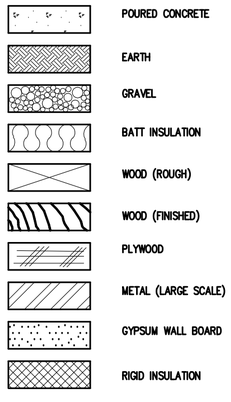
Division 13 – Special Construction
- 13100 – Lightning Protection
- 13852 – Fire Alarm Systems
- 13963 – Gaseous Fire Suppression Systems

Division 14 – Conveying Systems
- 14605 – Crane Rail
- 14620 – Trolley Hoist
- 14630 – Bridge Cranes
- 14650 – Jib Cranes

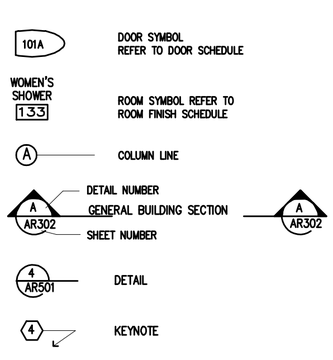
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- 15010 – General Provisions
- 15050 – Basic Mechanical Materials and Methods
- 15060 – Hangers and Supports
- 15081 – Duct Insulation
- 15100 – Valves
- 15122 – Meters and Gages
- 15170 – Motors
- 15185 – Hydronic Pumps
- 15241 – Mechanical Vibration Controls and Seismic Restraints
- 15411 – Water Distribution Piping
- 15420 – Drainage and Vent Piping
- 15440 – Plumbing Fixtures
- 15450 – Fire Protection Water Storage Tanks
- 15461 – Electric Water Heaters
- 15465 – Compressed-Air Equipment
- 15545 – Chemical Water Treatment
- 15815 – Metal Ducts
- 15851 – Centrifugal Fans
- 15985 – Sequence of Operations
- 15590 – Testing, Adjusting, and Balancing

Division 16 – Electrical
- 16000 – General Requirements for Electrical Work
- 16100 – Raceways, Boxes, and Cabinets
- 16114 – Cable Trays
- 16124 – Medium Voltage Cable – Single Conductor Cable
- 16140 – Wiring Devices
- 16170 – Motor and Circuit Disconnects
- 16180 – Overcurrent Protective Devices
- 16230 – Generator Assemblies
- 16425 – Distribution Switchboards
- 16450 – Electrical Grounding System
- 16460 – Dry Type Transformers
- 16470 – Panelboards
- 16473 – Transient Voltage Surge Protection
- 16481 – Motor Starters and Control Centers
- 16483 – Adjustable Frequency Motor Controller
- 16500 – Lighting Fixtures
- 16610 – Uninterruptable Power Supply (UPS)
- 16670 – Lighting Protection System
- 16720 – Fire Alarm System
- 16990 – Testing

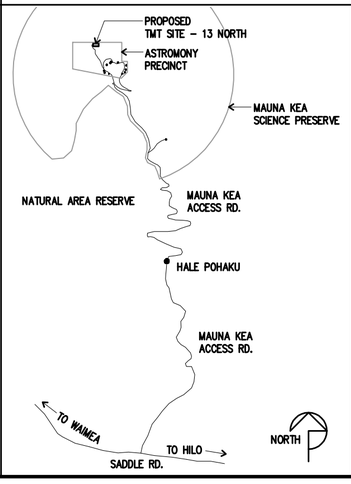
MATERIAL SYMBOLS (NOT ALL SYMBOLS ARE USED IN THIS SET OF DRAWINGS)



KEYING SYMBOLS



LOCATION MAP



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

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MAUNA KEA, HAWAII

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ARCHITECTURE
CONSTRUCTION MANAGEMENT

Revisions

	Description	Date
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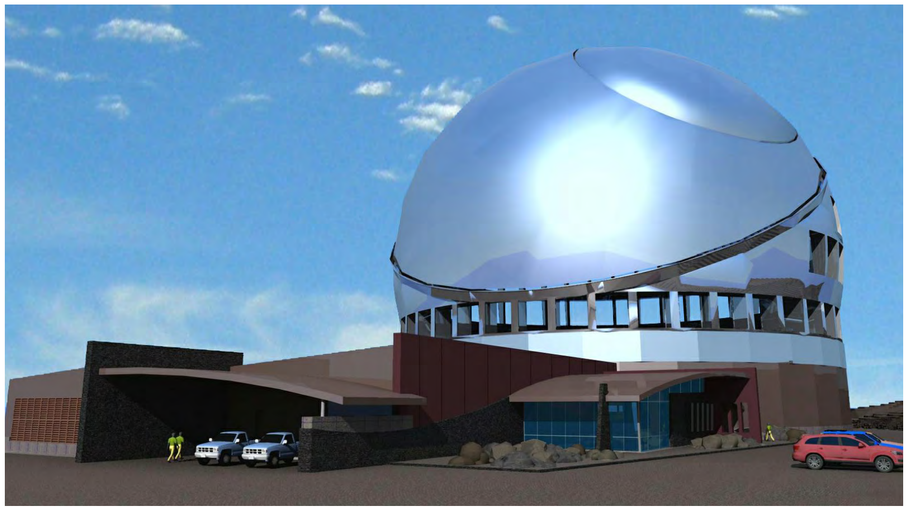
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Issue Date: 4-5-10

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DRAWING INDEX, ABBREVIATIONS, AND SYMBOLS

Sheet Number
GI002

M3PN 07131

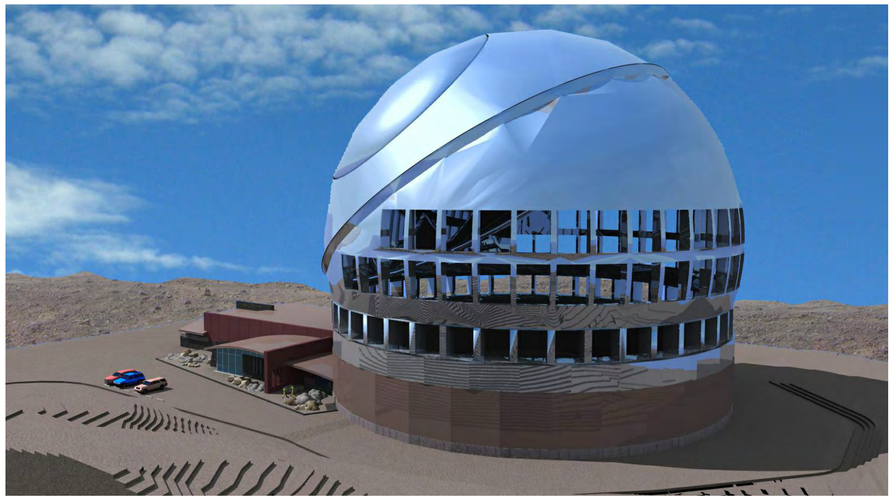
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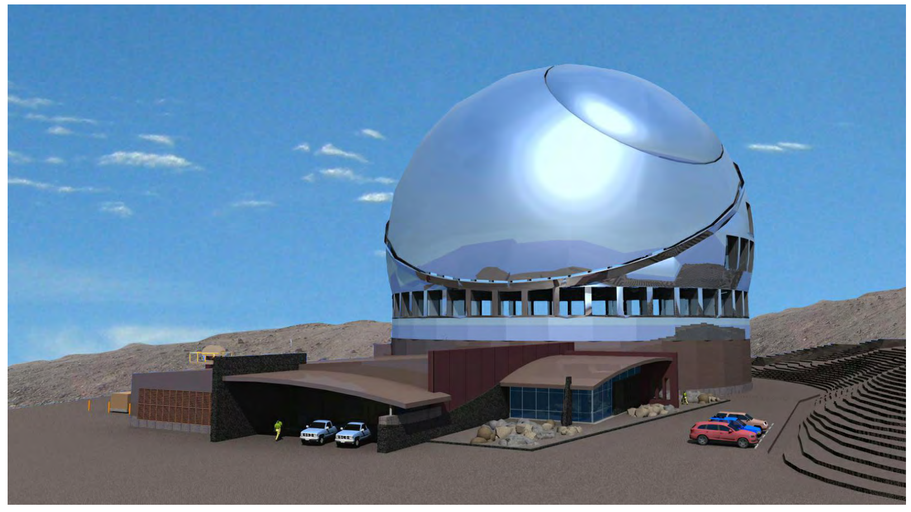
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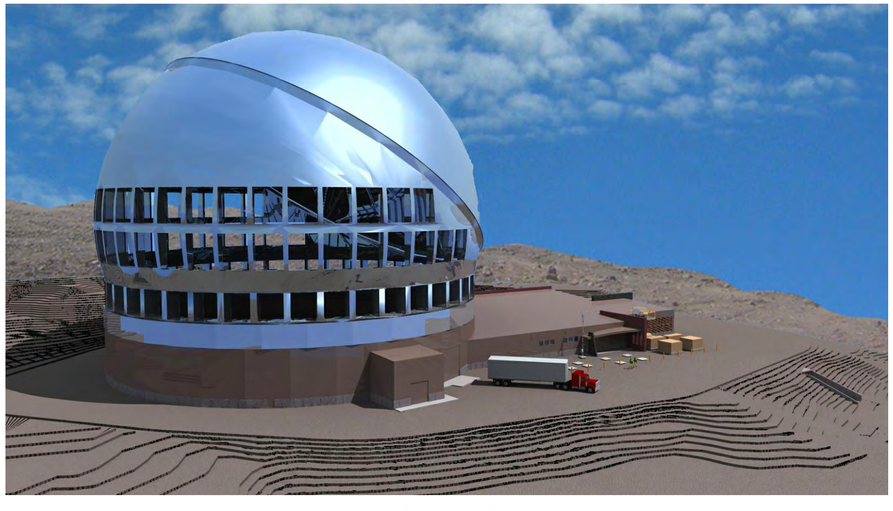
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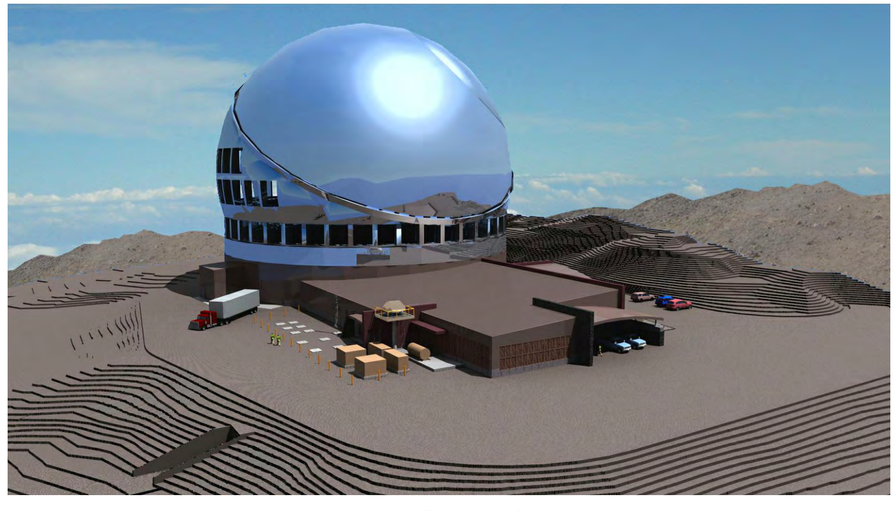
SOUTHEAST VIEW



SOUTHWEST VIEW



NORTHEAST VIEW



NORTHWEST VIEW

PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

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ARCHITECTURE
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CONSTRUCTION MANAGEMENT

Revisions

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Checked: –
Issue Date: 4–5–10

Drawing Title

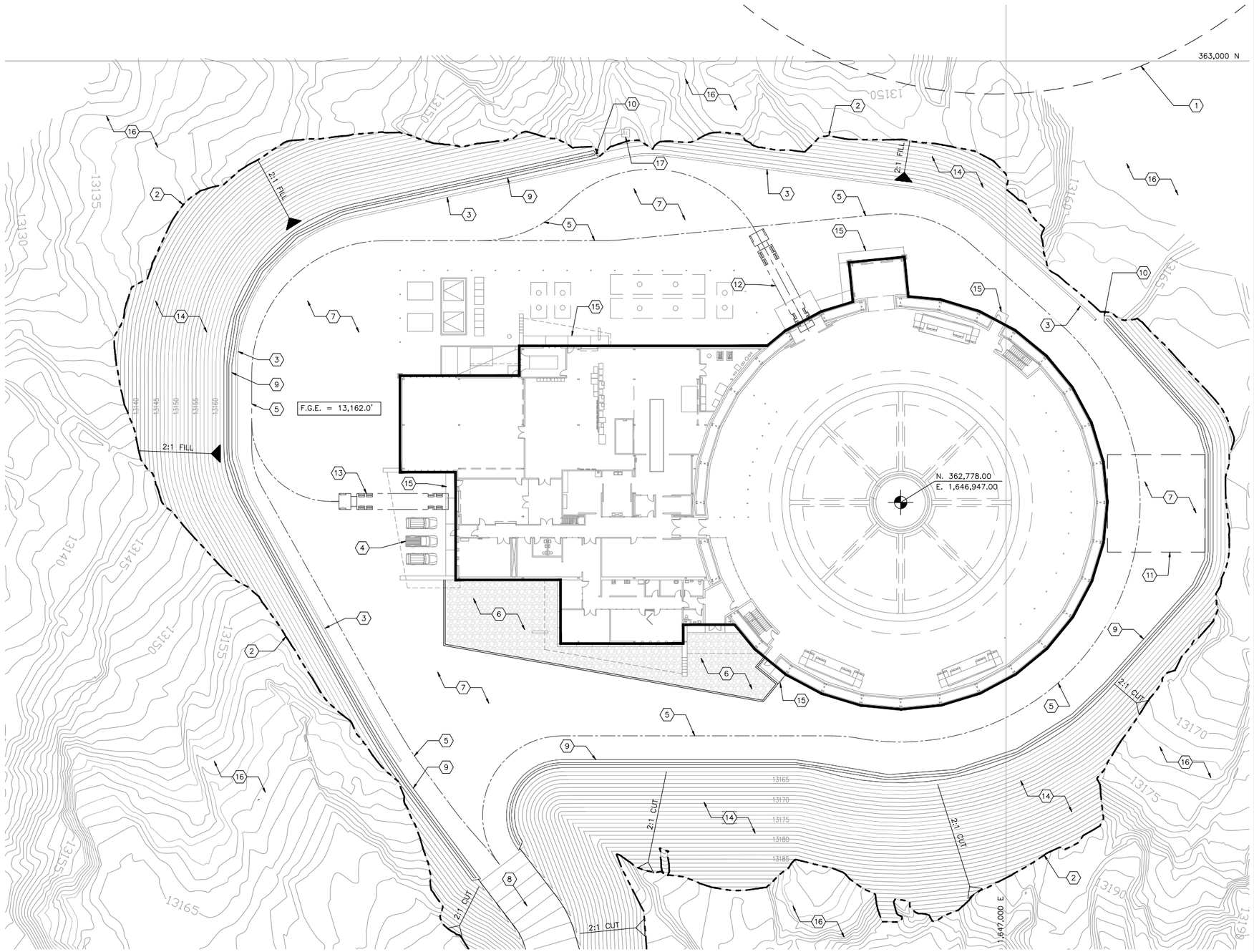
3-D MODEL RENDERINGS

Sheet Number

GI003

M3PN 07131

Last Update: 3.26.2010



ARCHITECTURAL SITE PLAN

20' 10' 0' 20' 40'
1"=20'-0"

NORTH

KEY NOTES

1. 200'-0" ENVIRONMENTAL AREA RADIUS
2. PROPOSED DISTURBED SITE AREA LIMITS
3. VEHICULAR GUARDRAIL
4. TMT STAFF PARKING
5. CIRCULATION PATH (CENTERLINE)
6. NATURAL LANDSCAPING
7. 2" DECOMPOSED GRANITE OR CRUSHED BASALT
8. TMT ACCESS ROAD
9. SITE DRAINAGE SWALE
10. SITE DRAINAGE SWALE OUTLET
11. 49'-0" x 49'-0" DOME CRANE ACCESS
12. TRUCK ACCESS TO FIXED ENCLOSURE & DOME
13. TRUCK ACCESS TO SUMMIT FACILITIES
14. DISTURBED AREA TO BE GRADED SIMILAR TO THE EXISTING SITE CONTOURS TO CREATE A MORE NATURAL SURFACE
15. CONCRETE WALK
16. UNDISTURBED AREA
17. WEATHER STATION TOWER (TMT)

GENERAL INFORMATION

PROPOSED LOCATION:
MAUNA KEA SCIENCE PRESERVE
ASTRONOMY PRECINCT
AREA 'E' – 13 NORTH

PROPOSED SITE ELEVATION
F.G.E. 13,162.0'

PROPOSED DISTURBED SITE AREA
AREA: APPROX. 4.5 ACRES
(3.9 ACRES BEFORE 'RE-CONTOURING')

PROPOSED SITE GRADING
CUT: 36,881 CUBIC YARDS
FILL: 22,356 CUBIC YARDS

PROPOSED BUILDING SIZE:
52,679 GROSS SQUARE FEET
SINGLE LEVEL FACILITY
(OVERALL FOOTPRINT OF THE FIXED ENCLOSURE AND SUMMIT FACILITY)

PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE
SCHEMATIC DESIGN PACKAGE
MAUNA KEA, HAWAII

TMT

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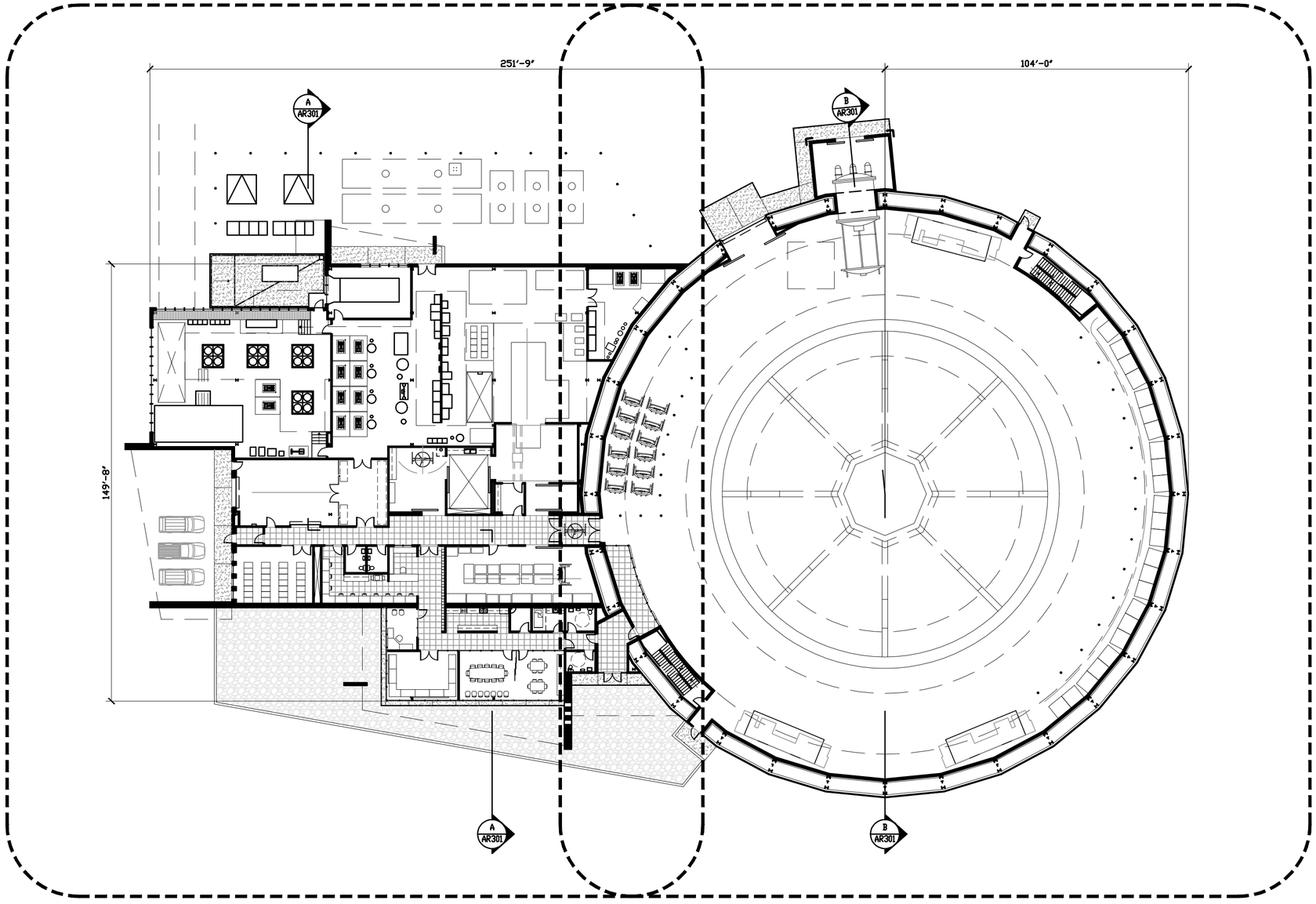
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Issue Date: 9-1-10

Drawing Title
ARCHITECTURAL SITE PLAN

Sheet Number
AS101

M3PN 07131

Last Update: 8.19.2010



SEE SHEET AR103 FOR
FLOOR PLAN OF THIS AREA

SEE SHEET AR102 FOR
FLOOR PLAN OF THIS AREA

OVERALL FLOOR PLAN

16' 8' 0' 16' 32'

1/16"=1'-0"

NORTH

KEY NOTES

PRELIMINARY
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THIRTY METER TELESCOPE

DESIGN DEVELOPMENT SUBMITTAL
FOR THE OFFICE OF MAUNA KEA MANAGEMENT
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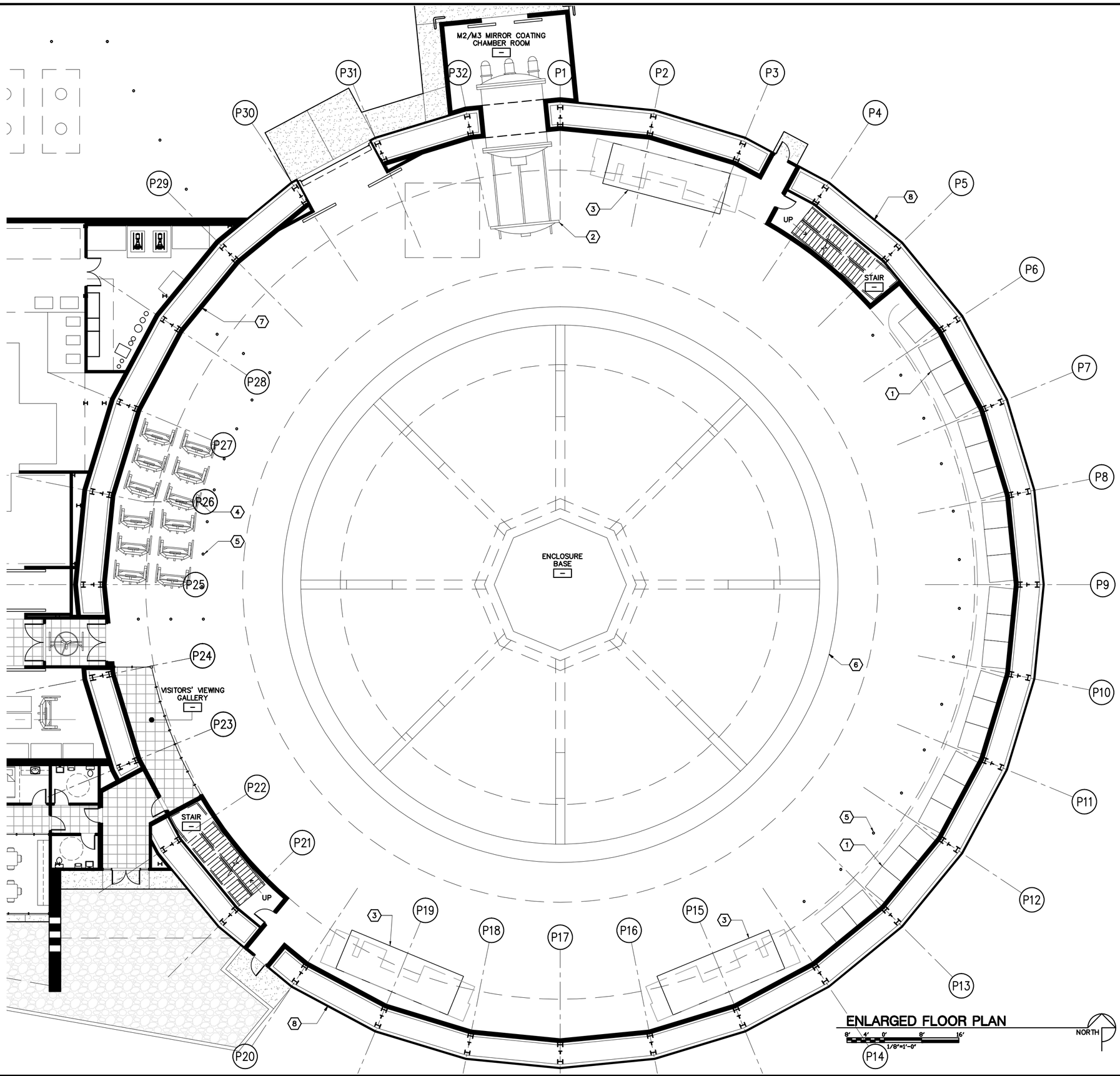
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Issue Date: 4-5-10

Drawing Title
OVERALL
FLOOR PLAN

Sheet Number
AR101

M3PN 07131

Last Update: 3.26.2010



ENLARGED FLOOR PLAN

8' 4' 0' 8' 16'

1/8"=1'-0"

NORTH

KEY NOTES

1. M1 MIRROR STORAGE CABINETS
2. M2/M3 COATING CHAMBER
3. DOME COOLING AIR HANDLER UNITS (TYPICAL OF 3)
4. M1 SEGMENT STAGING AREA
5. BOLLARD, TYP.
6. CONCRETE PIER
7. 10" INSULATED METAL WALL PANEL
8. EXTERIOR METAL PANEL

PRELIMINARY
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THIRTY METER TELESCOPE

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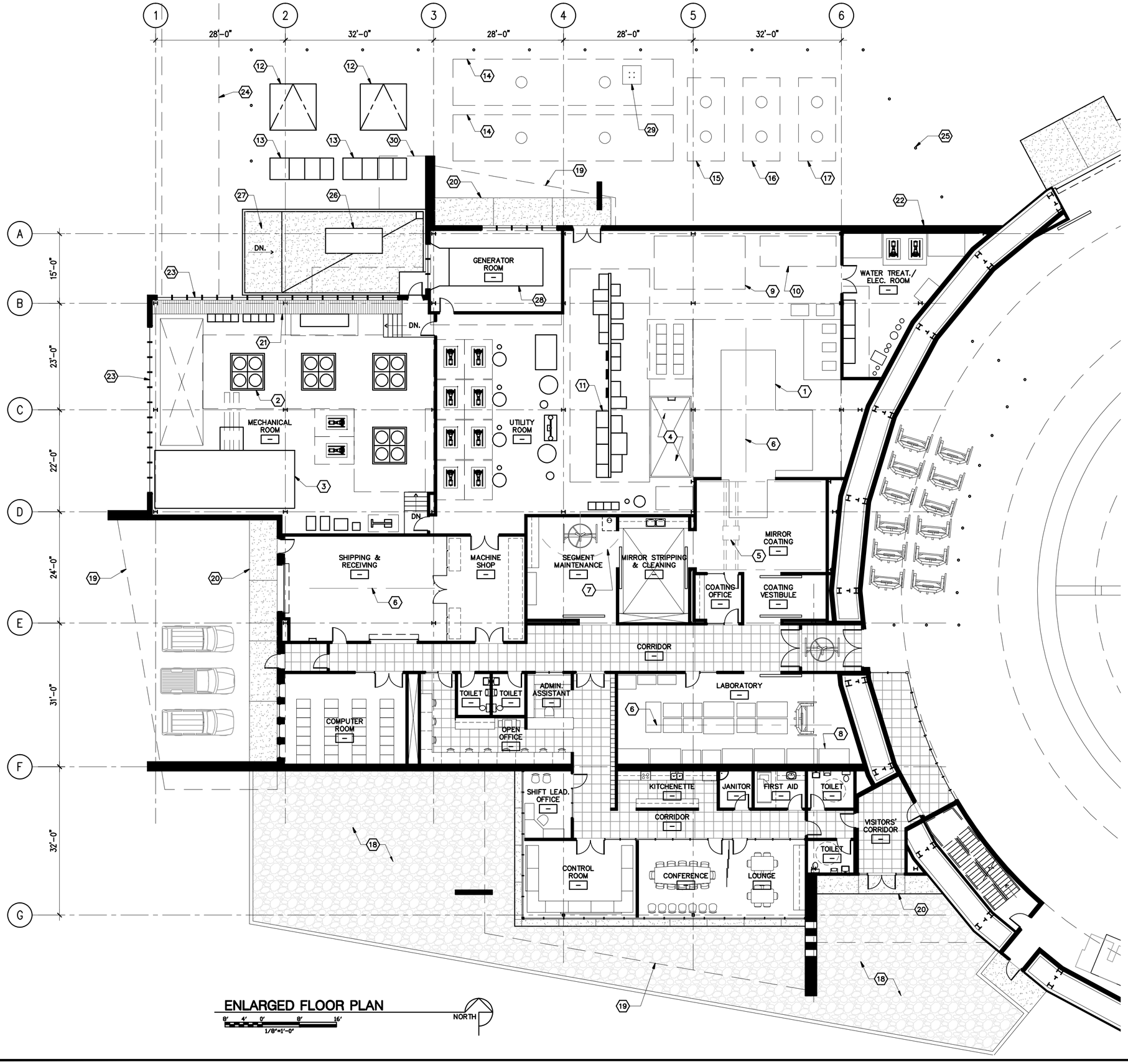
ENLARGED FLOOR PLAN

Sheet Number

AR102

M3PN 07131

Last Update: 3.24.2010



ENLARGED FLOOR PLAN

8' 4' 0' 8' 16'

1/8"=1'-0"

NORTH

KEY NOTES

1. M1 COATING CHAMBER
2. MECHANICAL CHILLERS (TYPICAL OF 4)
3. AIR ECONOMIZER
4. UTILITY CHASE
5. BRIDGE CRANE ABOVE
6. MONORAIL CRANE ABOVE
7. JIB CRANE
8. LABORATORY EQUIPMENT
9. HYDROSTATIC OIL EQUIPMENT
10. HYDROSTATIC OIL TANK
11. ELECTRICAL EQUIPMENT
12. HELCO SERVICE TRANSFORMER
13. ELECTRICAL SERVICE ENTRANCE SWITCHBOARD
14. UNDERGROUND FIRE WATER STORAGE TANK
15. UNDERGROUND 5,000 GALLON WATER STORAGE TANK
16. UNDERGROUND 5,000 GALLON WASTE STORAGE TANK
17. UNDERGROUND 5,000 GALLON DOUBLE CONTAINED CHEMICAL WASTE STORAGE TANK
18. NATIVE LANDSCAPING
19. ROOF ABOVE
20. CONCRETE WALK
21. DUCT SILENCER
22. EXTERIOR METAL PANEL
23. ACOUSTICAL LOUVER
24. UNDERGROUND EXHAUST TUNNEL
25. BOLLARD, TYP.
26. 2,000 GALLON ABOVE-GROUND DIESEL FUEL TANK
27. CONCRETE CONTAINMENT PAD AND FILL STATION
28. EMERGENCY GENERATOR
29. WEATHER STATION TOWER
30. ATMOSPHERIC TURBULENCE MONITOR ABOVE

PRELIMINARY
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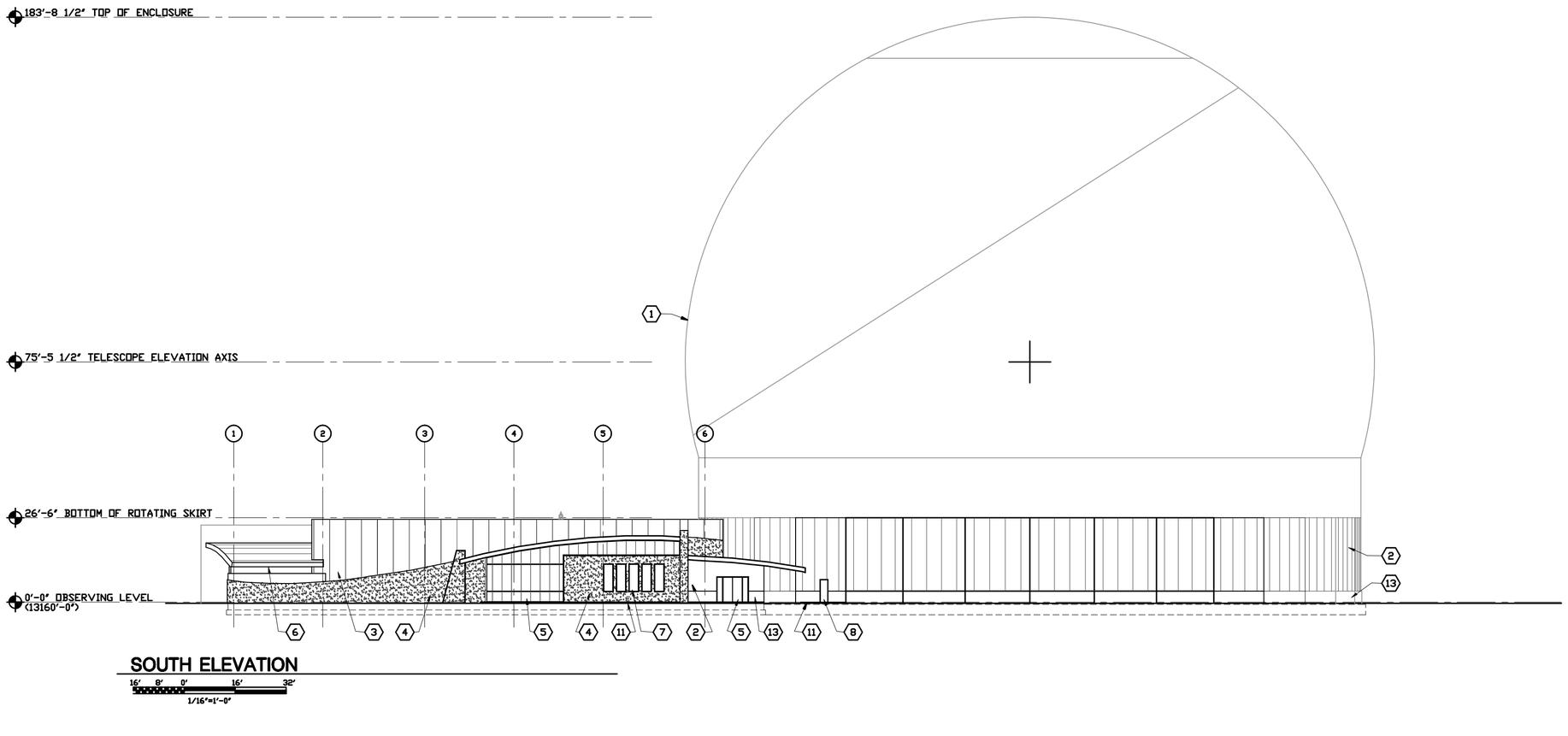
ENLARGED FLOOR PLAN

Sheet Number

AR103

M3PN 07131

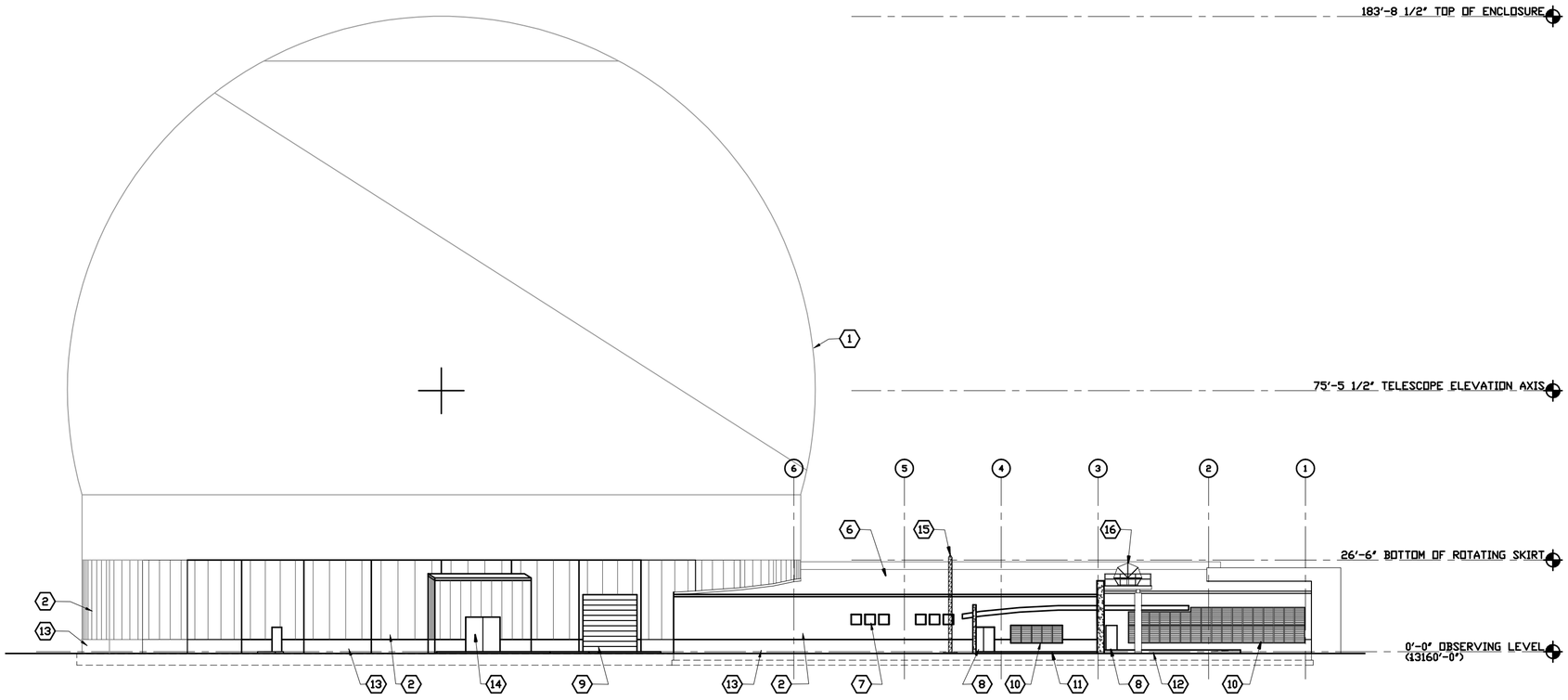
Last Update: 3.26.2010



SOUTH ELEVATION

16' 8' 0' 16' 32'

1/16"=1'-0"



NORTH ELEVATION

16' 8' 0' 16' 32'

1/16"=1'-0"

KEY NOTES

1. DOME STRUCTURE N.I.C.
2. METAL SIDING
3. SMOOTH METAL SIDING
4. LAVA ROCK VENEER
5. ALUMINUM STOREFRONT WITH INSULATED GLAZING
6. METAL ROOF
7. ALUMINUM WINDOWS WITH INSULATED GLAZING
8. HOLLOW METAL DOORS AND FRAME (PAINT)
9. INSULATED COILING ROLL UP DOOR
10. ACOUSTICAL LOUVER
11. CONCRETE WALK OR STOOP
12. CONCRETE UTILITY PAD
13. CONCRETE WAINSCOT
14. INSULATED SLIDING DOOR
15. WEATHER STATION TOWER
16. ATMOSPHERIC TURBULENCE MONITOR

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THIRTY METER TELESCOPE

DESIGN DEVELOPMENT SUBMITTAL
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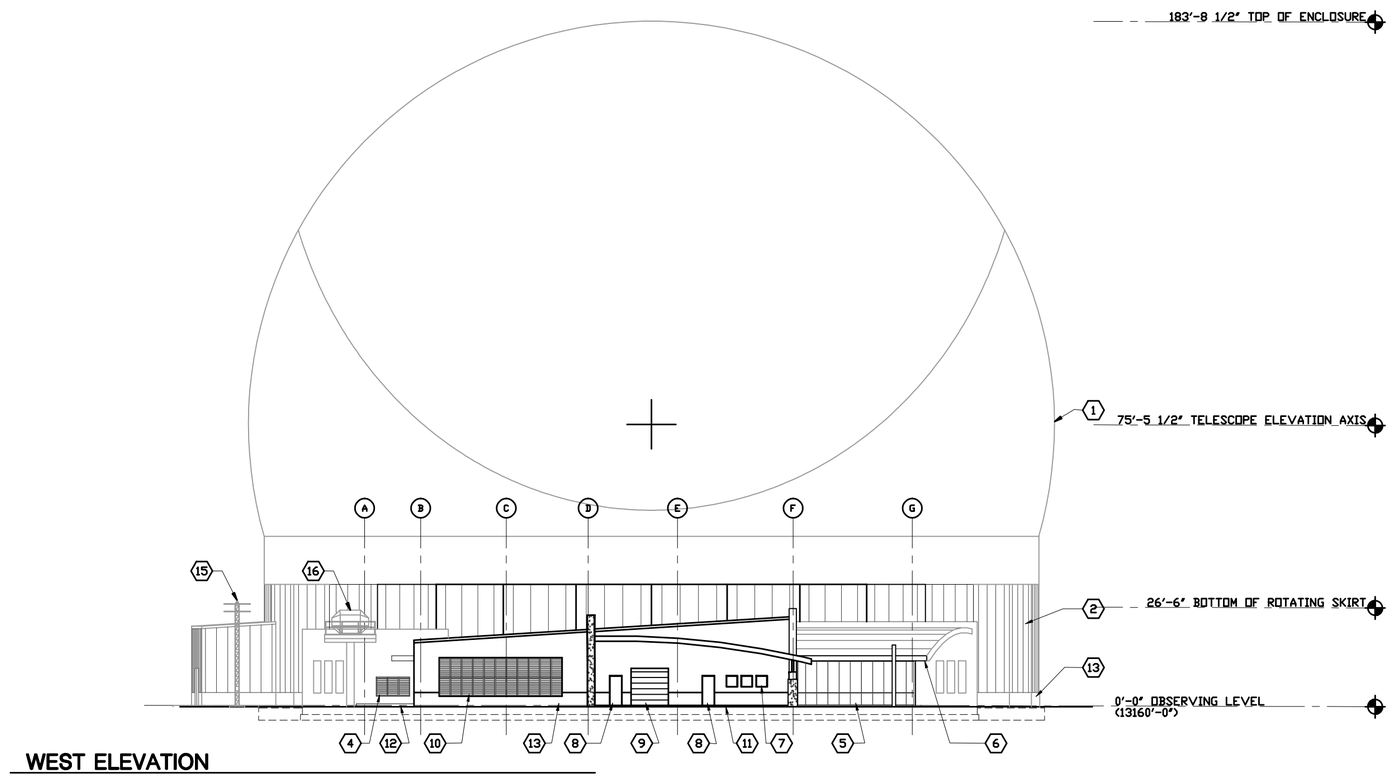
BUILDING ELEVATIONS

Sheet Number

AR201

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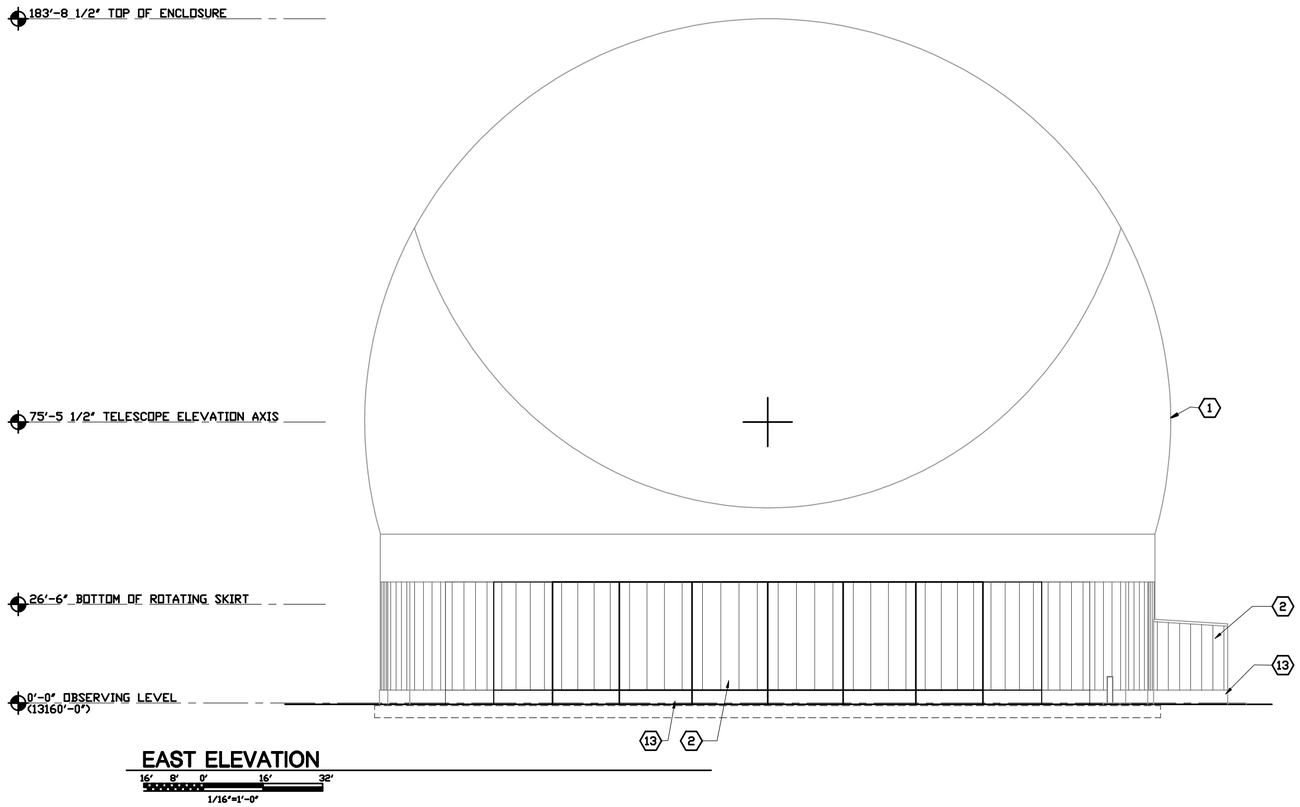
Last Update: 3.26.2010



WEST ELEVATION

16' 8' 0' 16' 32'

1/16"=1'-0"



EAST ELEVATION

16' 8' 0' 16' 32'

1/16"=1'-0"

KEY NOTES

1. DOME STRUCTURE N.I.C.
2. METAL SIDING
3. SMOOTH METAL SIDING
4. LAVA ROCK VENEER
5. ALUMINUM STOREFRONT WITH INSULATED GLAZING
6. METAL ROOF
7. ALUMINUM WINDOWS WITH INSULATED GLAZING
8. HOLLOW METAL DOORS AND FRAME (PAINT)
9. INSULATED COILING ROLL UP DOOR
10. ACOUSTICAL LOUVER
11. CONCRETE WALK OR STOOP
12. CONCRETE UTILITY PAD
13. CONCRETE WAINSCOT
14. INSULATED SLIDING DOOR
15. WEATHER STATION TOWER
16. ATMOSPHERIC TURBULENCE MONITOR

PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

DESIGN DEVELOPMENT SUBMITTAL
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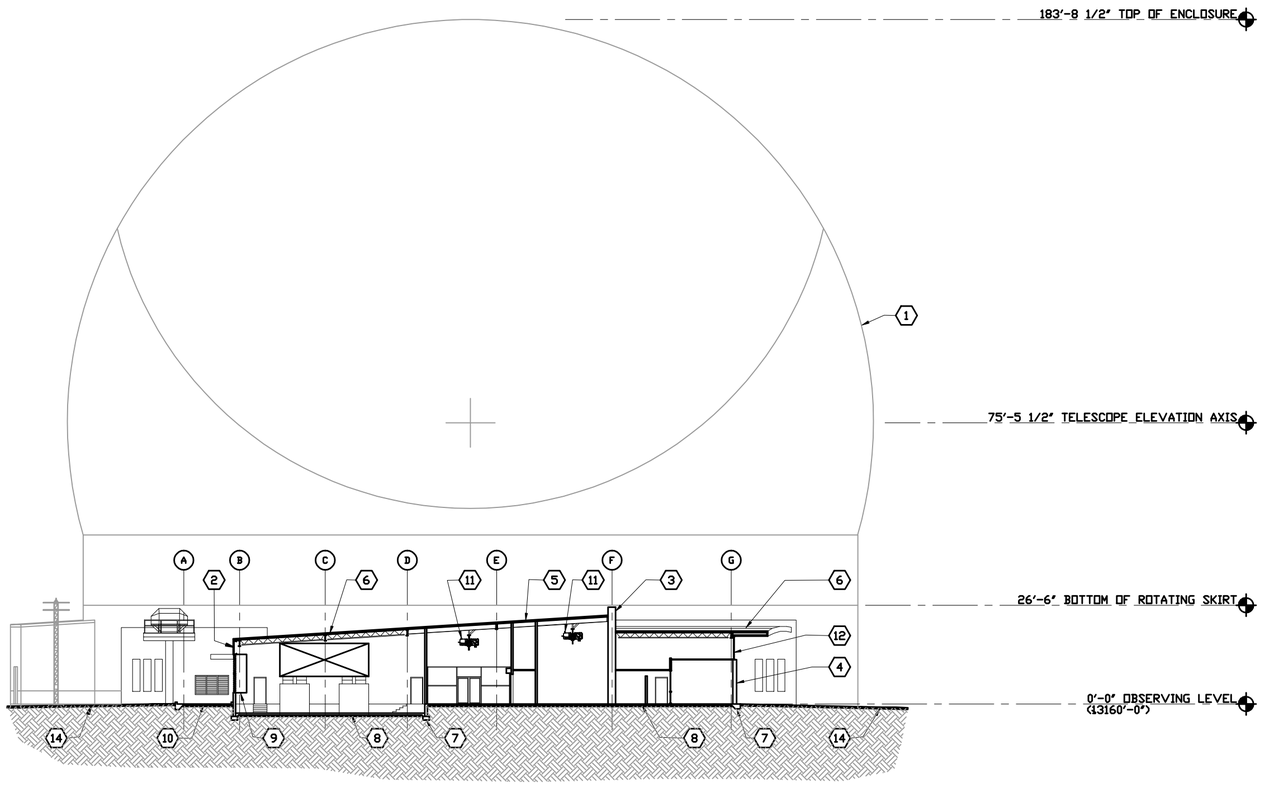
BUILDING ELEVATIONS

Sheet Number

AR202

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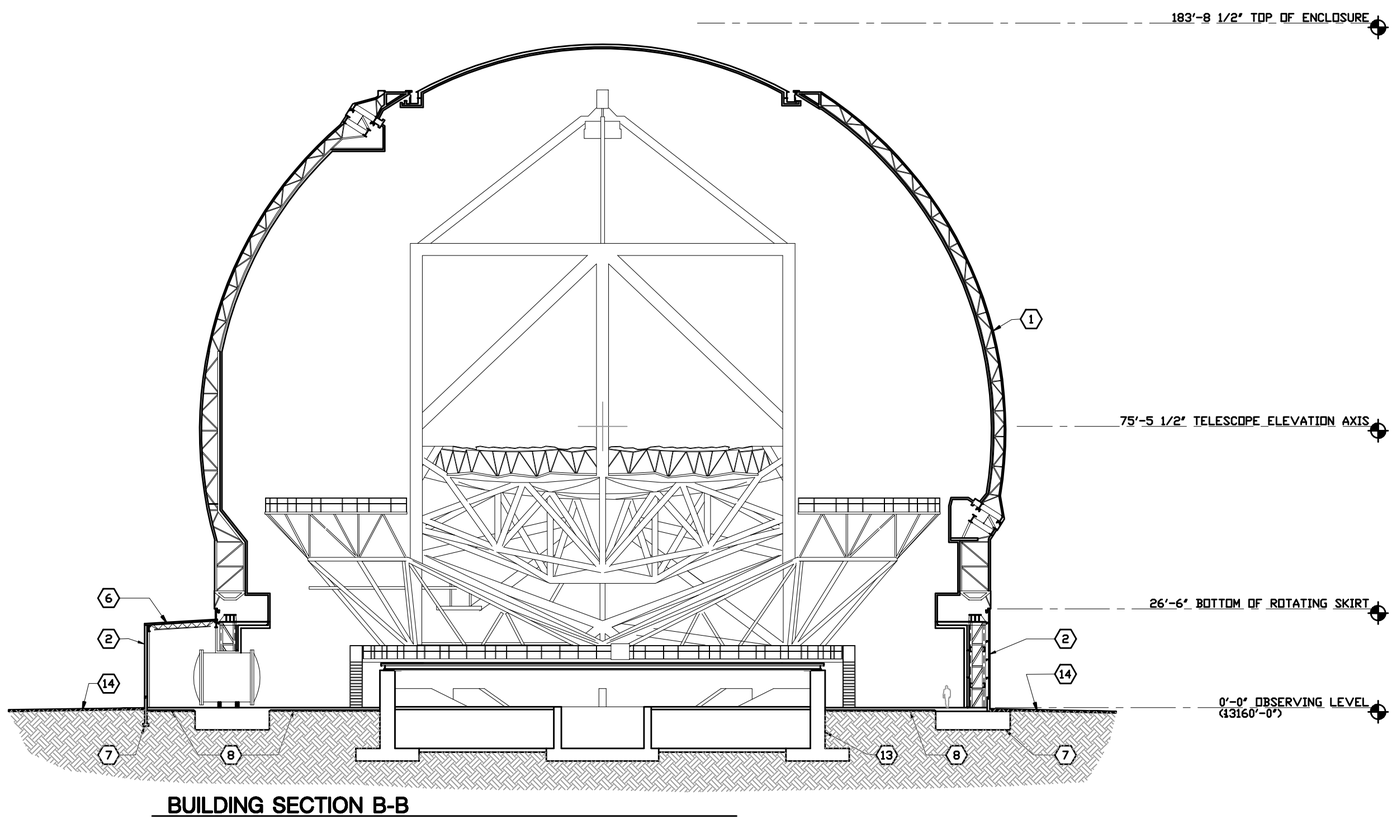
Last Update: 3.26.2010



BUILDING SECTION A-A

16' 8' 0' 16' 32'

1/16"=1'-0"



BUILDING SECTION B-B

16' 8' 0' 16' 32'

1/16"=1'-0"

KEY NOTES

1. DOME STRUCTURE N.I.C.
2. METAL SIDING ON GIRTS
3. SMOOTH METAL SIDING ON GIRTS
4. LAVA ROCK VENEER ON STRUCTURAL STEEL STUDS
5. METAL ROOF ON METAL DECK OVER STEEL BEAMS
6. METAL ROOF ON METAL DECK OVER METAL JOISTS
7. CONCRETE FOOTING – SEE STRUCTURAL DRAWINGS
8. CONCRETE FLOOR – SEE STRUCTURAL DRAWINGS
9. ACOUSTICAL LOUVER AND DUCT SILENCER
10. CONCRETE UTILITY PAD
11. MONORAIL HOIST
12. ALUMINUM STOREFRONT WITH INSULATED GLAZING
13. CONCRETE PIER – SEE STRUCTURAL DRAWINGS
14. FINISH GRADE

PRELIMINARY
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THIRTY METER TELESCOPE

DESIGN DEVELOPMENT SUBMITTAL
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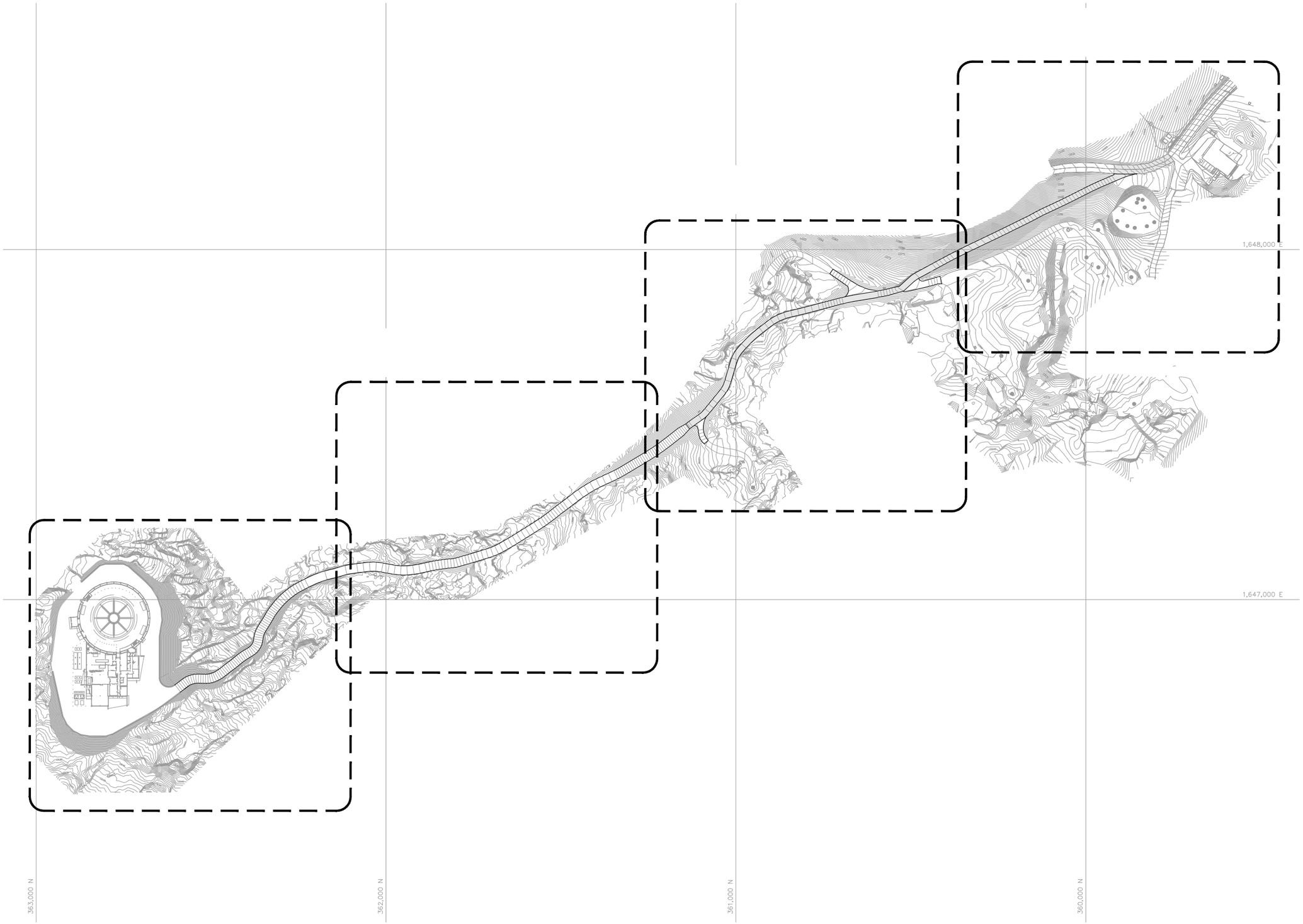
BUILDING SECTIONS

Sheet Number

AR301

M3PN 07131

Last Update: 3.26.2010



CIVIL OVERALL SITE PLAN

100' 50' 0' 100' 200'

1" = 100'

NORTH

PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE SCHEMATIC DESIGN PACKAGE

MAUNA KEA, HAWAII

TMT

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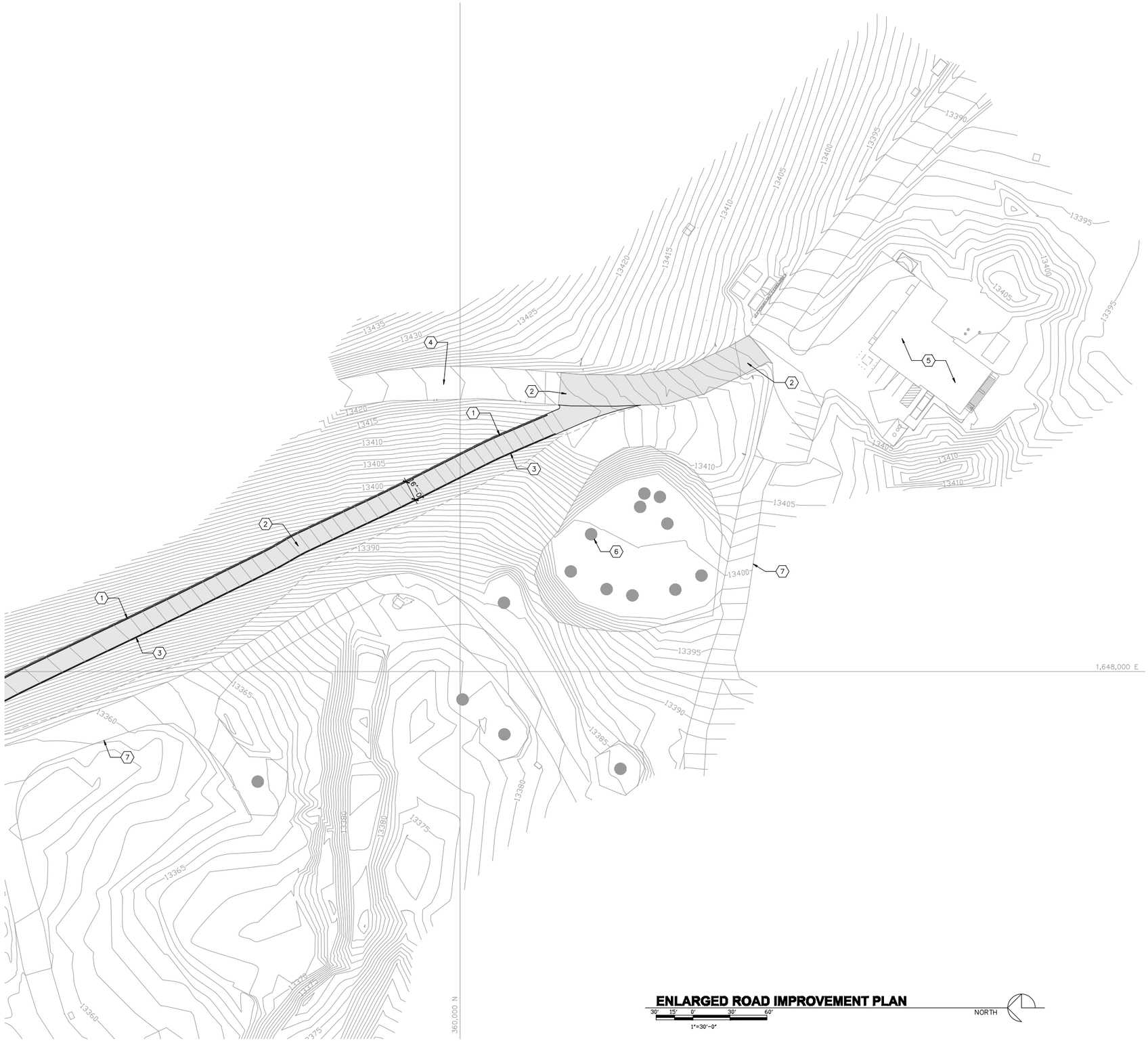
CIVIL OVERALL SITE PLAN

Sheet Number

CS101

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Last Update: 8.30.2010



KEY NOTES

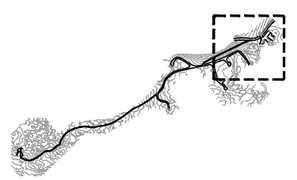
1. 6" VERTICAL CONCRETE CURB
2. 3" ASPHALT OVER 4" ABC
3. VEHICULAR GUARDRAIL
4. EXISTING MAUNA KEA LOOP ROAD (DIRT)
5. SMA ARRAY FACILITY
6. SMA CONCRETE ANTENNA PAD, TYP.
7. EXISTING SMA ACCESS ROAD (DIRT)

ENLARGED ROAD IMPROVEMENT PLAN

30' 15' 0' 30' 60'
1"=30'-0"

NORTH

KEY PLAN



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE
SCHEMATIC DESIGN PACKAGE
MAUNA KEA, HAWAII

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Drawing Title
ENLARGED ROAD IMPROVEMENT PLAN

Sheet Number
CI401

M3PN 07131

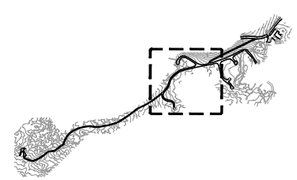
Last Update: 8.30.2010



KEY NOTES

1. 6" VERTICAL CONCRETE CURB
2. 3" ASPHALT OVER 4" ABC
3. VEHICULAR GUARDRAIL
4. EDGE OF ASPHALT
5. TMT ACCESS ROAD – DIRT
6. –

KEY PLAN



PRELIMINARY
NOT FOR CONSTRUCTION

ENLARGED IMPROVEMENT PLAN

30' 15' 0' 30' 60'
1"=30'-0"

NORTH

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE
SCHEMATIC DESIGN PACKAGE
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ENLARGED IMPROVEMENT PLAN

Sheet Number
CI402

M3PN 07131

Last Update: 8.17.2010



ENLARGED IMPROVEMENT PLAN

30' 15' 0' 30' 60'

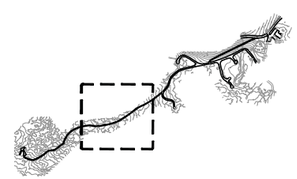
1"=30'-0"

NORTH

KEY NOTES

1. TMT ACCESS ROAD – DIRT
2. –

KEY PLAN



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE

SCHEMATIC DESIGN PACKAGE

MAUNA KEA, HAWAII

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Drawing Title

ENLARGED IMPROVEMENT PLAN

Sheet Number

CI403

M3PN 07131

Last Update: 8.17.2010



ENLARGED IMPROVEMENT PLAN

30' 15' 0' 30' 60'

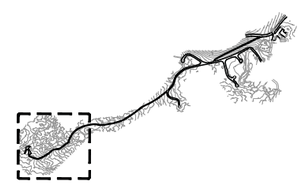
1"=30'-0"

NORTH

KEY NOTES

1. VEHICULAR GUARDRAIL
2. SITE DRAINAGE SWALE
3. 2" DECOMPOSED GRANITE
4. –
5. –
6. –

KEY PLAN



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE

SCHEMATIC DESIGN PACKAGE

MAUNA KEA, HAWAII

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ENLARGED IMPROVEMENT PLAN

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CI404

M3PN 07131

Last Update: 8.17.2010

Exhibit B. TMT Management Plan

In addition to the Management Plan itself, this exhibit contains the following 5 appendices.

- Appendix A: Draft Historic Preservation Mitigation Plan
- Appendix B: Construction Plan
- Appendix C: Historical & Archaeological Site Plan
- Appendix D: Maintenance Plan
- Appendix E: Arthropod Monitoring Plan

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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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 Hawai‘i 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 Observatory[2] within an area below the summit of Mauna Kea that is known as "Area E". The TMT Observatory Corporation[3] 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 BLNR[5]; 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.

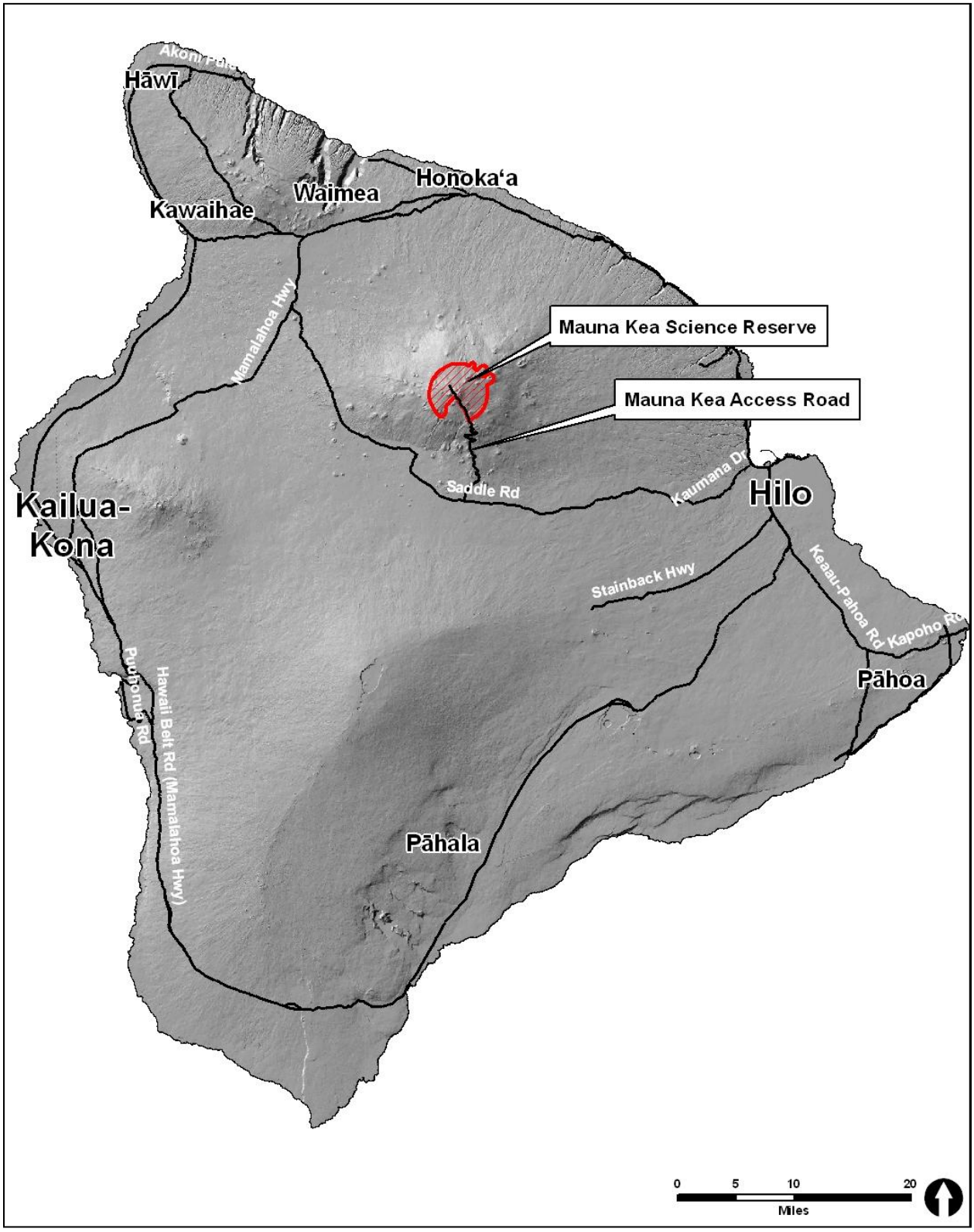
The proposed project would be developed and operated in compliance with the Conservation District rules and with all conditions that may be attached to the Conservation District Use

[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.

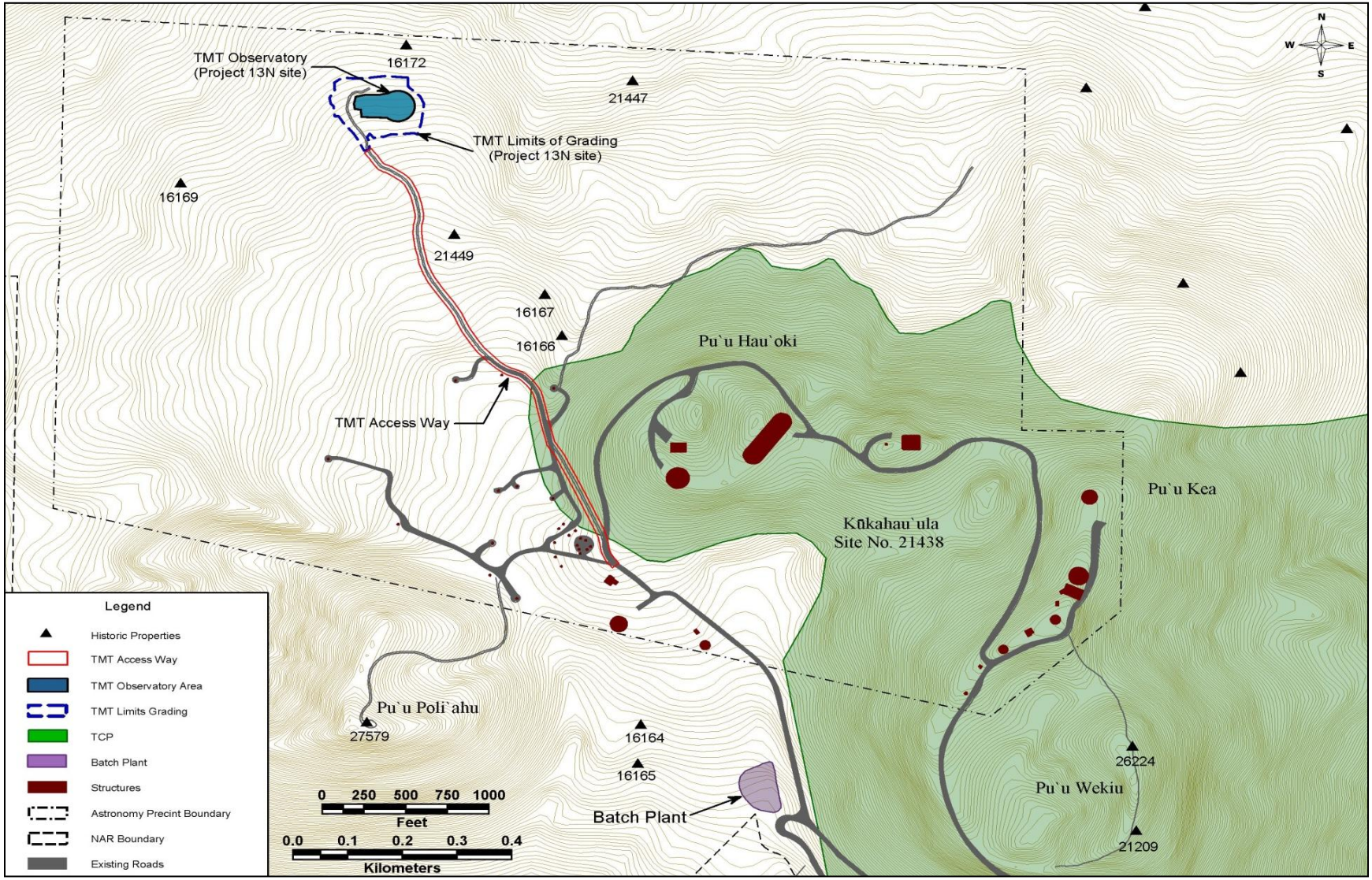
Figure 2-1 shows the individual historic properties that have been identified in the vicinity of the TMT Project area. There are no historic properties located within 200 feet of the limits of grading at the proposed TMT Observatory 13N site. Approximately 1,100 feet of the 3,400 foot long Access Way 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 engendered 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 (*Pterodrama 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.

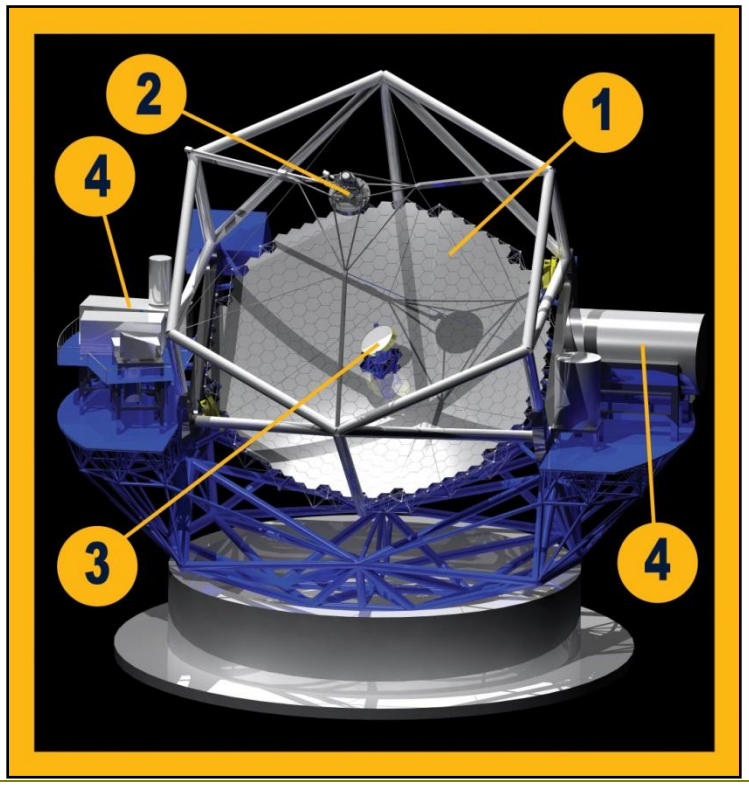
In addition to these facilities and activities, construction and operation of the TMT Project would entail several other uses that do not require a new CDUP. These include the use of existing roadways to transport construction workers and materials from the place where they live/are landed on the island, 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



1. The primary mirror – the "eye" of telescope– will be 98 feet (30 meters) in diameter. This mirror will be comprised of 492 individual mirror segments operating as one.
2. The secondary mirror sits above the primary mirror and will direct the light collected by the primary mirror to the tertiary mirror.
3. The tertiary mirror sits in the middle of the primary mirror and will direct the collected light into different instruments for analysis.
4. Interchangeable instruments and sensors mounted to the side of the mirror will collect and process light from wide array of wave lengths.

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.

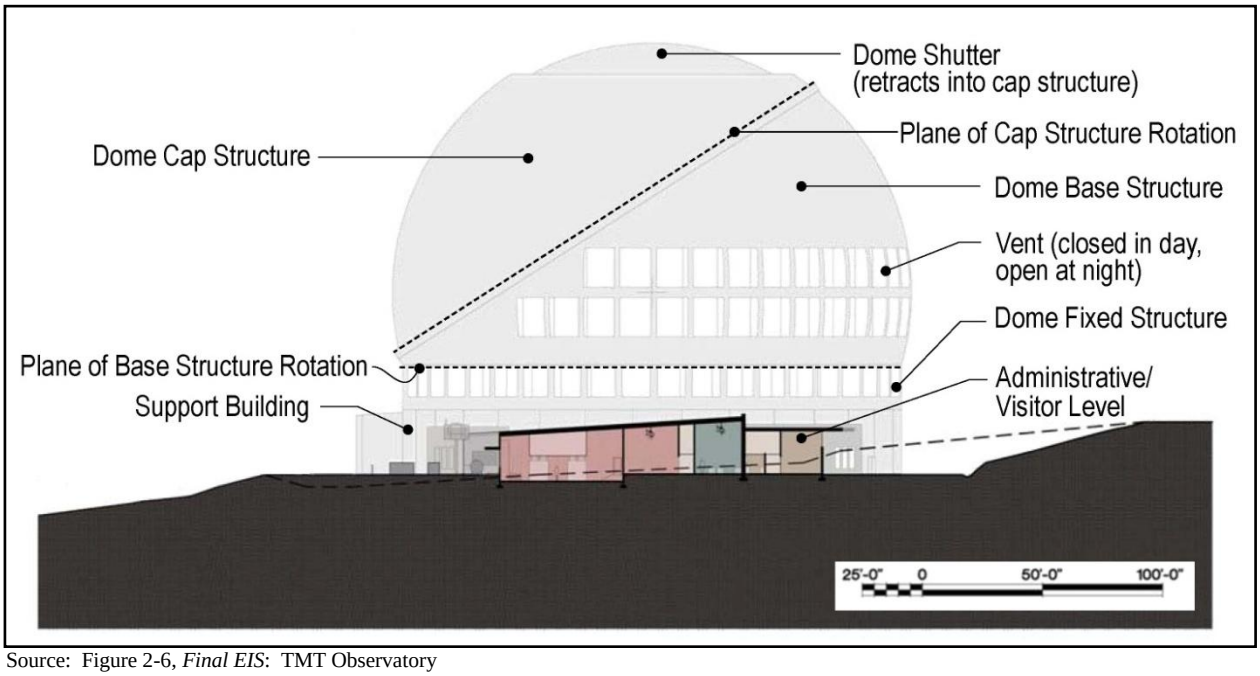
[8] CMP Management Action IM-11 encourages existing facilities and new development to incorporate sustainable technologies, energy efficient technologies, and LEED standards, whenever possible, into facility design and operations.

- 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.

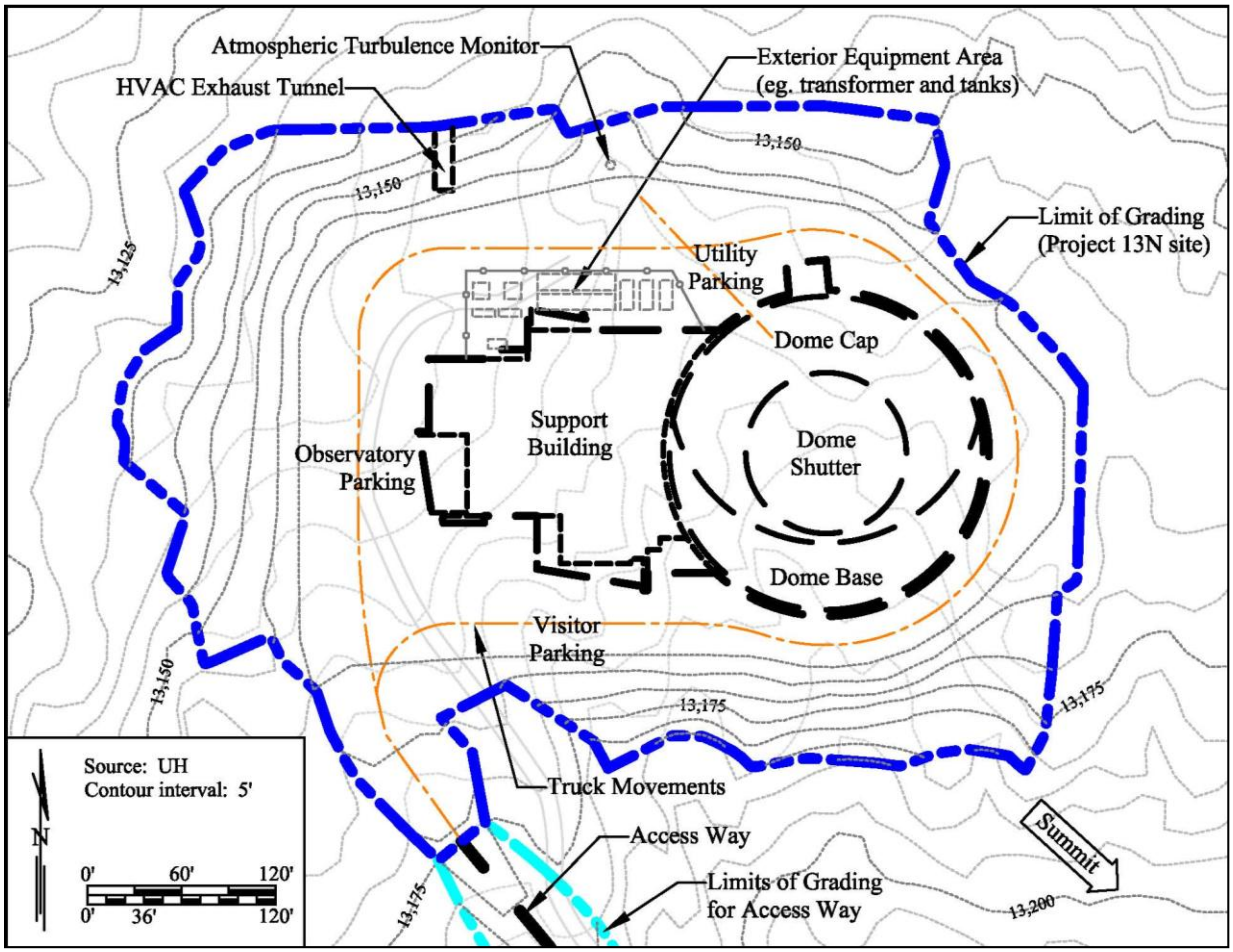
[10] A Calotte type dome features a circular shutter and two planes of rotation instead of the rectangular shutter and single plane of rotation characteristic of standard domes. Benefits of a Calotte type dome include (a) overall smaller dome size, (b) improved air flow/lower air turbulence around the 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

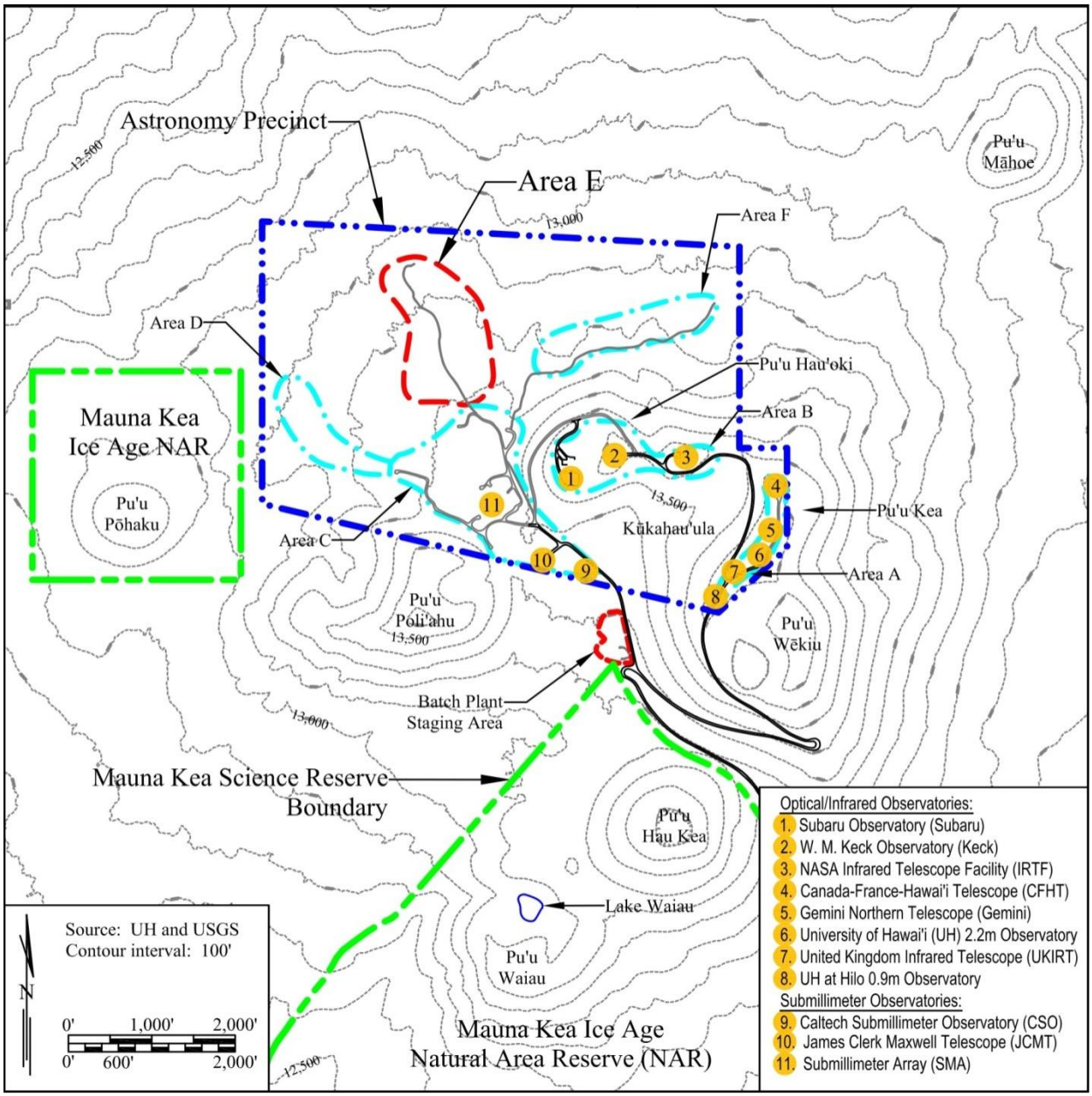


    - Utility spaces – including electrical services, chillers, a generator, pumps for fire suppression and other non-potable water needs, restrooms, and fluid dynamic bearing pumps that control the movement of the telescope.
    - Administration space, including offices and a kitchenette.

- 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

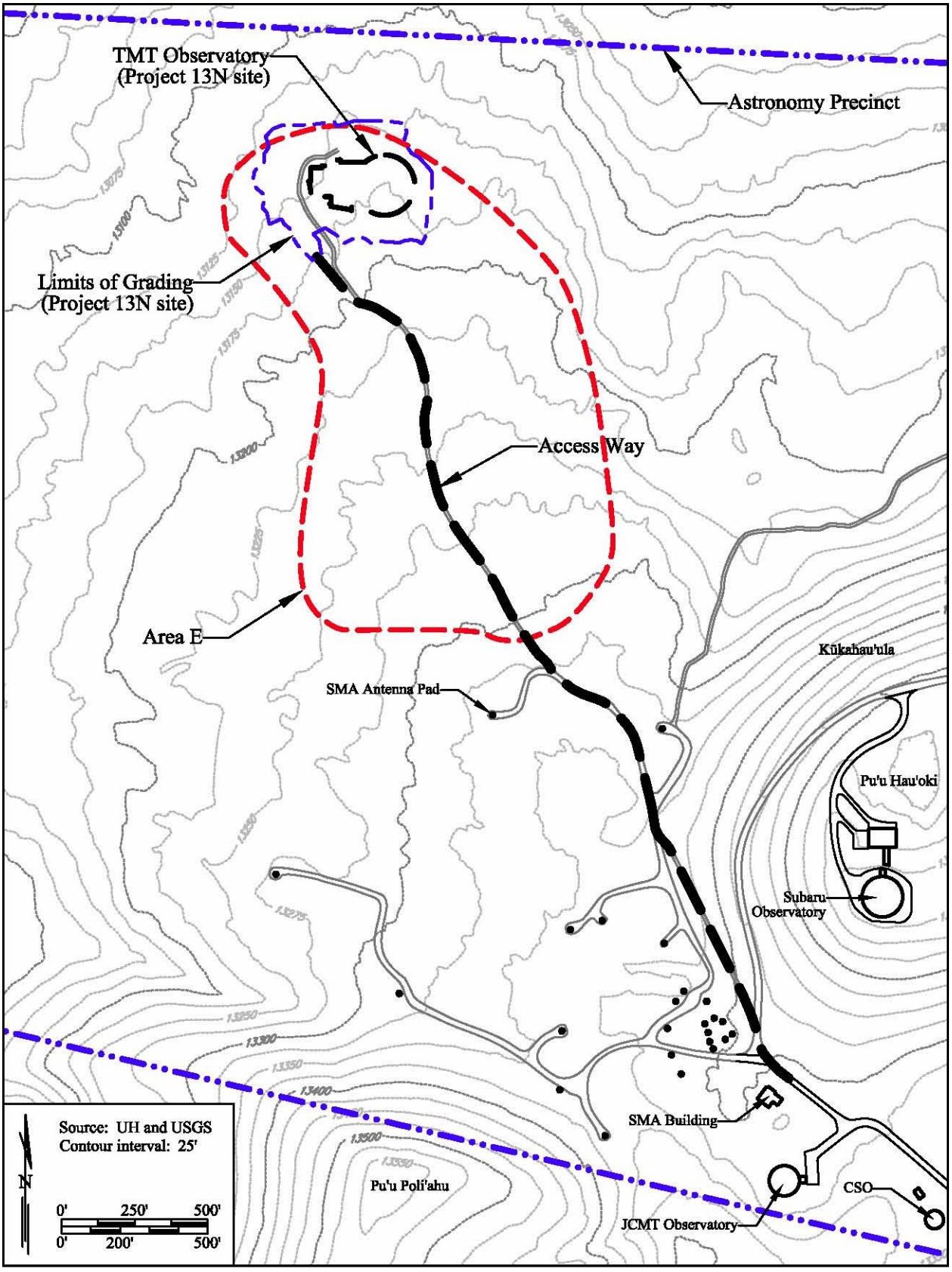
Currently, utility services exist along the Mauna Kea Access Road to a point near the intersection of the Mauna Kea Loop Road and the SMA roadway. The proposed Access Way would start at that point and extend to the TMT Observatory; for the most part it would follow either existing 4-wheel drive roads 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

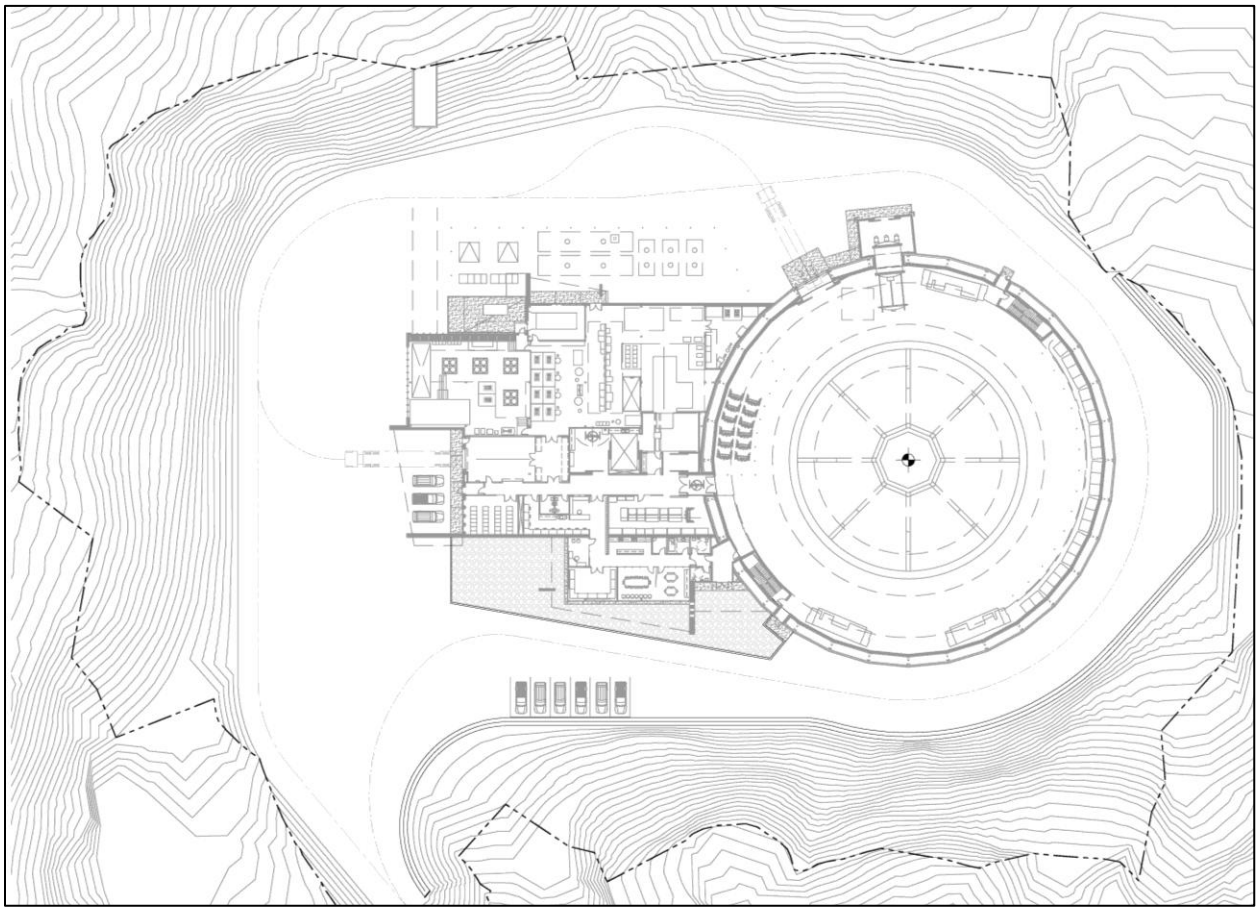
[11] The proposed Access Way design is a refinement of one of the routes covered in the *Final EIS*.

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

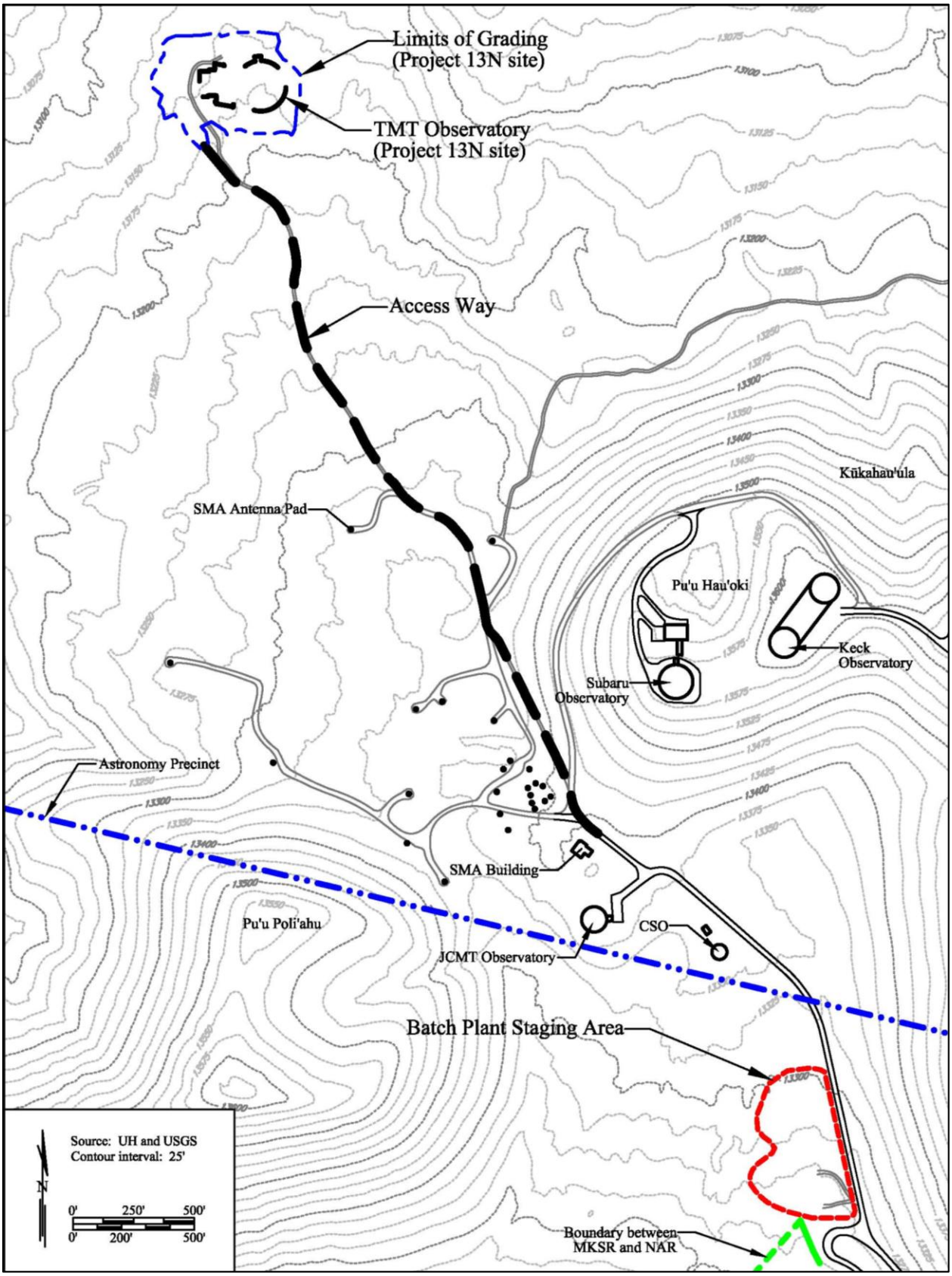
modifications of cinder cone morphology. The cumulative impact to the alpine shrublands and grasslands and māmane subalpine woodlands has also been substantial, adverse, and significant, primarily due to grazing by hoofed animals. The magnitude of significance of cumulative impact to the alpine stone 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 Puʻu Hauʻoki, one of the puʻu that make up Kūkahauʻula, 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 culturally 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.	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: • Cultural and Natural Resources Training Program: 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
			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. • TMT Outreach Office: 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. • Mauna Kea Resources Exhibit: 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. • Community Cultural Training and Events: 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. • Sublease Rent: 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. 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.
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.	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: • 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: • 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
			archaeological sites and their importance. • 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.	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: • 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.	behavior in the summit area. • 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: - 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. 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.

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 Apendix 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.	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: • Materials Control and Reduction. 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: - 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. • Washing/Cleaning. 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
			will be done at lower elevation base yards, such as the Port Staging Area, and could include: - 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. • Inspections. 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. • Monitoring. 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. • Control. 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. • Education/Training. 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. • Updates. 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 contactor 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 Start 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 (PICHTR), 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 needed16	One to two (1-2) years prior to start of deconstruction
Other permits, as needed17	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

Office of Mauna Kea Management (OMKM), 2010b. Public Access Plan for the UH Management Areas on Mauna Kea; A Sub-Plan of the Mauna Kea Comprehensive Management Plan. January 2010. Prepared by Sustainable Resources Group International, Inc., Island Planning, and Island Transitions, LLC, approved by BLNR on March 25, 2010.

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McCoy, Patrick and Nees, Richard, et.al., Final Report, Archaeological Inventory Survey of the Mauna Kea Science Reserve, Ka'ohe Ahupua'a, Hāmākua District, Island of Hawai'i. TMK: (3) 4-4-015:009. Volumes 1 and 2. PCSI, 2010.

Appendix A. Draft Historic Preservation Mitigation Plan

I. General Project Background & Description

On behalf of the Thirty-Meter-Telescope (TMT) Observatory Corporation, the University of Hawai‘i is seeking a Conservation District Use Permit from the State of Hawai‘i Board of Land and Natural Resources (BLNR) that will allow the construction, operation, and eventual decommissioning of the TMT Observatory[18] within an area below the summit of Mauna Kea that is known as “Area E”. In addition to the observatory facilities, other uses in the summit region that would occur under the permit include construction of an Access Way and equipment and materials staging in the Batch Plant Staging Area.

This plan presents brief descriptions of the proposed project activities, the historic properties known to be present in or near each area where uses/activities would occur, and the mitigation measures that will be implemented to reduce or eliminate adverse effects on historic properties and cultural practices. It also includes a draft Archaeological Monitoring Plan (AMP). The AMP will be formally submitted to the State Historic Preservation Division (SHPD) of the Department of Land and Natural Resources (DLNR) for review and approval after detailed construction plans are completed and prior to the start of any construction activities.

II. General Historical and Archaeological Background

Located within the ahupua`a of Ka`ohe in the Hāmākua District of Hawai`i Island, the summit of Mauna Kea was traditionally described as an abode of the ancestral *akua* (gods, goddesses, deities). Native Hawaiians believed that the *pu`u* (cinder cones) and other features of the summit such as Lake Waiau were the physical manifestations of these deities.

The information on historic properties in the following sections comes from the recently completed archaeological inventory survey (AIS) report by McCoy and Nees (2010) that documents historic properties in the 11,288-acre Mauna Kea Science Reserve (MKSR). The TMT Observatory site, the Access Way, and the existing Batch Plant Staging Area are all within the MKSR and 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 Mauna Kea Summit Region Historic District includes a concentration of significant historic properties that are linked through their setting, historic use, traditional associations, and ongoing

[18] An observatory includes the telescope(s), the dome(s) that contain the telescope(s), and the instrumentation and support facilities for the telescope(s) that fall under a common ownership.

cultural practices. The historic properties recorded during the AIS include shrines, adze quarry complexes and workshops, burials, stone markers/memorials, temporary shelters, historic campsites, traditional cultural properties (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 (McCoy & Nees 2010). 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 Hawaii Administrative Rules §13-275 -6.

III. Regulatory Background and Mitigation Requirements

Regulatory oversight of historic preservation compliance for construction of the TMT falls under Chapter 6E-8, Hawaii Revised Statutes (HRS), which covers the review of the effects of State projects on historic properties. This historic preservation mitigation plan has also been developed in accordance with the provisions of the implementing regulations at Hawai‘i Administrative Rules (HAR) 13-275-8 on mitigation, and HAR 13-279, on archaeological monitoring.

In addition, the *Mauna Kea Comprehensive Management Plan* (CMP) approved by the BLNR in 2009 requires on-site monitors during construction activities on Mauna Kea, as determined by the appropriate agency. CMP Management Action C-1 provides for an overall construction monitor who has oversight and authority to ensure that all aspects of ground-based work comply with protocols and permit requirements. Specifically, the CMP's Management Action C-5 calls for on-site monitors (archaeologist, cultural resources specialist, entomologist) during construction, as determined by the appropriate agencies. Section 3.15 of the *Final Environmental Impact Statement* (FEIS) for the TMT project commits to having on-site cultural and archaeological monitors during construction.

IV. Description of Project Areas and Activities

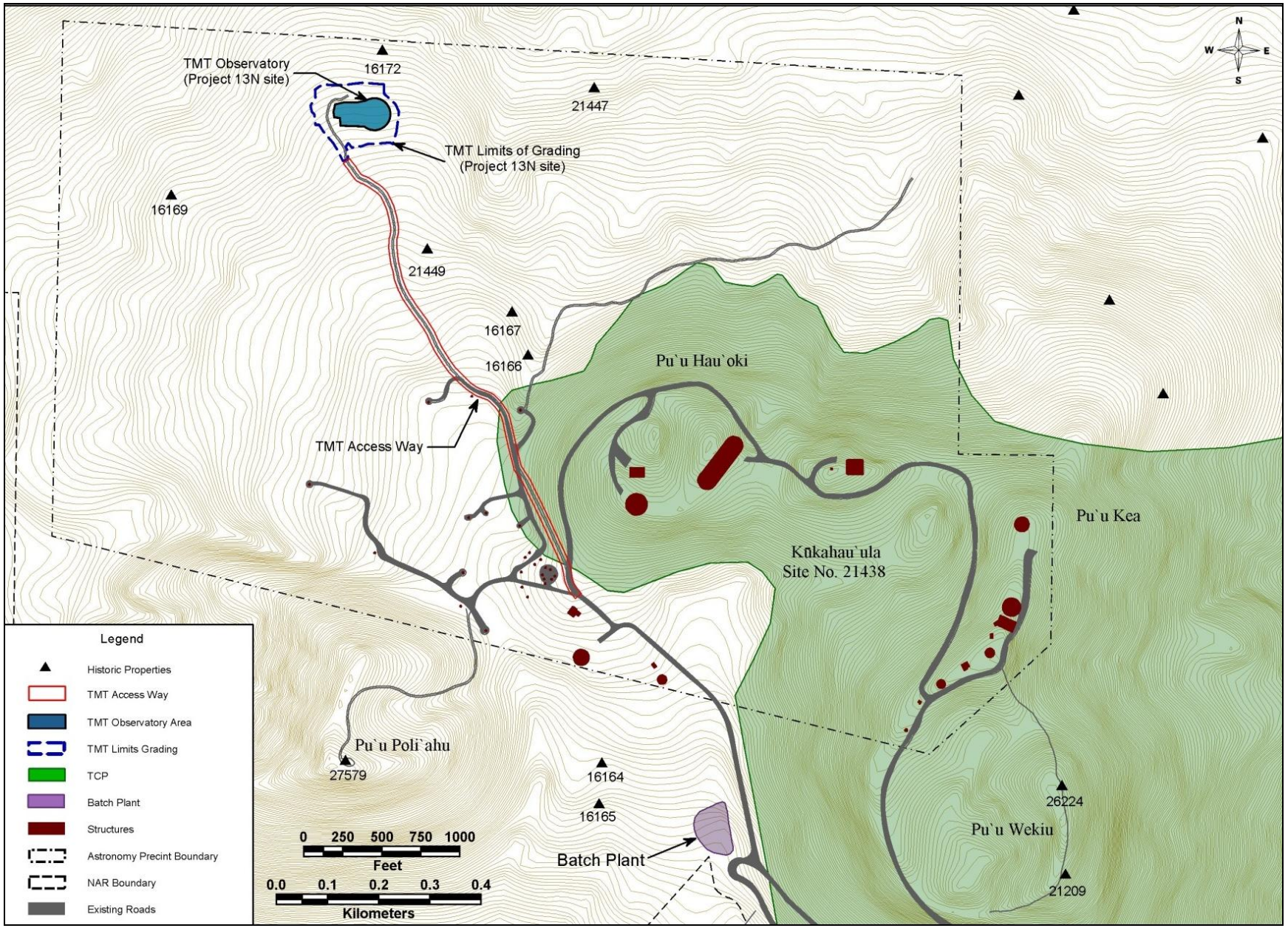
TMT Observatory Site and Access Way

Approximately five acres would be disturbed during construction of the TMT Observatory. The TMT Observatory would consist 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 TMT Observatory would be located on what is referred to as the 13-North (13N) site in Area E within the Astronomy Precinct of the MKSR.

The Access Way consists of the road and underground utility (power and telecommunications) improvements that would be constructed to connect the TMT Observatory with existing roads and utilities. Currently, utility services exist along the Mauna Kea Loop Road to a point near the intersection of the Mauna Kea Loop Road and the Submillimeter Array (SMA) building. The proposed Access Way would start at that point and extend to the TMT Observatory; it would follow either existing 4-wheel drive roads or the wider roads that currently serve the SMA facility.

Figure A-1 illustrates the planned location of the TMT Observatory and Access Way.

Figure A-1: Planned Location of the TMT Observatory and Access Way



Batch Plant Staging Area

The Batch Plant Staging Area is a roughly 4-acre area northwest of where the Mauna Kea Access Road forks to form the Loop Road near the summit (see Figure A-1). It is just outside the boundaries of the Astronomy Precinct. This area would be used only during construction primarily for storing bulk materials and for a concrete batch plant, as it has been during past construction.

Electrical Plant and Utilities Upgrades

The Hawaii Electric Light Company (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. In addition to the work within the substation, HELCO plans to reconductor the existing 12 kV electrical power line from the transformer compound near Hale Pōhaku to the existing utility boxes across the road from the SMA building (see Figure 1-8 in the CDUA). The new wires would be pulled through 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 line alignment follows a former access road alignment that is now within the Mauna Kea Ice Age Natural Area Reserve (Ice Age NAR). Because existing pull boxes are available approximately every 300 feet along the conduit, no new ground disturbance would be needed for the upgrade, but HELCO would need to access the pull boxes to install the new cable.

V. Description of Known Historic Properties in Project Area

Historic Properties in the Vicinity of the TMT Observatory Site and the Access Way

Figure A-1 shows the location of all historic properties in the project area. The site proposed for the TMT Observatory is nearly one-half mile northwest of the TCP named Kūkahauʻula, and the Access Way leading to the observatory would intersect the northwestern edge of the TCP for approximately 800 feet. Kūkahau`ula has been described and referred to as a traditional cultural property (TCP) by the SHPD within DLNR.[19]

Kūkahauʻula includes the summit cinder cones (referred to separately as Puʻu Wēkiu, Puʻu Kea, and Puʻu Hauʻoki) and covers roughly 463 acres, of which nearly one third is within the Astronomy Precinct. The Kūkahauʻula TCP is associated with the activities of Native Hawaiian deities as identified in numerous legends and oral histories, and plays an important role in ongoing traditional and religious practices carried out by modern-day Native Hawaiians. Kūkahauʻula is a contributing property to the Mauna Kea Summit Region Historic District.

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

There are several archaeological sites near the location of the proposed Access Way and TMT Observatory. Three historic shrines, first identified during a 1982 survey, are in the vicinity:

- SIHP No. -16172 is located about 225 feet north of the proposed TMT Observatory site and consists of a single upright with several support stones.
- SIHP No. -16167 is located approximately 500 feet east of the Access Way and about 1,300 feet southeast of the proposed TMT Observatory site and consists of one, possibly two, uprights placed in a bedrock crack. In 1995, the site was revisited and both stones were found in a vertical position.
- SIHP No. -16166 is approximately 350 feet east of the Access Way and 1,600 feet southeast of the proposed TMT Observatory site and is a multi-feature shrine with a total of eight, possibly nine uprights arranged in two groups. When the site was revisited in 1999 it was noted that several of the uprights had been reset in a vertical position along the edge of the outcrop.

In addition to the shrines, a terrace of unknown function (SIHP No. -21449) was documented in 2005; it is located in Area E approximately 200 feet east of the Access Way and 700 feet south of the proposed TMT Observatory site.

Historic Properties in the Vicinity of the Batch Plant Staging Area

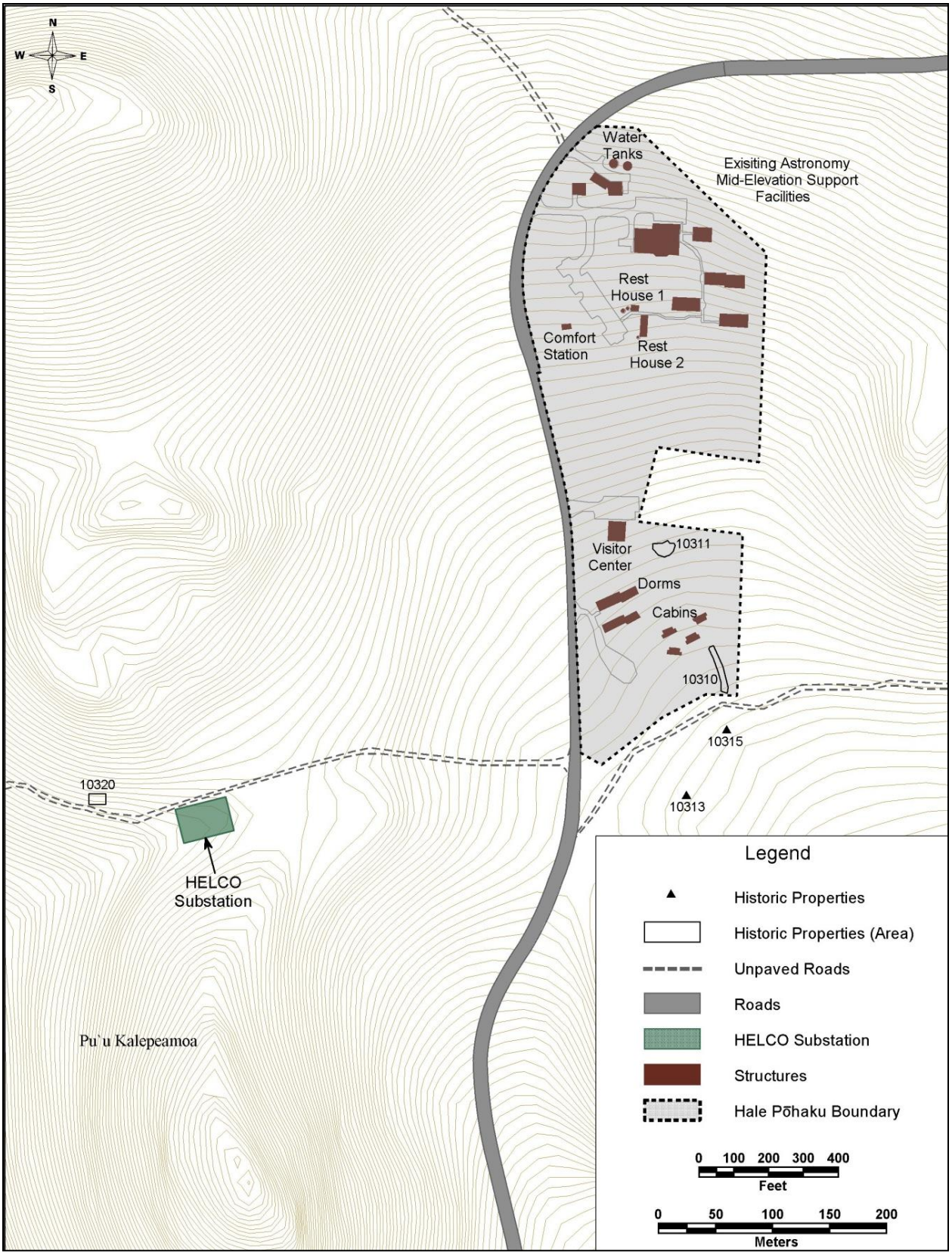
The Batch Plant Staging Area is adjacent to the southwestern boundary of the Kūkahauʻula TCP, across the Mauna Kea Loop Road. Figure A-1 shows the Batch Plant and surrounding historic properties. The Batch Plant Staging Area has undergone considerable ground disturbance over the years due to a series of construction-related activities. No historic properties are known to be present in this area and none has been recorded during previous surveys. The locations of two traditional shrines – SIHP Nos. -16164 and -16165 – were originally recorded in 1982 at some distance from the disturbed area; their locations were verified during the survey for the TMT Project. Both shrines are more than 500 feet west of the Batch Plant Staging Area.

Historic Properties in the Vicinity of the HELCO Electrical Upgrades

Figure A-2 shows the HELCO Hale Pōhaku substation and surrounding historic properties. In 1985, two lithic scatters were identified in the Hale Pōhaku area and determined to be part of the Puʻu Kalepeamoa Site Complex, which includes two shrines and a stone tool quarry and workshop complex. Two workshop areas – designated as SIHP Nos. 50-10-23-10310 and 50-10-23-10311 -- subsequently underwent archaeological data recovery after increased erosion in the site area made preservation of the sites difficult. The data recovery field work demonstrated the presence of both lithic workshops and manufacturing areas for octopus lure sinkers. The two shrines (SIHP Nos. 50-10-23-10313 and 50-10-23-10315) are located across the four-wheel drive access road and to the south about 190 feet away from Hale Pōhaku.[20] The sites are over 1,200 feet from the HELCO substation and from the nearest electrical pull box that will be accessed when HELCO upgrades the conductors in the existing conduits. None of the actions required to

[20] Note that the work within Hale Pōhaku itself that was discussed as a possibility in the *Final EIS* for the TMT has been determined to be unnecessary and is not a part of the Conservation District Use Application.

Figure A-2: Historic Properties in the Vicinity of the HELCO Substation



implement the proposed project would affect these historic properties. Only one known historic site is present near HELCO's Hale Pōhaku Substation, where transformer swaps would occur. SIHP No. 50-10-23-10320 (also part of the Puʻu Kalepeamoa Site Complex) is a lithic scatter that lies about 200 feet west of the existing substation. None of the potential activities in this area would be carried out near this site.

In addition to these archaeological sites, the original buildings of Hale Pōhaku – the "stone cabins" – are historic in age. Two rest houses date to the 1930s and were constructed by participants in the Civilian Conservation Corps; one comfort station dates to 1950. They are over a thousand feet from the work that would be done within the existing HELCO Hale Pōhaku Substation, and would not be used or otherwise affected by the TMT Project.

VI. Archaeological Monitoring Plan (AMP) Components

This section describes the components of the AMP that will be prepared and submitted to SHPD for review and approval prior to commencing uses/activities with a potential to impact historic properties on Mauna Kea.

Anticipated Finds

In view of the prior archaeological findings within the MKSR (summarized in Appendix C to the Management Plan), pre-contact and/or historic properties that have not been identified in past studies may be present within one or more portions of the project area. Such properties may include the following: isolated artifacts such as adzes or worked stone fragments; archaeological sites such as shrines, workshops, or camp sites; buried deposits; and buried human remains.

Extent of Archaeological Monitoring

A qualified archaeologist will conduct **on-site monitoring** of all ground-disturbing activities potentially extending into previously undisturbed ground; these are listed in Table A-1. Activities to be monitored include excavations and grading activities, as well as the excavation of utility trenches that would occur in previously undisturbed areas.

Table A-1: List of Specific Activities that Require On-Site Archaeological Monitoring

Proposed Action	Estimated Excavation Depth[21]	Monitoring Necessary?
Ground disturbance in areas that have been previously disturbed through construction and/or use (e.g., existing facilities or parking areas)	TBD	No
Drilling exploratory borings at the TMT Observatory site	TBD	Yes
Performing excavation activities at the TMT Observatory site	TBD	Yes
Performing fill activities at the TMT Observatory site beyond where excavation activities took place	TBD	Yes
Performing excavation activities for the Access Way	TBD	Yes
Excavation of utility trenches along the Access Way	TBD	Yes
Performing fill activities on the Access Way beyond where excavation activities took place	TBD	Yes
Performing excavation and fill activities in previously undisturbed ground in the Batch Plant Staging Area	TBD	Yes
Replacing transformers at existing HELCO facility	TBD	No
Replacing conductors in existing conduits	TBD	No

Treatment of Cultural Materials

If any archaeological materials are encountered during the monitoring of ground-disturbing activities, work will be stopped immediately in that area, and the monitoring archaeologist will investigate the nature of the discovery. If an intact cultural layer, living surface, structural components (e.g., foundations), archaeological sub-surface features (e.g., hearths, pits, postholes, etc.), artifacts, charcoal, or midden deposits/trash pits were encountered, then the following actions will be taken:

- Selected, sorted charcoal samples from discrete fire features will be collected for radiocarbon analysis where appropriate (particularly if the charcoal appears in a prehistoric context).
- Bulk samples of midden material will be collected, such as shell, bones, etc.
- All prehistoric artifacts will be collected.
- All historic artifacts will be collected unless large trash or refuse pits are encountered, in which case only diagnostic samples will be taken, such as bottle and ceramic bases containing maker's marks.
- Standard documentation will be carried out, including scale maps, profiles, photographs, detailed soil and provenience descriptions, and interpretation.
- Photographs of excavations will be included in the monitoring report even if no historically significant sites are documented during the monitoring field work.

[21] Depths of excavation are to be determined (TBD) prior to preparation of the AMP for submittal to SHPD for review.

Treatment of Human Remains

If human remains are identified, work will immediately stop in the area that the archaeologist determines could contain related material, and the SHPD/DLNR and the OMKM will be notified immediately of the find. OMKM will immediately notify the Hawaii County Medical Examiner, via the Hawai`i County Police Department, if the discovery of human remains is verified by the monitoring archaeologist. No further work will take place in that locale—including screening of back dirt, cleaning and/or excavation of the burial area, or exploratory work of any kind—unless explicitly requested by the SHPD.

Halting of Excavation Activity

The archaeological monitor has the authority to halt construction in the vicinity of the find, so that the provisions of the AMP can be carried out. The independent construction monitor will make it clear to the construction personnel that the archaeologist is authorized to halt work when it is deemed appropriate.

Pre-Construction Conference

Before works begins on the project, the on-site archaeological monitor will, with the cultural resource specialist (described below in Section VI), participate in a pre-construction conference. At that conference, the archaeological monitor will explain to the entire construction crew what materials may be encountered and the procedures to follow if archaeological materials are found, as well as the role of the archaeological monitor. At this time the project construction manager will make it clear to construction supervisors and all other members of the construction team that the archaeological monitor has the authority to stop work ***immediately***, if necessary. Before supervisors, subcontractors, or other construction workers not present at the pre-construction conference are assigned to work on ground disturbing activities, they will meet with/be briefed by the on-site archaeological monitor so that they receive the same guidance as those who were present at the pre-construction conference. Additional steps during the pre-construction phase may also include having the archaeological monitor flag the limits of ground disturbance prior to the start of work in order to indicate clearly the areas that are off-limits to construction equipment and personnel.

Laboratory Work

Artifacts will be cataloged and analyzed, along with any samples of midden materials that were collected. Charcoal and other datable materials will be submitted for dating analysis, provided samples were collected in-situ from prehistoric contexts that show no signs of intermixing with historic materials; e.g., charcoal obtained from distinct fire features in solely pre-contact deposits.

In the event human remains are encountered, as noted above all work will stop in the vicinity until SHPD/DLNR authorizes resumption of activity. SHPD/DLNR, in consultation with the OMKM, the Kahu Kū Mauna, and the Hawai`i Island Burial Council, will determine if it is appropriate to remove and relocate any human remains encountered. If SHPD/DLNR authorizes removal of the human remains, the archaeological monitor will remove and inventory the

remains in accordance with Hawaii Administrative Rules 13-300, and the remains will be stored temporarily at the SHPD/DLNR Hawai`i Island office until re-interment plans are finalized.

Report Preparation

The archaeological monitor will compile daily monitoring logs. These logs will minimally include a description of daily activities, sites or features cleared and recorded, personnel on-site, problems encountered, and corrective action taken. Reports will be filed as appropriate with the SHPD detailing any new sites or features identified within the project area boundaries, if necessary and appropriate. Following completion of monitoring fieldwork and any required laboratory analyses, a draft archaeological monitoring report will be prepared and submitted to SHPD/DLNR for review. The archaeological monitor will submit a final archaeological monitoring report after receiving any comments on the draft report.

Collections Archiving

All burial remains and associated materials will be given to the SHPD/DLNR Hawai`i Island office for curation until re-interment plans are finalized. Non-burial materials will be stored temporarily at OMKM's facilities until an appropriate curation facility is available on Hawai`i.

VII. Cultural Monitoring

In accordance with the CMP and with the commitments described in the FEIS for the TMT, TMT Observatory Corporation will hire a cultural resource specialist to work in conjunction with the archaeological monitor at all times and in all places or situations where on-site archaeological monitoring is required. Currently, there are no statutory or regulatory mandates for cultural resource specialist or monitors, nor are there any recognized policies or guidelines that set out standards for cultural monitoring. However, preliminary consultations with Kahu Kū Mauna have led to the following basic recommendations for the cultural resource specialist and monitoring during TMT construction work:

- A cultural monitor will be present on-site at all times whenever the archaeological monitor is present.
- Individuals selected to be cultural monitors will have the appropriate background in order to serve as a cultural monitor and as a cultural resource specialist for cultural matters. Such individuals are to serve as mediators among the various stakeholders.
- Cultural monitors will not be affiliated with the archaeological firm that is hired to provide archaeological monitoring support.
- Cultural monitors will participate in any pre-construction briefings with the archaeological monitors.
- In addition to providing direct oversight of construction activities, cultural monitors will maintain regular records of attendance and activity on the job site.
- Cultural monitors will provide the Kahu Kū Mauna and OMKM with a report of activities and findings, if any, on a regular basis.

A detailed protocol and plan for cultural monitoring during TMT construction will be developed in consultation with the Kahu Kū Mauna and will be adopted prior to the beginning of work.

VIII. Additional Direct Mitigation Measures to be Taken in the Project Area

This section describes the direct mitigation measures that will be taken to lessen the impacts of the project on cultural resources. Direct mitigation measures refer to actions that occur at the location of the project activity that will avoid or minimize effects to cultural resources and that would compensate for any unavoidable effects.

Direct Mitigation Measures to be Taken at the TMT Observatory Site and Access Way

The TMT Observatory project and Access Way have been designed to minimize their potential impacts on cultural resources. The observatory structure is sited in a portion of the Northern Plateau that is more than 200 feet from known historic properties. In addition, the visual effect of the observatory, including its visual impact from areas of cultural importance such as the summit of Kūkahauʻula, has been minimized through design steps such as reducing its size, finishing the support building and fixed structure exterior with a lava color, and finishing the dome with a reflective aluminum-like surface similar to that on the Subaru Observatory. Finally, to avoid the disposal of wastewater in the summit region (the discharge of wastewater within the summit region has been identified as an impact on cultural resources), the Project will implement a zero discharge wastewater system at the TMT Observatory and will remove all wastewater generated from the mountain for treatment elsewhere in an approved treatment facility.

Minimization measures are proposed for the Access Way that reduce the potential for both physical and visual impacts to the historic properties known to be in the vicinity. The Access Way that TMT has proposed is limited to a single-lane road (from a previous design of two-lanes) and follows an existing single-lane, 4-wheel drive road that was previously disturbed for access and testing of the 13N site in the 1960s. This proposed design omits the retaining wall that was required for the similar "Option 3" route described in the Draft EIS. The portion of the Access Way within the boundaries of Kūkahauʻula will be paved in order to reduce dust. Additionally, the pavement and guardrail will be a reddish color that blends with the surrounding area. Finally, utilities and electrical and communication lines, will be placed beneath the paved roadway instead of on a different or parallel alignment that would cause more ground disturbance, even though this design is not desirable from a utility agency service standpoint.

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. On up to four days per year, to be identified by Kahu Kū Mauna, the Project will endeavor to reduce construction noise and activities in the vicinity of cultural practices. During the operational phase, TMT Observatory operations will be reduced 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 on which TMT activities will be reduced. While the observatory will be operated during these periods, this measure will involve having only a skeleton crew at the

observatory, minimizing vehicle traffic, reducing noise and prohibiting visitors to the TMT Observatory.

TMT will provide initial and then annual or as-needed tours of the TMT Observatory, with the Native Hawaiian community invited at least two weeks prior to the tour. Insofar as practicable, these tours will be scheduled on the days (up to four each year) on which cultural events are scheduled.

The Project will comply with the Decommissioning Plan, a sub plan of the CMP. This provides a detailed methodology for planning the removal of the TMT Observatory and the Access Way exclusively used to access the TMT Observatory at the appropriate time.

Measures proposed for the summit area where the TMT Observatory and Access Way will be located that are designed to mitigate unavoidable effects include funding the restoration of the closed access road on Pu`u Poliahu to its natural state. Existing HELCO pull-boxes and other utility boxes that are visually distracting or intrusive at the summit and other key locations visible from other portions of Kūkahauʻula will be camouflaged by treating them so as to blend into the natural environment to the extent feasible. The method of treatment will be determined through consultation with Kahu Kū Mauna and may include one of the following options: painting the concrete and metal lid to match the surrounding natural colors; or affixing stones and cinders from near the utility box to the concrete using epoxy.

Construction best management practices (BMPs) will also be implemented to avoid potential disturbance of land beyond the planned limits of disturbance. Examples of BMPs that will be implemented include:

- Flagging the limits disturbance prior to the start of work to clearly indicate equipment and personnel should not move beyond those limits.
- Implementing a Materials Storage/Waste Management Plan with specific BMPs such as the use of water-tight trash receptacles that are secured to the ground and have attached lids that are secured to the receptacles.
- Conducting noise-emitting activities during normal work hours to the extent possible.

Direct Mitigation Measures to be Taken in the Batch Plant Staging Area

A portion of the Batch Plant Staging Area will be restored to a more natural condition upon the completion of its use during TMT construction. The area to be restored will depend on how much excess cut material is available at the end of TMT construction and how much of that material OMKM needs to reserve for its use for maintenance and other projects. Generally the restoration will involve placing available excess material within a portion of the Batch Plant Staging Area to form a more uneven terrain, resembling natural conditions to the degree possible, and producing a surface that cannot be driven over.

As in the case of the Observatory and Access Way, 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 Batch Plant Staging Area. On up to four days per year, identified by Kahu Kū Mauna, the

Project will endeavor to reduce construction noise and activities in the vicinity of cultural practices.

Direct Mitigation Measures to be Taken in the Vicinity of the HELCO Electrical Upgrades

Since no ground disturbance is required, and since the only work planned for this area will be the replacement and upgrading of existing electrical components, no direct mitigation measures are needed in this portion of the project area.

IX. Indirect Mitigation

Several forms of indirect mitigation will be carried out in conjunction with the construction of the TMT project. Most importantly, the Project will implement a Cultural and Natural Resources Training Program that will require all construction managers, contractors, supervisors, construction workers and TMT staff to be trained annually regarding the potential impact to cultural and archaeological resources and the measures to prevent such impact. The content of the training program will be determined by OMKM. Both the archaeological and cultural monitors will have the authority to enforce the tenets of this training. The training program will include but not be limited to the following objectives:

- Impart an understanding of Mauna Kea's cultural landscape, including cultural practices, historic properties, and their vulnerability to damage.
- Provide guidance and information on respectful and sensitive behavior and activities while in the summit region.
- Make clear that any disturbance of a historic property is a violation of Chapter 6E11, HRS, and punishable by fine and/or confiscation of equipment. All other applicable statutes and regulations pertaining to the protection of historic properties, including isolated artifacts and human burials, will also be explained during such training.

The training program will be updated regularly to incorporate any changes made by OMKM in any portion of the UH Management Area. All people involved in TMT Observatory operations and maintenance activities, including but not limited to scientists and support staff, will receive the training on an annual basis.

The TMT Observatory Corporation will fund a Community Benefits Package (CBP) of $1 million per year, to be administered via The Hawai‘i Island New Knowledge (THINK) Fund Board of Advisors. THINK Fund purposes could include scholarships and mini-grants, educational programs, college awards, educational programs specific to: Hawaiian Culture, astronomy, math, and science, and community outreach activities.

TMT will support, through financial contributions and utilization of its outreach office, the following measures related to cultural resources:

- Hosting an annual 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, and workshops on how to recognize archaeological sites and to determine their importance.

- 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.
- The translation of modern astronomy lessons into Hawaiian language for use at Hawaiian language charter schools.
- Development of exhibits regarding cultural, natural, and historic resources in coordination with OMKM and ʻImiloa that could be used at the VIS, ʻImiloa, TMT facilities, or other appropriate locations. Exhibits will include informational materials that explore the connection between Hawaiian culture and astronomy.

TMT will have an open door policy so that TMT's outreach management can be contacted by the Native Hawaiian community to discuss various issues.

TMT will request permission to attend meetings of the Kahu Kū Mauna council upon a quarterly basis. A TMT representative will be available on an ongoing basis to review cultural impact issues, should there be any related to the Project. By attending the meetings the TMT representative would become aware of other cultural resource issues on the mountain and then implement any necessary changes in TMT policies to address potential similar issues at the TMT Observatory.

The TMT Observatory will be furnished with items to provide a sense of place and encourage and remind personnel and visitors of the cultural sensitivity and spiritual quality of Maunakea. 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.

Appendix B. Construction Plan

This Construction Plan covers the three Project components to be built within the Conservation District: (1) the Access Way, (2) the TMT Observatory, and (3) utility extensions and upgrades. It outlines the anticipated construction schedule and the methods to be employed to complete the work are also described.

The contractor(s) selected to build the TMT Observatory and Access Way will be required, in its contract documents, to comply with the mitigation measures outlined in the Final EIS. This will entail complying with (and in some cases preparing) the following:

- Reporting Plan. A Reporting Plan will be developed by TMT and their contactor 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. TMT's contractor will prepare this plan.
- Cultural and Archaeological Monitoring Plan. A draft of this plan is provided as a component of the Draft Historic Preservation Mitigation Plan (Appendix A of the TMT Project Management Plan). This plan will be refined as the design and schedule for TMT construction is finalized; the plan will then be submitted to SHPD for review and approval. The 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. This program will be developed by OMKM in coordination with TMT and other stakeholders. 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 1.6 below and will be further refined by TMT and their selected contractor in coordination with OMKM. This plan will comply with CMP Management Action C-9.
- Waste Minimization Plan. TMT's contractor will prepare this plan as it relates to the construction phase of the Project.
- Ride-Sharing Program. TMT's contractor will prepare the construction phase part of this plan based on the framework provided in Section 3.15.2 of the Final EIS.
- Fire Prevention and Response Plan. TMT's contractor will prepare this plan based on the framework provided in Section 3.15.2 of the Final EIS, if applicable.
- Rock Movement Plan. TMT and their contractor will prepare this plan in coordination with OMKM based on the framework provided in Section 1.2.1 below. This plan will comply with CMP Management Action C-3.

- 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; the plan 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. This permit and component plans will comply with CMP Management Action C-2.
- Noise permit and noise variance. TMT's contractor will obtain and comply with both a noise permit and a noise variance, as applicable.
- Oversize and Overweight Vehicles Permit (OOVP). TMT's contractor will obtain and comply with an OOVP, as applicable.

1.1 Schedule

The conceptual Project construction schedule is presented in Table B-1. Project construction could begin as early as 2011 and take approximately seven years to complete.

Table B-1: Anticipated Construction Timeline

Phase	Start	End
Grading and foundation	2011	2013
Access Way	2011	2012
TMT Observatory 13N Site grading	2011	2012
TMT Observatory foundation	2012	2013
Electrical upgrades	2012	2012
Observatory construction	2012	2017
Dome assembly (exterior cranes active)	2013	2015
Internal telescope assembly	2015	2017
Support building construction (including foundation)	2015	2017
Observatory finish	2015	2017
Batch Plant Staging Area restoration/naturalization	2017	2017
Telescope/instrument testing	2017	2018

Source: TMT Observatory Corporation, July 17, 2010.

Drawings illustrating the construction phasing are provided in Attachment A.

Construction activities will take place 12-15 hours a day, seven days a week; however, work times will vary depending on activities and some special operations or construction phases will require longer work hours. Winter weather conditions at the TMT Observatory site will interrupt construction at times, until the dome is completed.

1.2 Grading, Underground Utilities, and Foundation

This section discusses ground level and underground construction activities. The grading of the Access Way and TMT Observatory will take place first, followed by TMT Observatory

foundation work. Plans, which illustrate proposed changes in contours, are included in Attachment B.

1.2.1 Rock Movement Plan

Project construction will require the excavation of rock from the TMT Observatory site and along the Access Way. Along the Access Way, the need to excavate rock is primarily governed by the need to generate a smoothly sloping road and the need to bury utilities within the Access Way. At the TMT Observatory site, excavation is necessary to prepare a level work surface plus place a foundation for the telescope and the observatory dome. TMT and their contractor will prepare a Rock Movement Plan prior to construction in compliance with CMP Management Action C-3 and submit it to the Office of Mauna Kea Management (OMKM) for review and approval. The Rock Movement Plan will detail excavation and grading activities.

Preliminary engineering plans indicate that the total volume of excavated material ("cut" material) will be 64,000 cubic yards. These preliminary engineering plans, which illustrate proposed changes in contours, are included in Attachment B. The estimated cut and fill volumes are based on geotechnical assumptions concerning the subsurface in the area and could change following the completion of geotechnical borings. As summarized in Table B-2, roughly 32,000 cubic yards of the cut material will be reused at the TMT Observatory site or Access Way. An estimated 32,000 cubic yards of material will be excess cut and will be used to provide some restoration of the Batch Plant Staging Area and a portion of which will be stored at a location designated by OMKM for use as determined by OMKM. By using most of the material on the TMT Observatory site and Access Way, that material will be available for later use to restore the TMT Observatory site and the portion of the Access Way exclusively used by TMT during decommissioning.

Table B-2: Estimated Cut and Fill Volumes

Site	Cut (cubic yards)	Fill (cubic yards)
TMT Observatory 13N site	34,000	29,000
Access Way	30,000	3,000
Batch Plant Staging Area	None	30,000
Saved for OMKM Use	NA	2,000

Source: TMT Observatory Corporation, July 17, 2010.

No soil or cinder that originates off the mountain used as fill within the Conservation District. Some courser material from on-island quarries will be transported to the TMT Observatory site and used under concrete foundation slabs as "base course". Aggregate from on-island quarries will also be used to make the foundation concrete.

1.2.2 Batch Plant

TMT will re-establish a temporary concrete batch plant at the previously utilized "Batch Plant Staging Area". Prior to utilizing the Batch Plan Staging Area, the site will be cleared of invasive species to the extent practicable, if any are observed by a biologist inspecting the area prior to use. Best management practices (BMPs) will also be installed to (a) limit the potential for the later establishment of invasive species; (b) limit the production of dust and mud; (c) limit and

control stormwater run-on, runoff, and quality; and (d) prevent disturbance of undisturbed areas beyond the previously disturbed batch plant area.

The batch plant will be required to produce roughly 5,900 cubic yards of concrete for the TMT Observatory foundations. As discussed above, this volume is an estimate based on geotechnical assumptions concerning the subsurface in the area and could change following the completion of geotechnical borings.

No mass grading of the Batch Plant Staging Area is planned prior to use of the site as a batch plant other than the storage of excess material from the TMT Observatory site and Access Way within the area. The stored material will be placed such that the entire Batch Plant Staging Area can be utilized (i.e., it will be graded and compacted after placement so that it can be driven over rather than left in a pile). The Project will utilize the area using a layout similar to that used by previous projects that utilized the area as a batch plant. During the Project's use of the Batch Plant Staging Area there will be temporary stockpiles of soil and rock, a concrete batch plant, and construction materials staged within the area.

Once the Project's use of the Batch Plant Staging Area is complete, the stored excess material will be regraded. The excess material will be utilized to restore/naturalize the Batch Plant Staging Area to the degree practicable. A portion or all of the excess material will be spread over a portion of the Batch Plant Staging Area in such a way as to create a rough, more natural surface that could not be driven over. Some of the excess material may be left in a stockpile within the Batch Plant Staging Area depending on OMKM's desires. This restoration of the Batch Plant Staging Area would reduce the size of the Batch Plant Staging Area that could be used for parking and other uses following the construction of the TMT Observatory; however, the restored area could be temporarily reclaimed as a staging area by future projects, if needed.

1.2.3 Access Way

The Access Way has two distinct sections (1) the southernmost portion where the Access Way will follow existing roads on cinder, and (2) the rest of the Access Way where it will primarily follow existing roads on lava flows. These two sections are discussed below.

Southernmost Cinder Section

Generally, grading along the Access Way will be performed to achieve a smooth and level travel surface. In the cinder section, the existing 4-wheel drive road (the "jeep trail") travel surface has degraded over the years and no longer provides a level travel surface. Where the Access Way occurs on the cinder lower slope of Puʻu Hauʻoki, the Access Way features will be as illustrated in Figure B-1 – a 12 foot wide paved travel way (1 lane), a four foot paved shoulder with drainage channel and guardrail, and slope graded to 2.5:1.

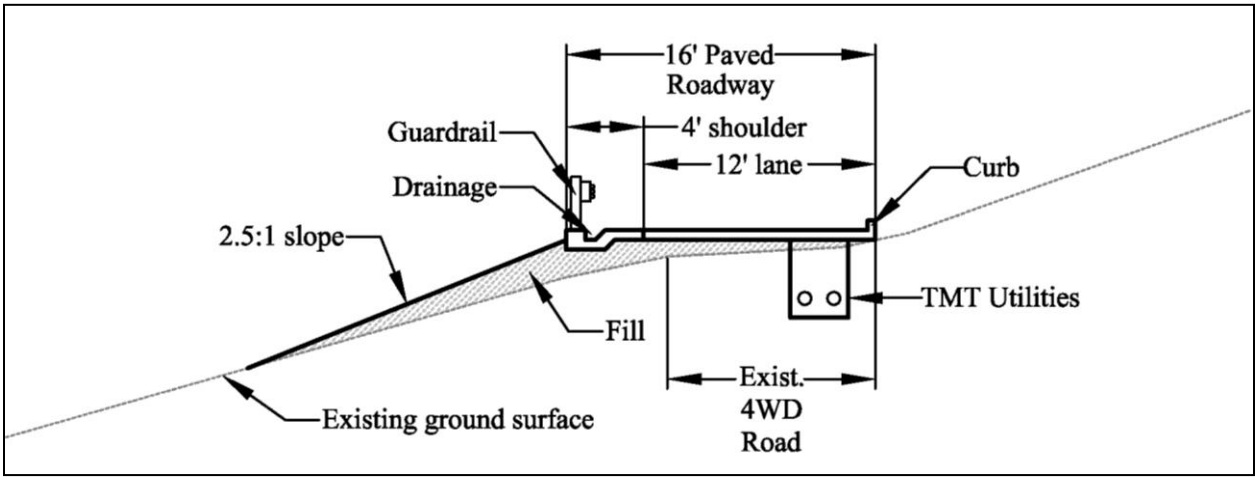


Figure B-1: Cross Section of Access Way in Southernmost Cinder Section Overlapping 4-Wheel Drive Road

Lava Flow Section

Generally, grading along the Access Way will be performed to achieve a smooth travel surface. In the lava flow section the Access Way will follow an existing SMA road and the 4-wheel drive road through Area E. Although the SMA road already provides a smooth travel surface, grading will be done to raise the grade of the travel surface in order to protect the SMA utilities under the roadway, as illustrated in Figure B-2. During early construction activities when sufficient material has not been cut to install the 18-inch cushion over the SMA utilities as shown in the figure, steel plates will be used to cover and protect the SMA utilities until sufficient material is available.

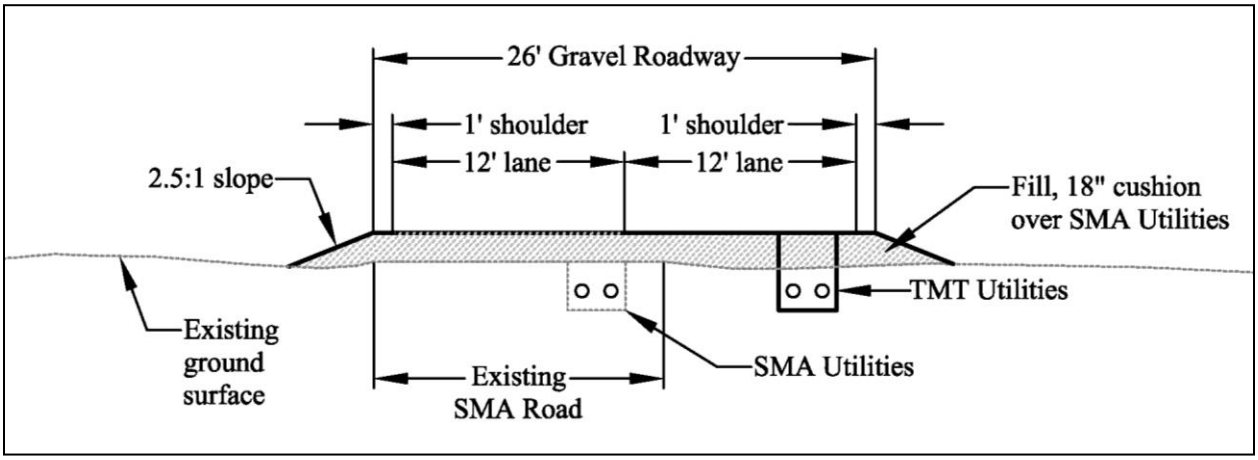


Figure B-2: General Cross Section of Access Way in Lava Flow Section Overlapping SMA Road

In addition to the steps discussed above to protect the SMA utilities where the SMA utilities and TMT utilities run parallel to each other, additional measures will be taken where they cross. They will cross at two points – (1) where the SMA road branches to a SMA pad on the east side

of the SMA Area near where the Access Way comes off the cinder cone, and (2) where the SMA road and the 4-wheel drive road split. At those locations additional measures will be taken to protect the SMA utilities, including the use of steel plates and additional cushion so that the TMT utilities can cross over the SMA utilities but still provide the necessary cover over the TMT utilities.

The 4-wheel drive road portion in the cinder cone section will have to be graded to a greater extent because it is not straight and the slope changes dramatically. Throughout the lava flow section, the Access Way features will be as illustrated in Figure B-3 – a 24 foot wide gravel travel way (two lanes), one foot shoulders, and slopes graded to 2.5:1. The slopes beyond the shoulder of the Access Way will vary depending on the topography and steeper embankment slopes may be used depending on geotechnical conditions encountered.

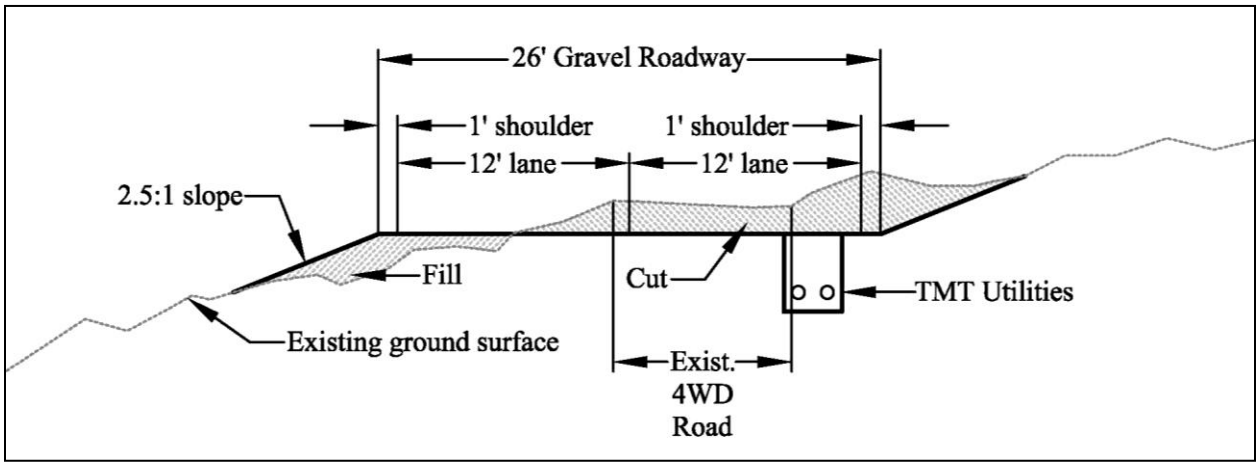


Figure B-3: General Cross Section of Access Way in Lava Flow Section Overlapping 4-Wheel Drive Road

Utilities

A trench for electrical and communications lines will be excavated along the Access Way on one side of the road as illustrated in Figure B-1, Figure B-2, and Figure B-3. The conduits will be encased in concrete per governing code requirements. Excavated material will be used to raise the Access Way road surface where required to improve grades on the road and to provide a smooth and level driving surface where a rough surface from excavation will otherwise be exposed.

1.2.4 TMT Observatory

The limits of grading activities (the area that will be affected by the cut and fill), the existing contours, and proposed contours at the TMT Observatory 13N site are shown in Figure B-4. Grading and foundation details are illustrated on preliminary plans included in Attachment A and B.

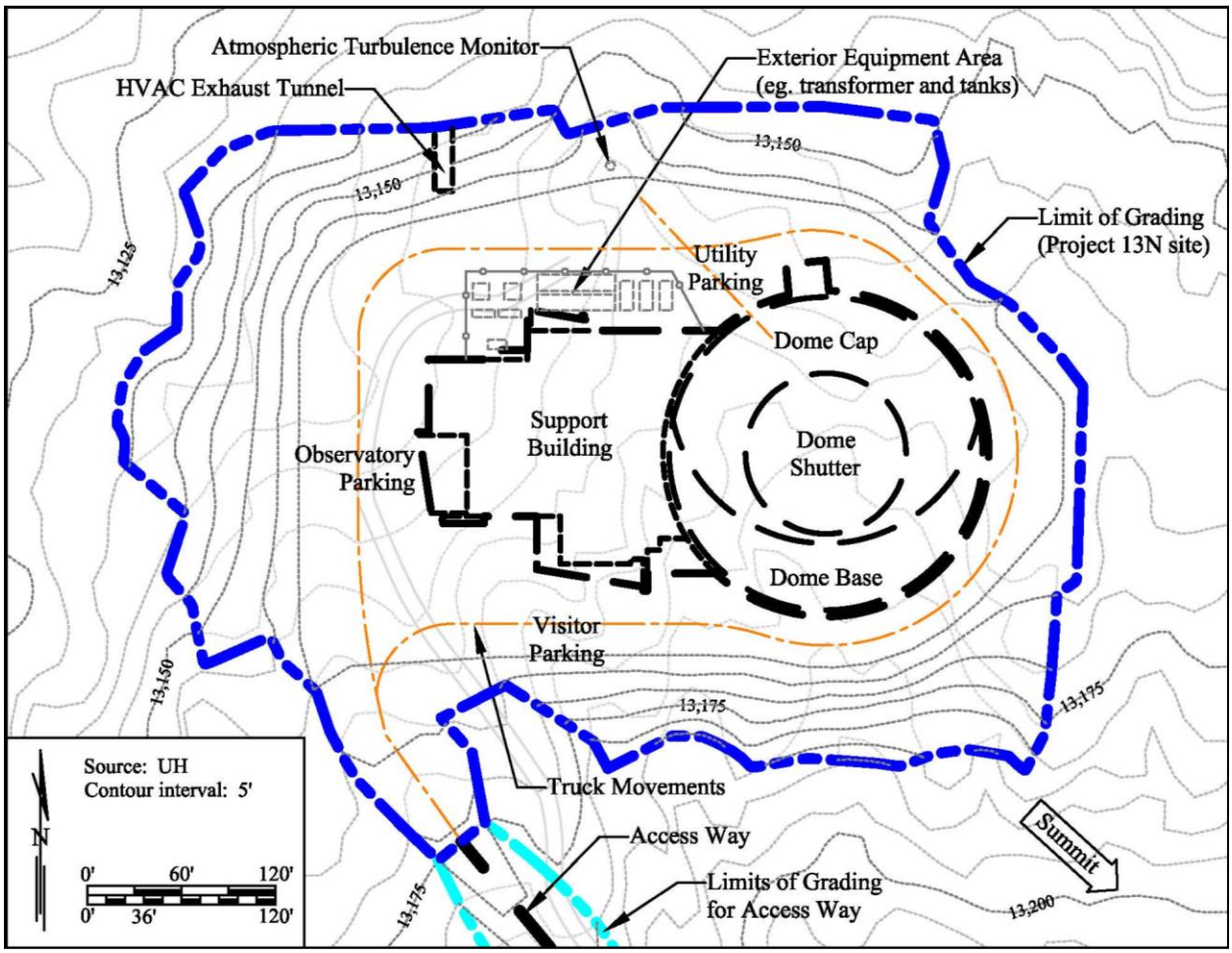


Figure B-4: TMT Observatory 13N Site Grading Plan

The construction at the TMT Observatory site will start with the rough grading of the 13N site, followed by the excavation for foundations, as depicted in the construction sequence drawings provided in Attachment A.

The TMT pier foundation will consist of a continuous, circular outer wall shallow concrete spread footing that will bear on the soil at a depth of approximately 20 feet below the finished floor grade. There will be a central shallow concrete pad for a pintle bearing, used to hold the center of rotation of the telescope in place when at rest, that will bear on the soil at a depth of 16 feet below finished floor grade. The central shallow concrete pad will be connected to the telescope pier outer wall and footing with six radial concrete spokes. A utility tunnel bearing on the soil at a depth of 21.5 feet below the finished floor elevation will connect the telescope pier with the mechanical equipment room on the utility level of the support building. A utility tunnel for venting warm air from the mechanical room out to the north side of the site will bear on the soil at a depth of 21.5 feet below the finished floor elevation.

The dome foundation will be shallow continuous spread footings bearing at a varying depth of 6 to 10 feet below finished floor grade, depending on the depth of original rock. Floors will be

concrete slabs-on-grade bearing on a six-inch layer of material obtained from excavated (cut) material. Some utility piping and conduit will be located below the concrete floor slabs.

The support building foundation will consist of shallow spread footings bearing at approximately 6 feet below the finished floor grade. Floors will be concrete slabs-on-grade bearing on a six-inch layer of material obtained from excavated (cut) material.

An electrical grounding system will be installed in the excavations for the dome and support building foundation footings. Beneath the dome footings, the grounding system will consist of a grid of #3/0 cables (10 feet by 10 feet cable grid spacing) will be placed prior to pouring the concrete. Beneath the support building footings, the ground system will consist of #3/0 cables placed at the bottom of the excavations prior to pouring concrete.

1.2.5 Utilities

As discussed in Section 1.2.3, electrical and communication utilities exclusively for TMT will be located under the roadway in the Access Way. Underground utilities from the HELCO electrical substation to the switch boxes near the SMA building (which are shared with other uses in the summit region), will also be upgraded. This activity will include the replacement of existing conductors in existing conduits. In order to avoid interruption of services to current observatories and uses in the summit region, this work will be performed using the following steps:

- Transition all existing electrical loads to one of the two existing transformers and conductors.
- Remove and properly dispose/recycle the unused transformer and conductor.
- Install a new, larger-capacity transformer within the HELCO compound and conductor in the recently vacated conduit.
- Transition all electrical loads to the new transformer and conductor.
- Remove and properly dispose/recycle the unused transformer and conductor.
- Install a new, larger-capacity transformer within the HELCO compound and conductor in the recently vacated conduit.
- Allocate the electrical loads between the two transformers and conductors as appropriate.

The removal and replacement of the transformers is discussed in Section 1.3.4. The removal and replacement of the conductor will be done by accessing the handholds along the conduit, which is within a 20-foot wide HELCO electrical easement within the Mauna Kea Forest Reserve, Mauna Kea Ice Age NAR, and MKSR. The handholds are spaced roughly 300 feet apart for the length of the conduit and will be accessed only by driving along the utility easement.

1.3 Above Ground Construction

Following foundation work, the dome, telescope, and support building will be built. All buildings and structures with indicated use, including floor plans, are illustrated on preliminary design plans in Attachment B. Table F-3 summarizes the buildings to be constructed at the TMT Observatory 13N site.

Table F-3: Summary of Buildings

Project Component	Gross Floor Area (square feet)	Net Floor Area (square feet)	Height (feet above finished grade)
Observatory Dome	34,304	31,400	26.5 (fixed enclosure) 183.7 (top of dome)
Support Building	18,376	15,961	26

Source: TMT Observatory Corporation, July 17, 2010.

1.3.1 Dome Construction

Crane Selection Process

Prior to determining how the dome would be built, the equipment that would be used to build it had to be selected. The biggest consideration is what type of crane will be used. Three crane options were considered: gantry type, tower type, and crawler type cranes.

The pros and cons of each viable option are outlined in Table B-4. Based on the review performed, a 300-ton crawler crane, in combination with a 200-ton assisting crawler crane, was selected to be used to erect the dome.

Table B-4: Crane Option Pros and Cons

Crane Option	Pros	Cons
Gantry Crane	• Can be custom-designed to take construction loads and wind loads and meet project specific needs with additional built-in safety redundancy. • Possibility with variation to lower crane when storms are forecast.	• Requires track and foundations be installed, which would be complex as it would have to be circular due to site restrictions. • Requires assist crane to erect and dismantle. • Need additional clearance around enclosure so there is space between gantry rail and the dome to transport large pieces. This would require a larger flat area around the dome and, therefore, result in a larger area of impact to the environment. • Serious safety issues with lifting large pieces right next to the crane supports, as these could collide with the crane during windy conditions. This could be mitigated by using widely spread columns; however, this would increase the impact to the environment.

Crane Option	Pros	Cons
Tower Crane	• Quick set up and erection time for this option. • Has the option of one tower crane in the center in order to perform all lifting operations from one point. • Has the option of having the crane on a track around the enclosure so the crane can maneuver. • Some tower cranes have been rated to work at 45 mile-per-hour winds. These are readily available.	• Additional cost and labor impacts for having an assist crane with enough boom and capacity to erect and dismantle the tower crane. • Cannot erect the whole enclosure using this option. An assist mobile crane with enough boom and capacity has to be used to install the shutter plug. • Has to be set up permanently and cannot be lowered during ice storms. • May not be safe during ice storms with the 40-meter boom hanging out over the enclosure at all times. • Possibility of frequent break downs and seize up of mechanical parts at higher altitudes due to ice storms.
Crawler Crane	• Can be assembled and disassembled without the aid of another crane. • Can maneuver around to perform lifts. • Boom can be readily lowered at the end of every shift and during heavy winds to reduce the risk of tipping due to heavy wind loads. • Main boom and jib can be assembled in various lengths; the boom can be lengthened at various stages to reach higher areas as the job progresses. • Easy access to mechanical parts as most are located near ground behind the operator cab. • Wind charts are available for most crawler cranes to use as guidelines.	• Susceptible to tipping during high wind loads. • Requires ground preparation around the enclosure to take the required bearing load.

After a thorough review, it was concluded that an assist crane with considerable boom reach would be required to erect and dismantle both of the tower crane options. Also, the tower crane option does not provide any advantage in terms of wind safety; the tower crane could be considered even less safe than the crawler crane option since it cannot be lowered during strong winds. This is particularly important at Mauna Kea where strong winds are frequently combined with ice storms, which greatly increases both the weight on the crane structure and the wind cross section. The gantry crane option does not provide any advantage over the crawler crane option, and would require a larger area to be disturbed, increasing the Project impacts to the environment. This leaves the crawler crane option as the preferred crane option for construction of the TMT Observatory at the 13N Site.

Crawler Crane Construction Plan

A Manitowoc 2250 crane with 300 ton lifting capacity in combination with a 200 ton hydraulic assist crane, or similar, will be used to erect the enclosure and telescope structures. The

following subsections discuss the construction plan for the crawler crane option at the 13N site, including topics such as site layout and crane maneuvering.

Site Layout and Crane Access

It is envisioned that the crawler crane would be transported to the 13N site via transport trailers and assembled on site. An advantage of this type of crane is that is can be assembled without assistance from a second crane.

The width of the 300-ton crane is approximately 27 feet. The required minimum crane access width is roughly 33 feet around the whole enclosure, and about 40 feet where the crane will be setup for lifting; this yields a minimum clearance of approximately 11 feet between the boom and the enclosure.

Ground preparations must be made to take the full bearing load of the crane out to the 40-foot width in the specified setup areas. The crawler crane has a pressure on the ground of 3,400 psf with no load. With a 45 ton load (the likely maximum during this project), the pressure on the ground is 5,600 psf. Ground preparations to handle this load can be achieved by (1) preparing the soil, but this may not be possible and will only be known once the geotechnical studies have been completed, (2) temporary foundations, or (3) crane mats that spread the load further than the track widths.

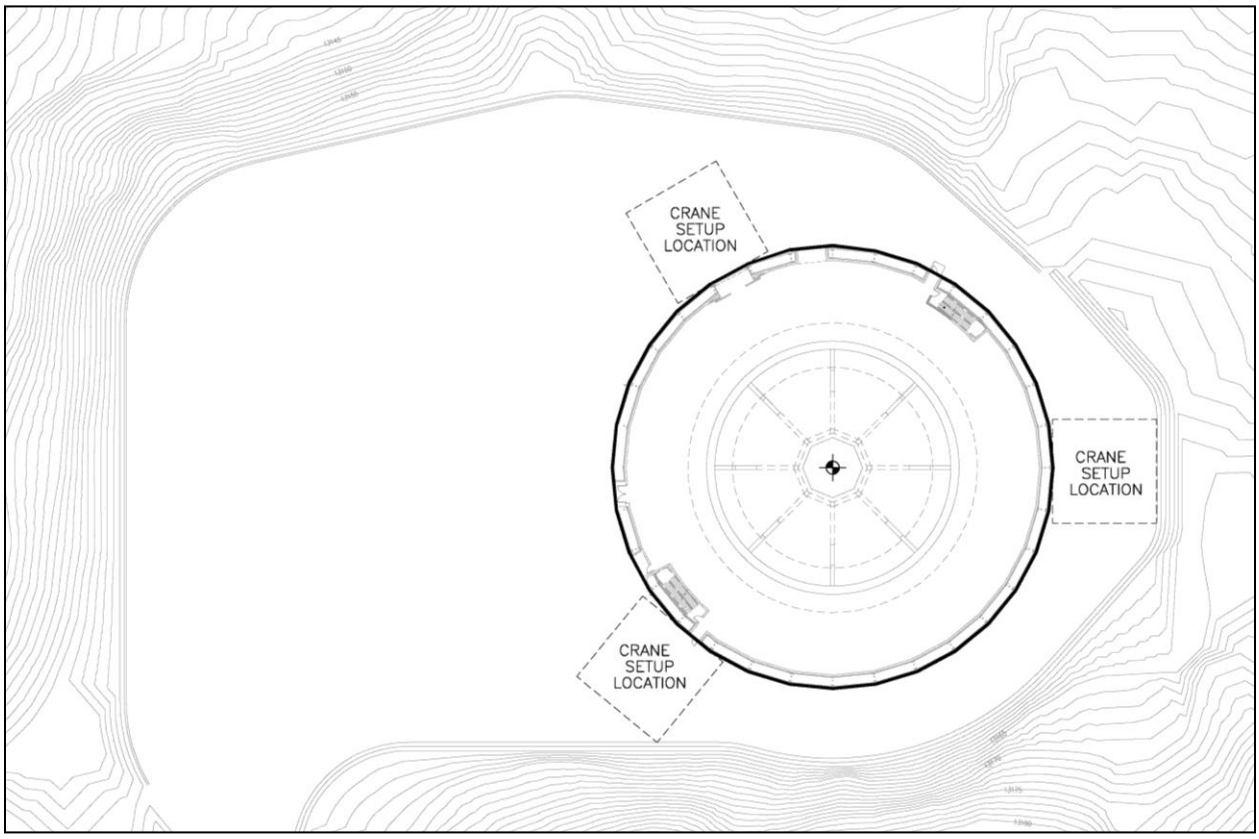


Figure B–5: 13N Site Crane Layout Plan View

As shown in Figure B–5 , the crane will sit at three strategic positions to cover all areas around the enclosure. A good crane layout results in the least number of moves or crane repositions to complete all lifts. Figure B–6 below shows an elevation view layout with the crane next to the enclosure.

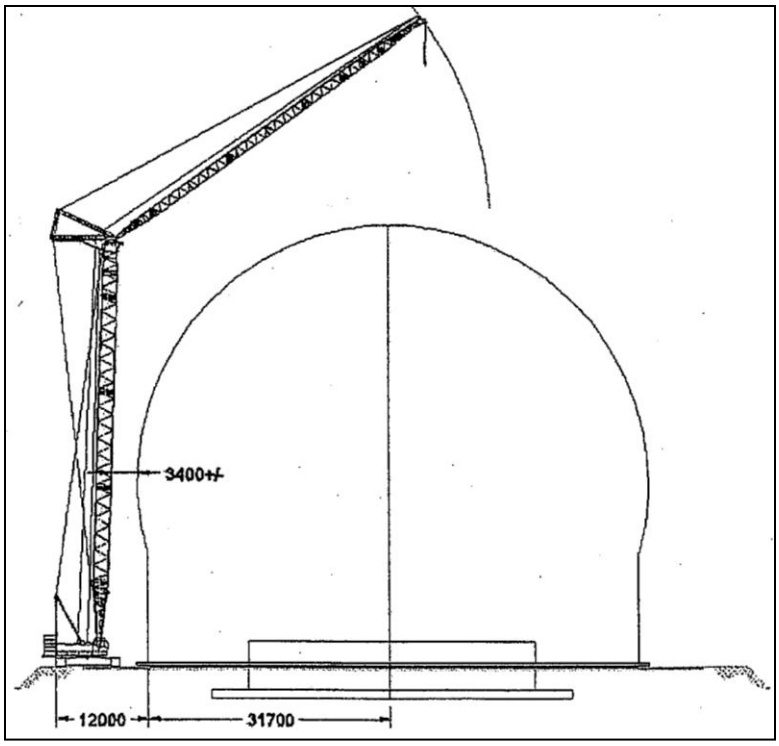


Figure B–6: 13N Site Crane Layout Elevation View

Dimensions in millimeters; 304.8 millimeters = 1 foot.

Figure B–7 below shows the boom lay down scenarios for the crawler crane at the 13N Site.

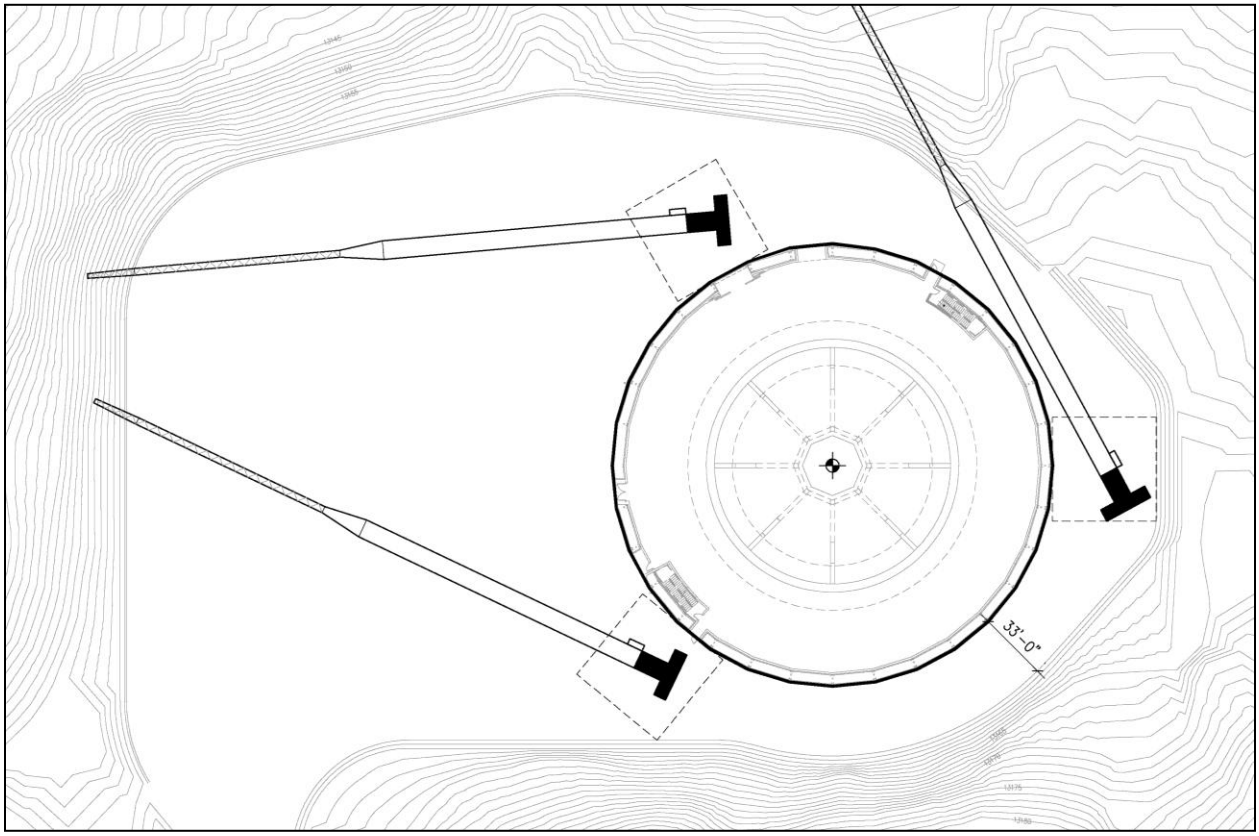


Figure B–7: Crawler Crane Boom Lay Down Scenarios

The enclosure structure will be built in two phases. The first phase involves building the enclosure structure to the point where the enclosure is fully enclosed. The second phase involves all work with regards to the mechanical setup, electrical install, insulation install, commissioning, and testing. Materials staging will be performed in the flat graded areas around the work area; during dome construction this is primarily the area west of the dome.

Crane Maneuvering

The crawler crane can readily maneuver around the site with minimum effort. Repositioning of the crane does not require it to boom down or be dismantled. To move the crane, all that needs to be done is to boom up and move to the desired location. That it requires minimum effort to reposition is another advantage of having a mobile crane onsite.

Observatory Dome Specifications

The dome will be a Calotte type enclosure with the following dimensions:

- Exterior radius: 108 feet (33.0 meters)
- Interior stay-clear radius: 95 feet (29.0 meters)
- Aperture (a.k.a. shutter, door, etc) diameter: 102 feet 6 inches (31.25 meters)
- Aperture pointing: 0 to 65 degrees zenith

- Height of dome center: 75 feet 5-1/2 inches (23.0 meters) above observatory floor elevation

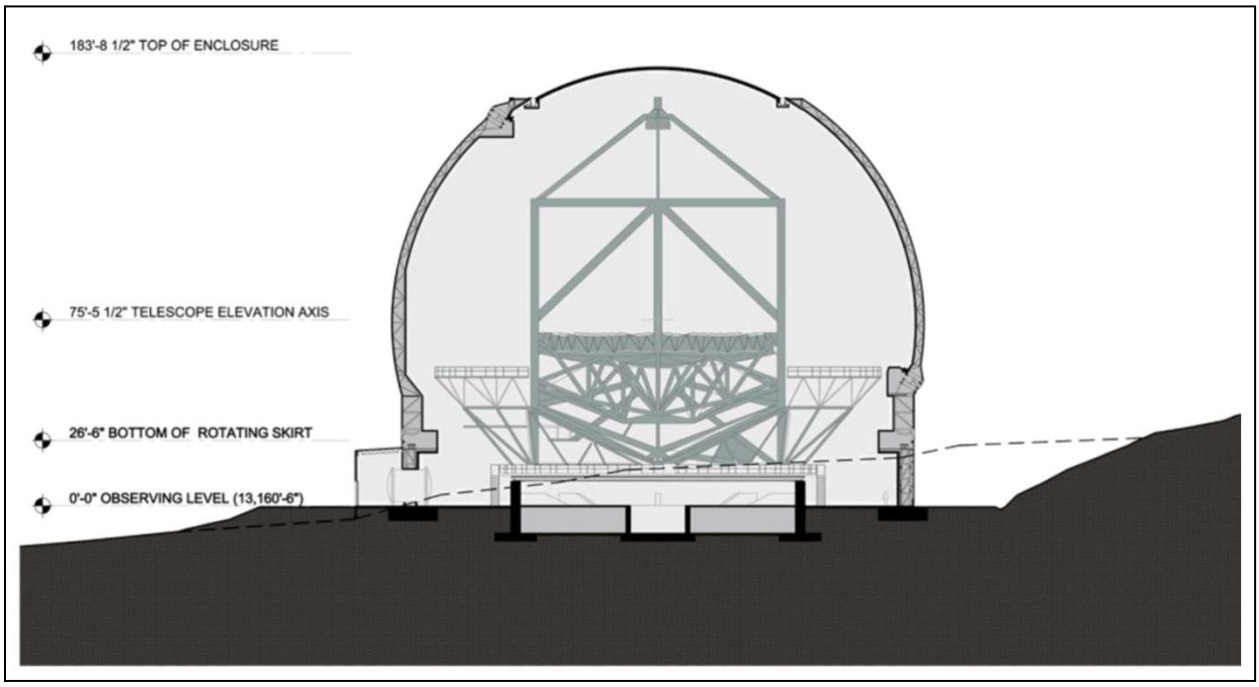


Figure B-8: Rotating Enclosure and Telescope Overview

1.3.2 Telescope Construction

Once the dome has been assembled, the telescope will be built within the dome. The construction will be accomplished by delivering telescope components directly into the dome on trucks and then assembling them using a hydraulic crane working inside the enclosure. The entire telescope structure will have been assembled where it is fabricated to ensure that the pieces fit together properly and will achieve the required tolerances. The telescope structure will then be disassembled and transported to the site in pieces.

The actual mirror surfaces will not be delivered to the site until the support building described in the following section has been completed.

1.3.3 Support Building Construction

Once the large structural components of the telescope have been delivered to the dome and assembled, the construction of the support building will begin. The support building is a relatively standard building and no special construction equipment will be required to build it. All building details with indicated use, including floor plans, are illustrated on preliminary design plans in Attachment B.

Table B-5 summarizes the support building use areas and their respective floor area and Figure B-9 provides a general illustration of the support building floor plan.

Table B-5: Summary of Support Building Areas

Use	Net Floor Area (square feet)
Utility and Mechanical Rooms	9,939
Mirror Cleaning, Coating, Staging	2,072
Computer Room and Laboratory	1,485
Office, Control, Conference, Kitchen Rooms	1,986
Restrooms	276
Visitors Lobby	203
Total	**15,961**

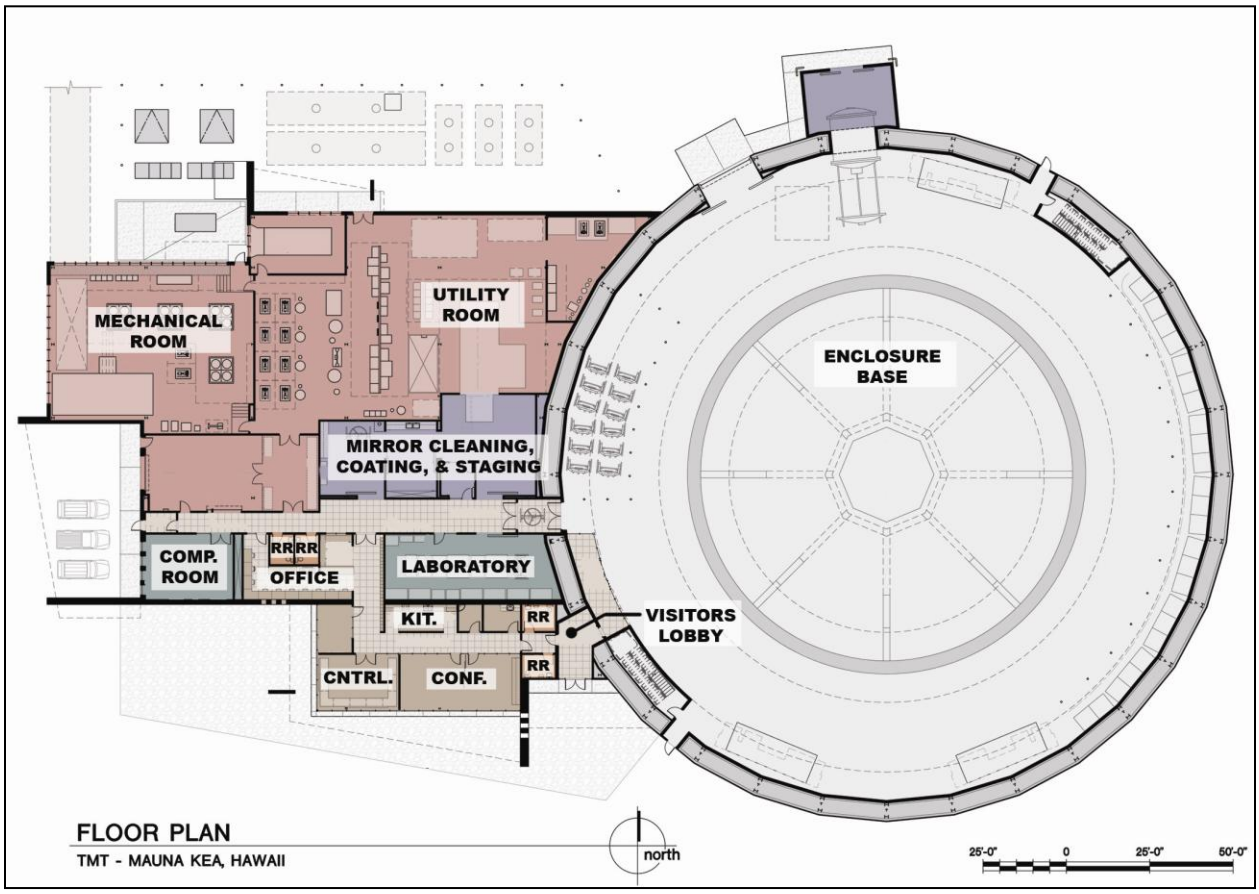


Figure B-9: Support Building Floor Plan

1.3.4 Transformer Replacement

As discussed in Section 1.2.5, the two transformers in the HELCO compound near Hale Pōhaku will be upgraded. The existing transformers will be removed and disposed of properly and new, higher-capacity transformers installed in their former location. This work will be achieved using truck-mounted cranes to position the equipment. The crane will be positioned on the existing roadway just outside the compound fence. Flat-bed trucks will be used to deliver and remove the equipment and will travel on existing roadways.

1.4 Port Staging Area and Transportation to Summit Area

Outside of the Conservation District near the port where materials are received on-island TMT will lease a "Port Staging Area". The Port Staging Area has not been selected yet. Figure B-10 illustrates a potential Port Staging Area layout. This layout would be modified to fit the site selected but the figure provides an overview of the types of activities that would take place at the Port Staging Area. Prior to utilizing the Port Staging Area, the site would be cleared of invasive species to the extent possible and best management practices (BMPs) installed to (a) limit the potential for the later establishment of invasive species; (b) limit the production of dust and mud; and (c) limit and control stormwater run-on, runoff, and quality.

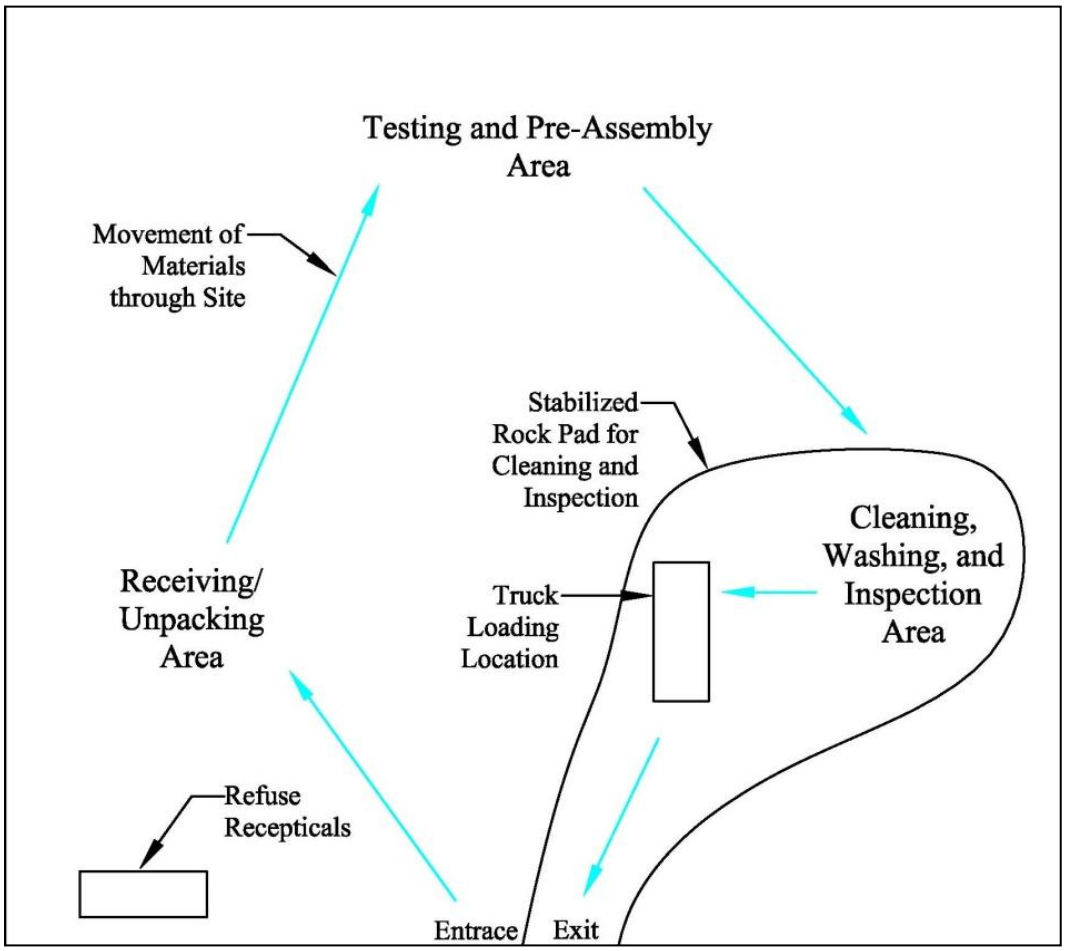


Figure B-10: Potential Port Staging Area Layout

Activities conducted at the Port Staging Area will include:

- Receiving/unpacking area. In this area materials received will be unpacked and excess packaging disposed of.
- Testing and pre-assembly area. In this are materials will be tested for use on the construction site and assembled to the extent possible prior to being transported to the summit region.

- Cleaning, washing, and inspection area. In this area materials and equipment will be cleaned and prepared for transportation to the summit region. Both the materials being transported and the vehicles transporting them will be cleaned and inspected, per the discussion in Section 1.6. Only minimal packing materials will be used.

Materials and equipment transport between the Port Staging Area or other area outside of the Conservation District to the summit region will follow a set route established using the Oversized and Overweight Vehicles Permit (OOVP) process administered by the State of Hawai‘i Department of Transportation (HDOT). Transport will be along established paved roads only. Drivers will not be allowed to divert from the route or stop for an extended period or time once cleared to transport materials and/or equipment to the summit region.

1.5 Construction Monitoring in the Conservation District

During all construction related activities in the Conservation District, TMT will comply with CMP Management Action C-1, which calls for an on-site construction monitor who will 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. A separate draft Cultural and Archaeological Monitoring Plan presented as section of the Draft Historic Preservation Mitigation Plan (Appendix A of the TMT Project Management Plan) spells out the details of monitoring related to cultural resources. These details will be refined as the design and schedule for TMT construction is finalized; the monitoring plan will then be submitted for approval to SHPD. Components of the monitoring plan include:

- Monitors, such as archaeologists, will have the appropriate training and experience, be selected by OMKM and approved by DLNR.
- A trained archaeologist and cultural specialist will be on site to monitor any impacts, real or potential, of construction activities on archaeological and historical resources.
- The trained archaeological cultural specialist will be funded by TMT.

All orders to cease construction issued by the construction monitor will immediately be reported to OMKM and DLNR. The monitoring provisions are consistent with the CMP and previous conditions on CDUPs approved by BLNR.

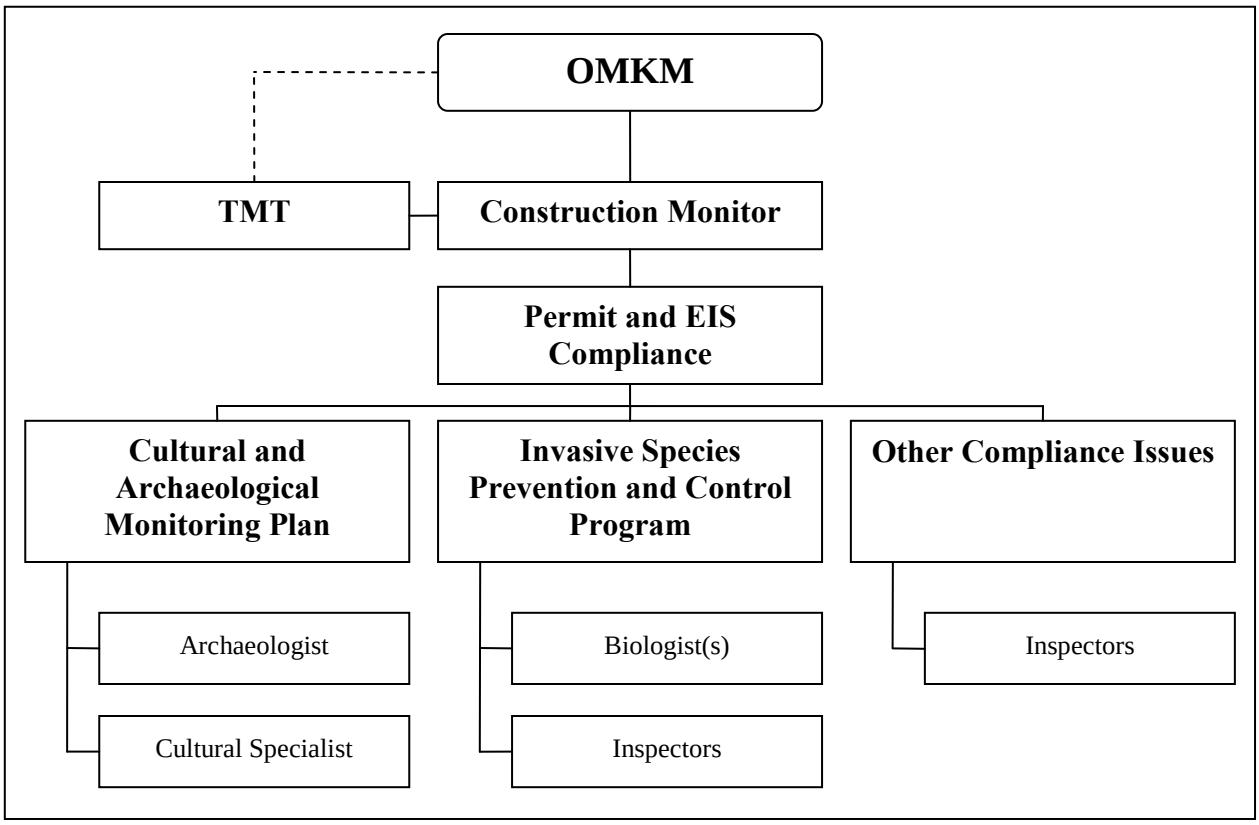


Figure B-11: Construction Monitoring Organization Chart

Likewise, prior to leaving the Port Staging Area or other location outside of the UH Management Area, all construction materials, equipment, crates, and containers carrying materials and equipment which are of substantial size and capable of harboring invasive flora and fauna will be inspected by a trained biologist, selected by OMKM and approved by DLNR, who will certify that such materials, equipment, and containers are free of any and all flora and fauna that may potentially have an impact on the Mauna Kea summit ecosystem. This provision is consistent with the CMP and previous conditions on CDUPs approved by BLNR.

1.6 Invasive Species Prevention and Control Program

This program is described below and will be further refined by TMT and their selected contractor in coordination with OMKM.

Movement of construction materials, earthmoving equipment, and vehicles to the construction areas may introduce non-indigenous weedy flora or invasive fauna pests to the Mauna Kea summit region or Hale Pōhaku. These alien species can out-compete and displace native species and thereby reduce their populations. The CMP requires this potential impact be addressed by new developments. Packaging material will be redone at the Port Staging Area prior to continuing up the mountain. To comply, the Project has developed and will implement an Invasive Species Prevention and Control Program to address this potential impact. Components of the program regarding materials movement during the construction phase include:

- Materials Control and Reduction. 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:
    - 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.
- Washing/Cleaning. Materials and clothing will be washed or otherwise cleaned prior to proceeding above Saddle Road. This will be done at lower elevation baseyards, such as the Port Staging Area, and will include:
    - 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. This will include containers at the Port Staging Area.
    - A requirement for pressure wash-down of all construction vehicles and heavy equipment.
- Inspections. Prior to proceeding to the summit region from the Port Staging Area or other location, all construction materials, equipment, crates, and containers carrying materials and equipment which are of substantial size and capable of harboring invasive flora and fauna will be inspected and certified free of invasive species by a trained biologist, selected by OMKM and approved by the DLNR.

The Invasive Species Prevention and Control Program will be part of project plans and specifications for construction bidding. The implementation of this plan will reduce the potential for accidental introduction of non-indigenous species and reduce the likelihood of adverse impacts associated with invasive species.

1.7 Other Plan Components

There will be no designated open space and recreations areas created as part of the Project.

Landscaping will be restricted to the graded slopes and rock features near the entrance to the TMT Observatory, as illustrated in Figure B-12. There will be no re-vegetation or plantings as part of the Project due to the natural conditions of the site being well above the tree line.



Figure B-12: Proposed Landscaping

All parking, workers and visitors, will occur within the TMT Observatory 13N site graded area as illustrated on Figure B-4.

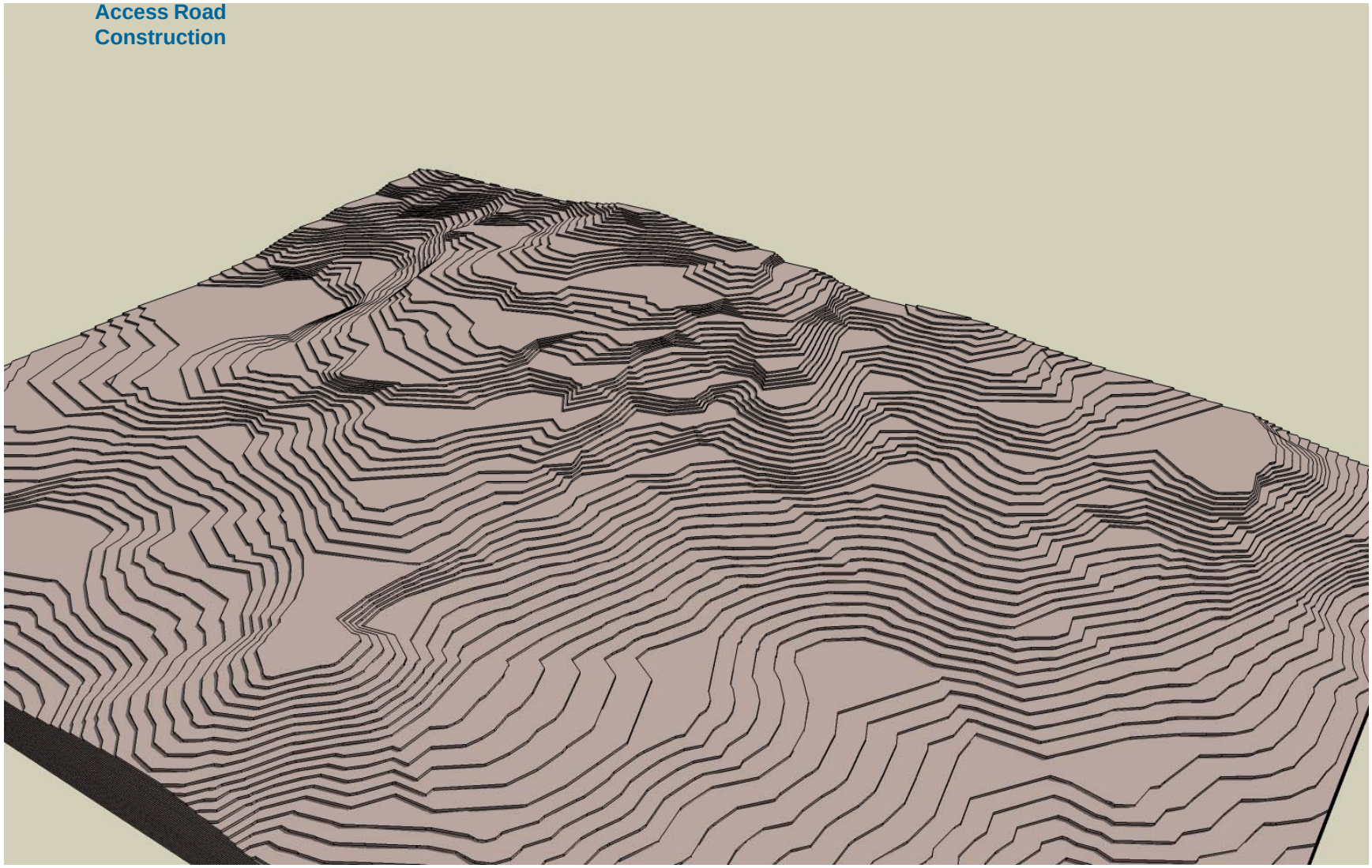
As rainfall in the summit region is infrequent and not extreme, no underground drainage systems will be constructed. Above-ground drainage facilities will be restricted to the drainage swale on the cinder section of the Access Way (the only paved portion of the Access Way) as illustrated in Figure B-1. Generally, water will flow from the impervious surfaces (the paved portion of the Access Way and the TMT Observatory dome and support building) to the surrounding graded parking areas, roadways, embankments and slopes, plus the surrounding natural area which consists of very permeable lava flows.

Attachment A: Construction Sequence

Construction Sequence
Summit (Pre-Construction)

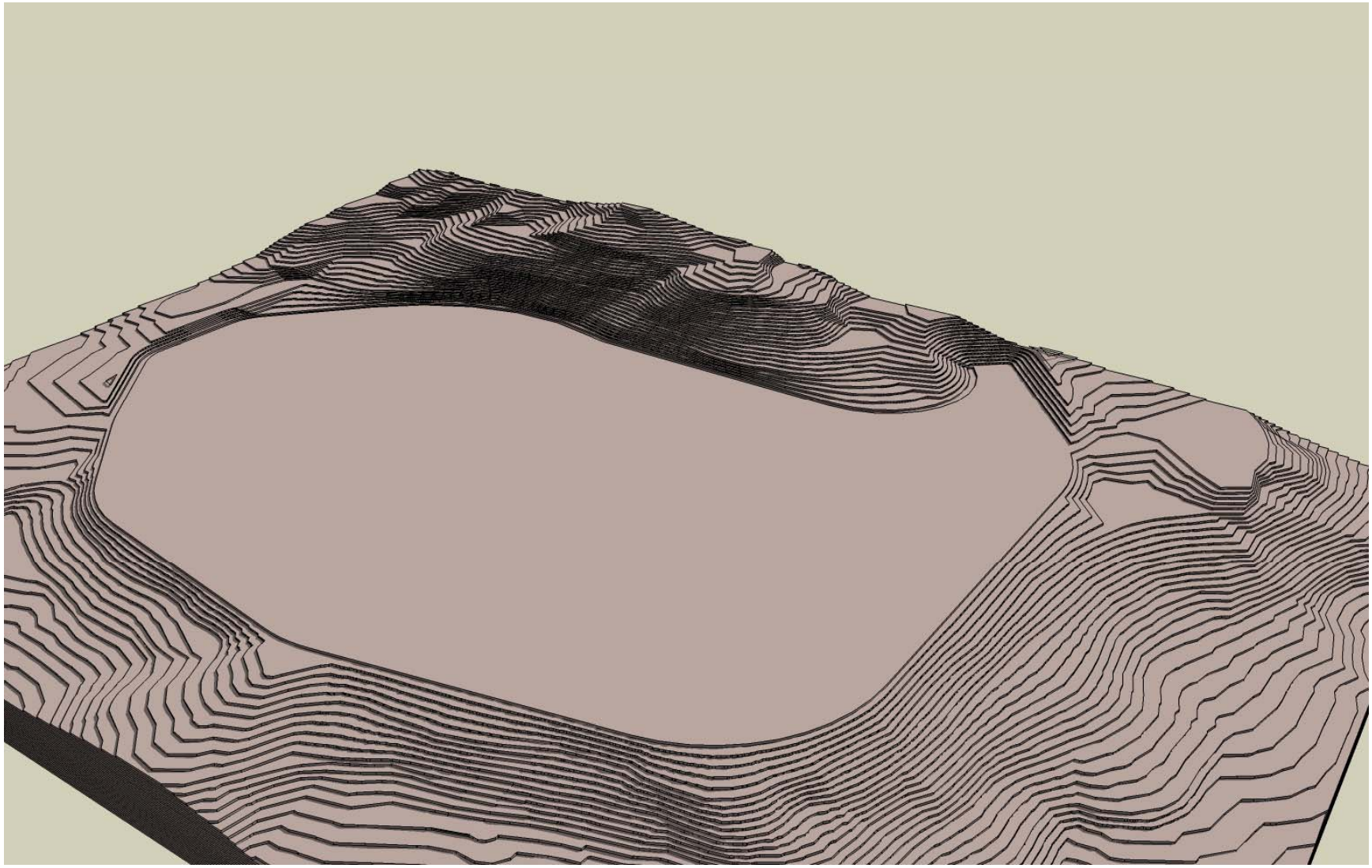
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Access Road Construction



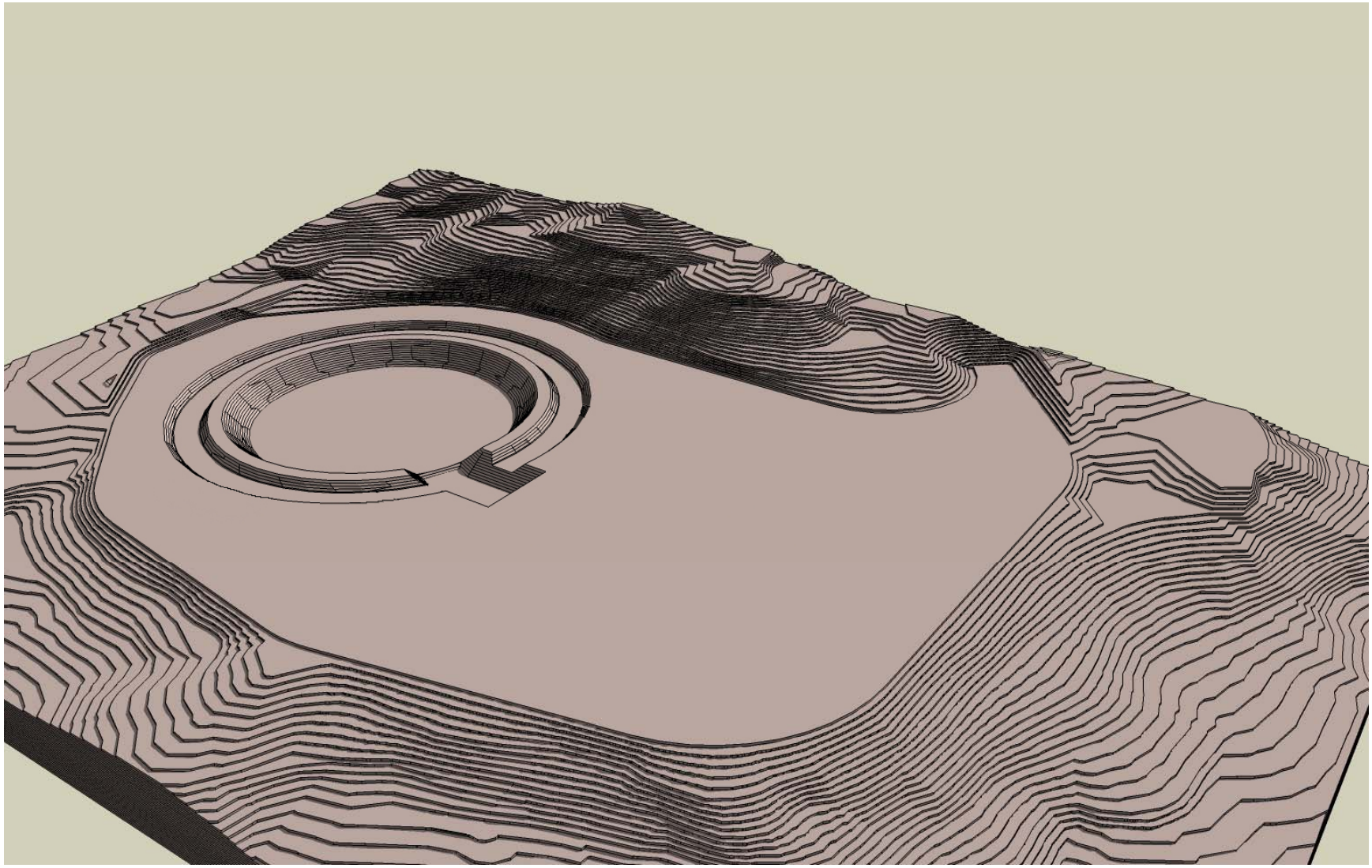
Construction Sequence
Rough Grading

2011				2012				2013				2014				2015				2016				2017				2018				2019			
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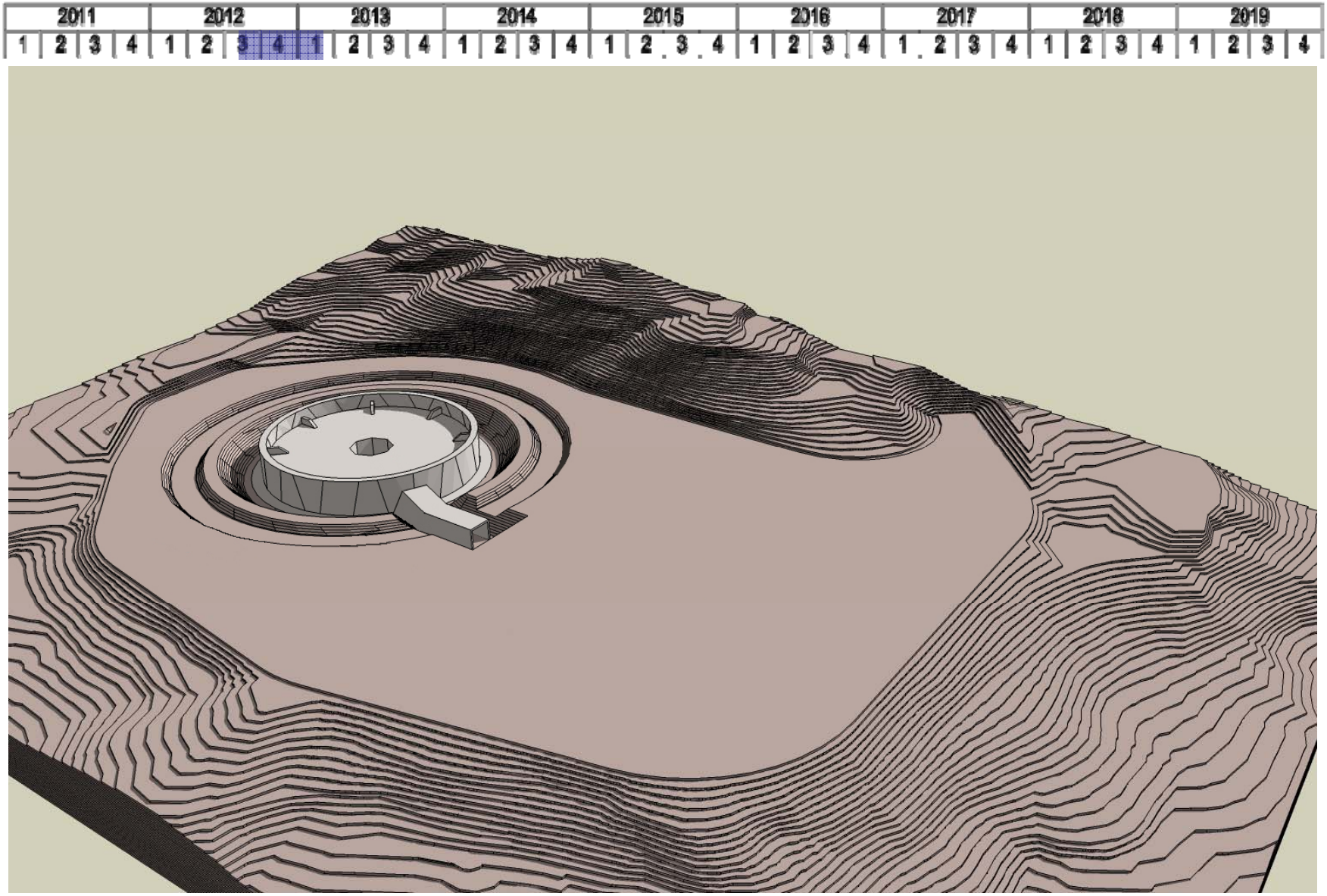


Construction Sequence
Pier / Foundation Excavation & Utilities

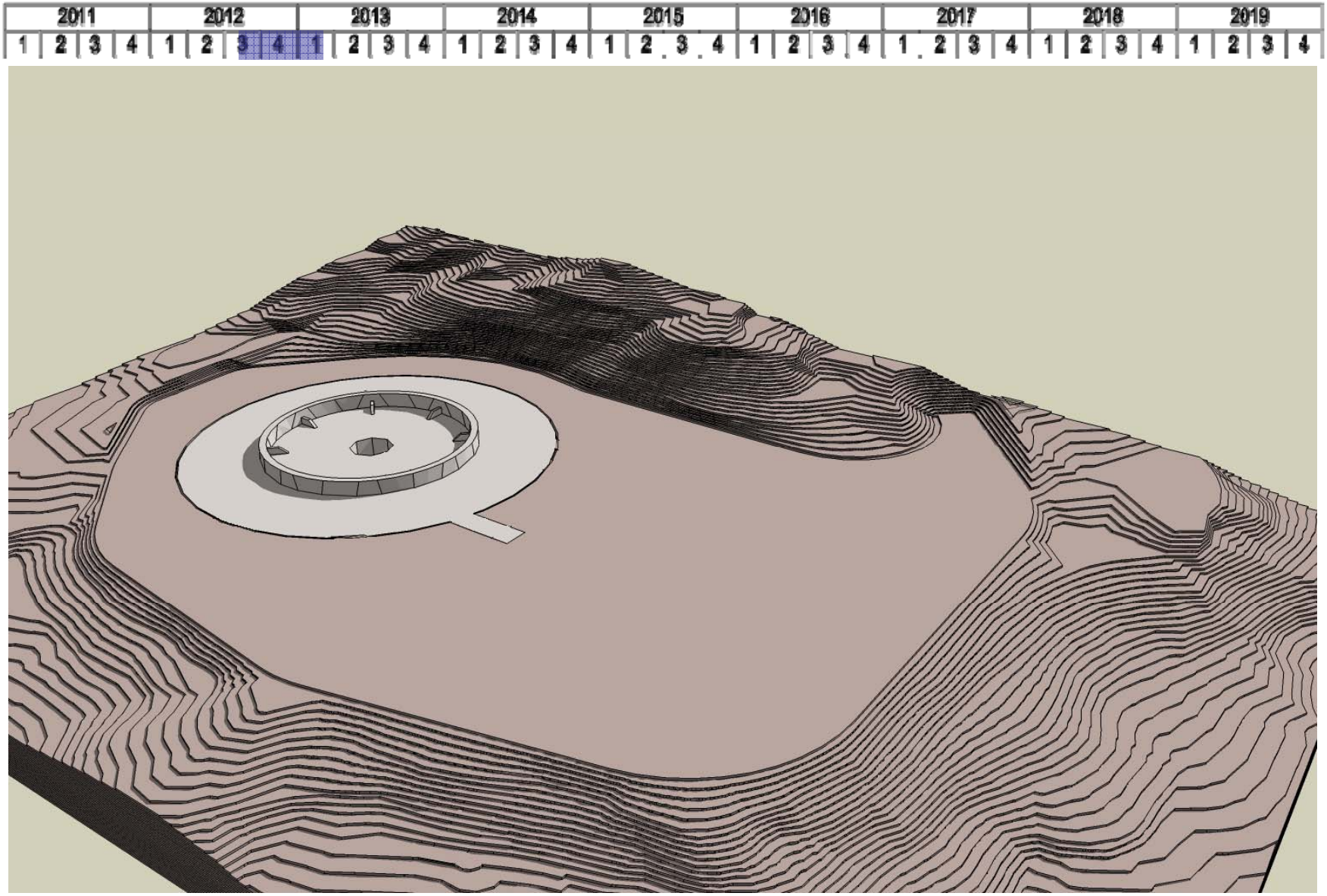
2011				2012				2013				2014				2015				2016				2017				2018				2019			
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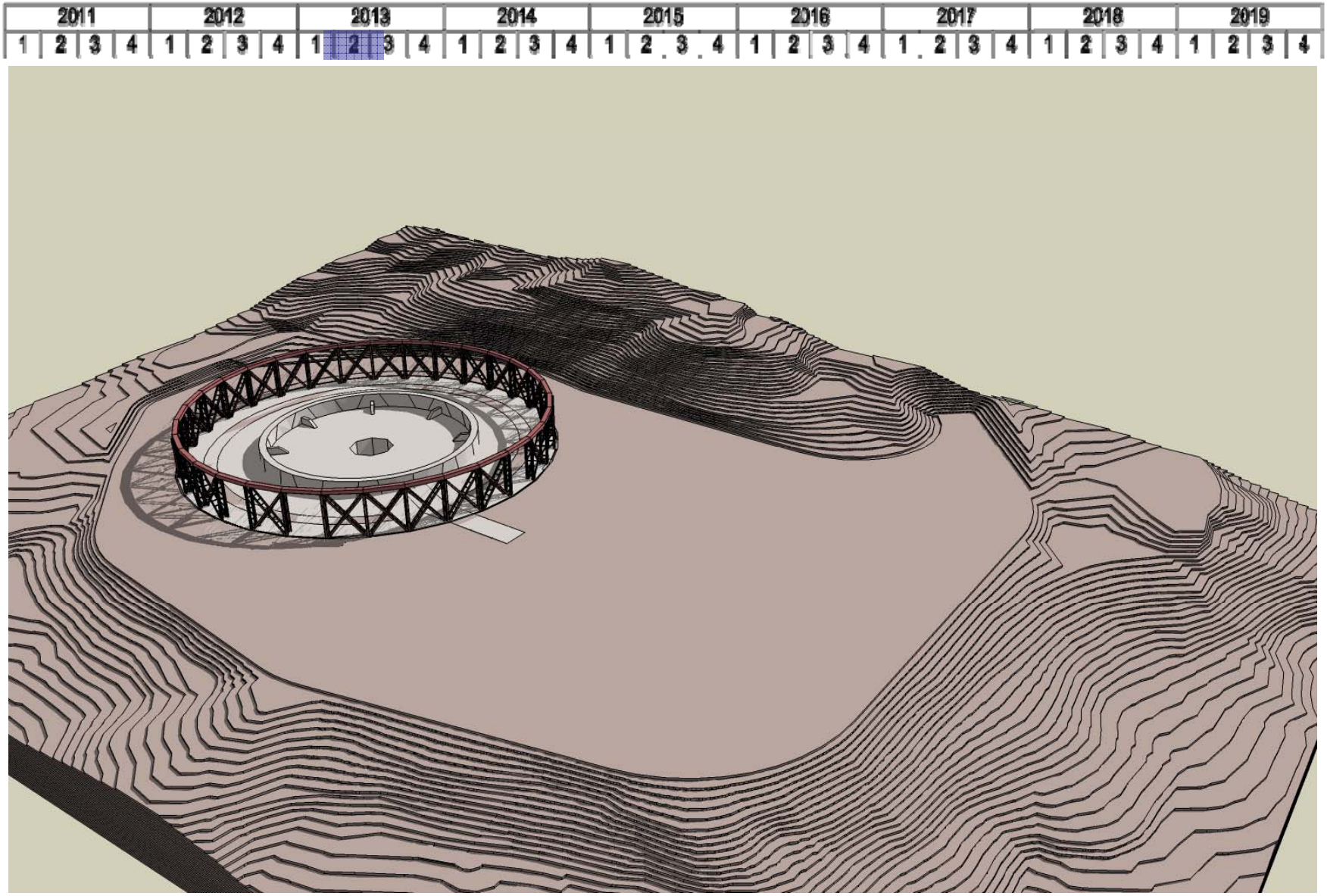
Construction Sequence
Pier and Tunnel Concrete



Construction Sequence
Fixed Enclosure Foundation & Concrete Slab

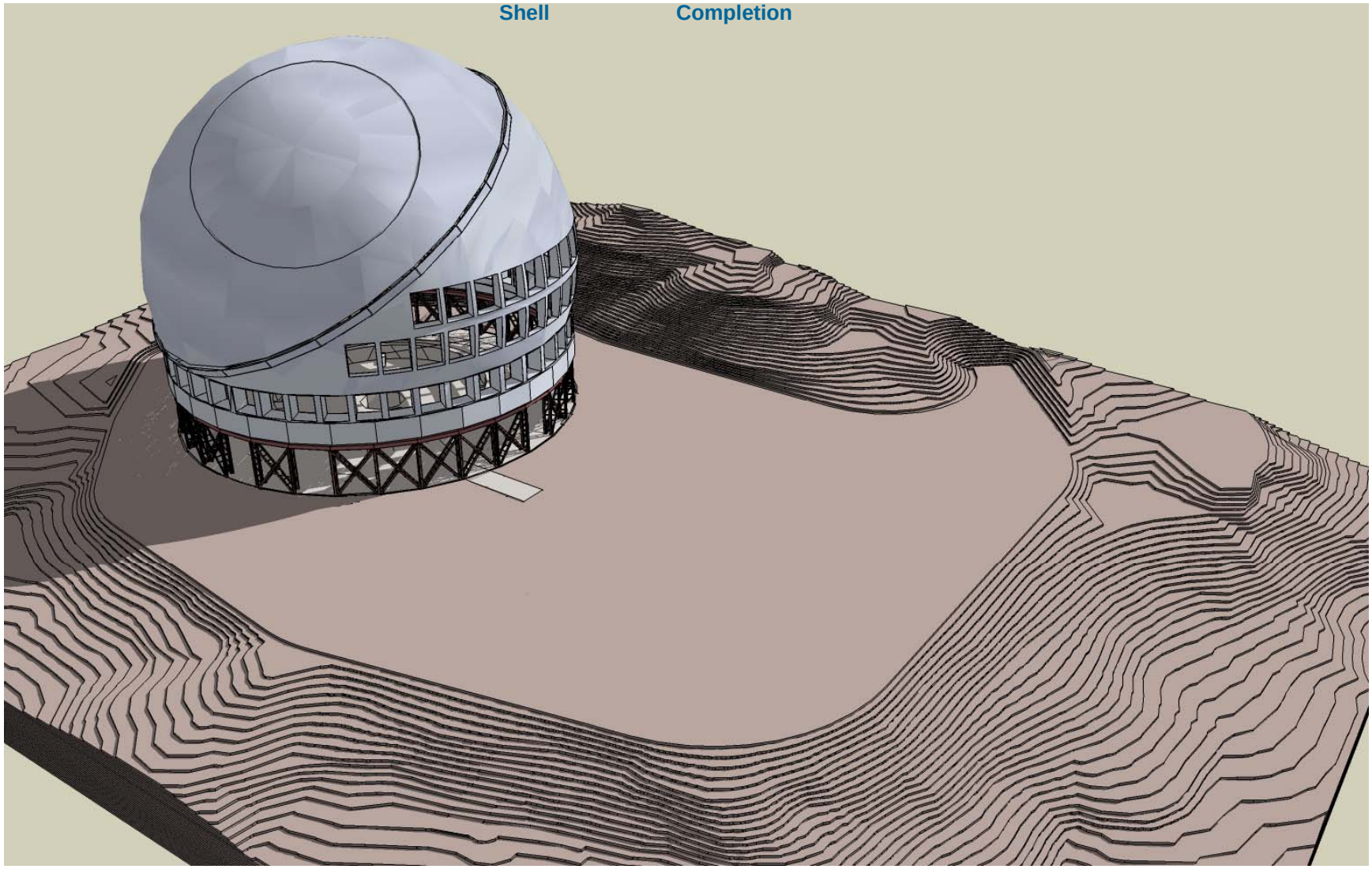


Construction Sequence
Fixed Enclosure Structural Steel



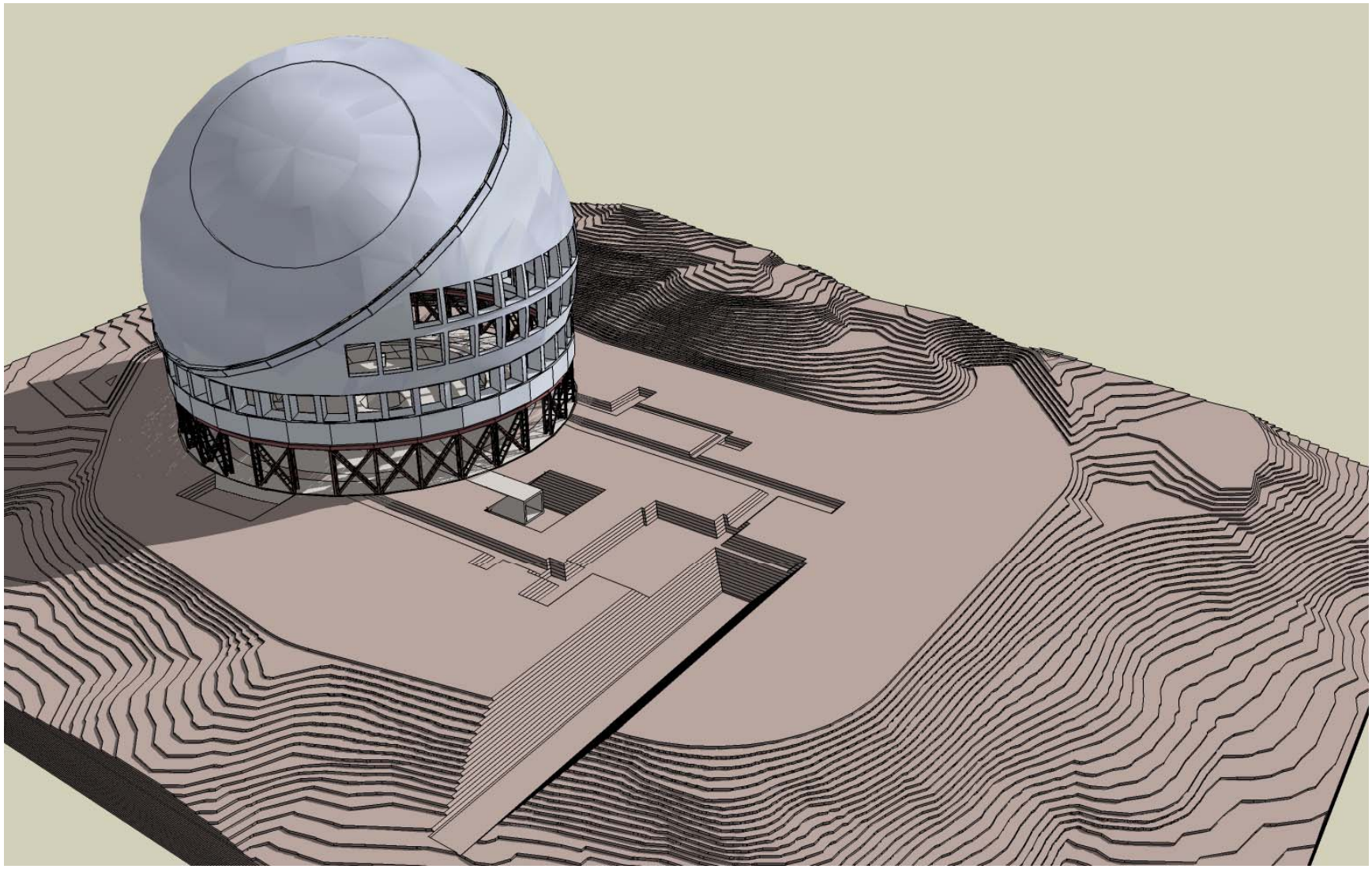
Construction Sequence
Rotating Enclosure Erection





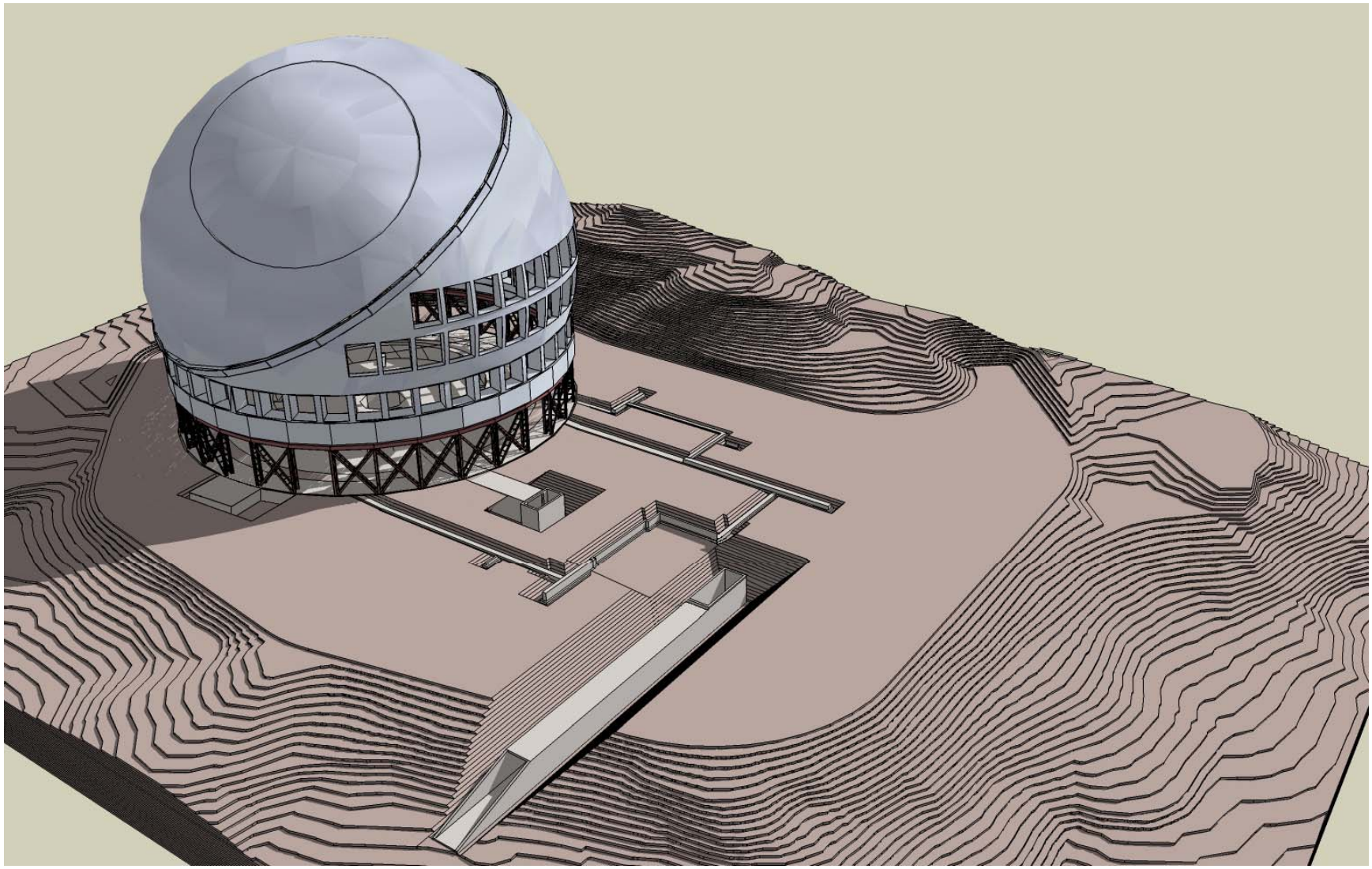
Construction Sequence
Summit Facility Rough Grading & Excavation

2011				2012				2013				2014				2015				2016				2017				2018				2019			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4



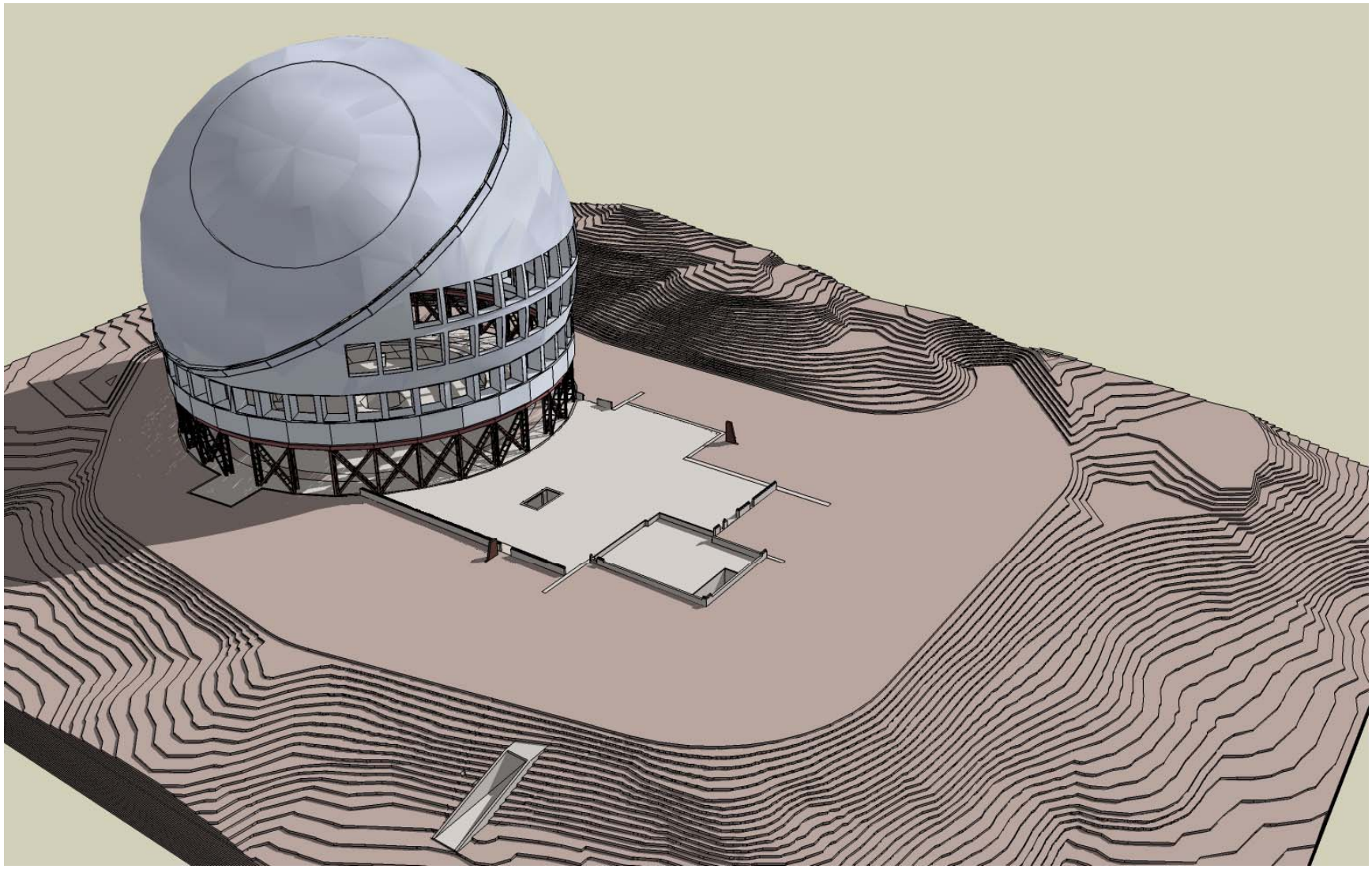
Construction Sequence
Summit Facility Foundation & Tunnel

2011				2012				2013				2014				2015				2016				2017				2018				2019			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4



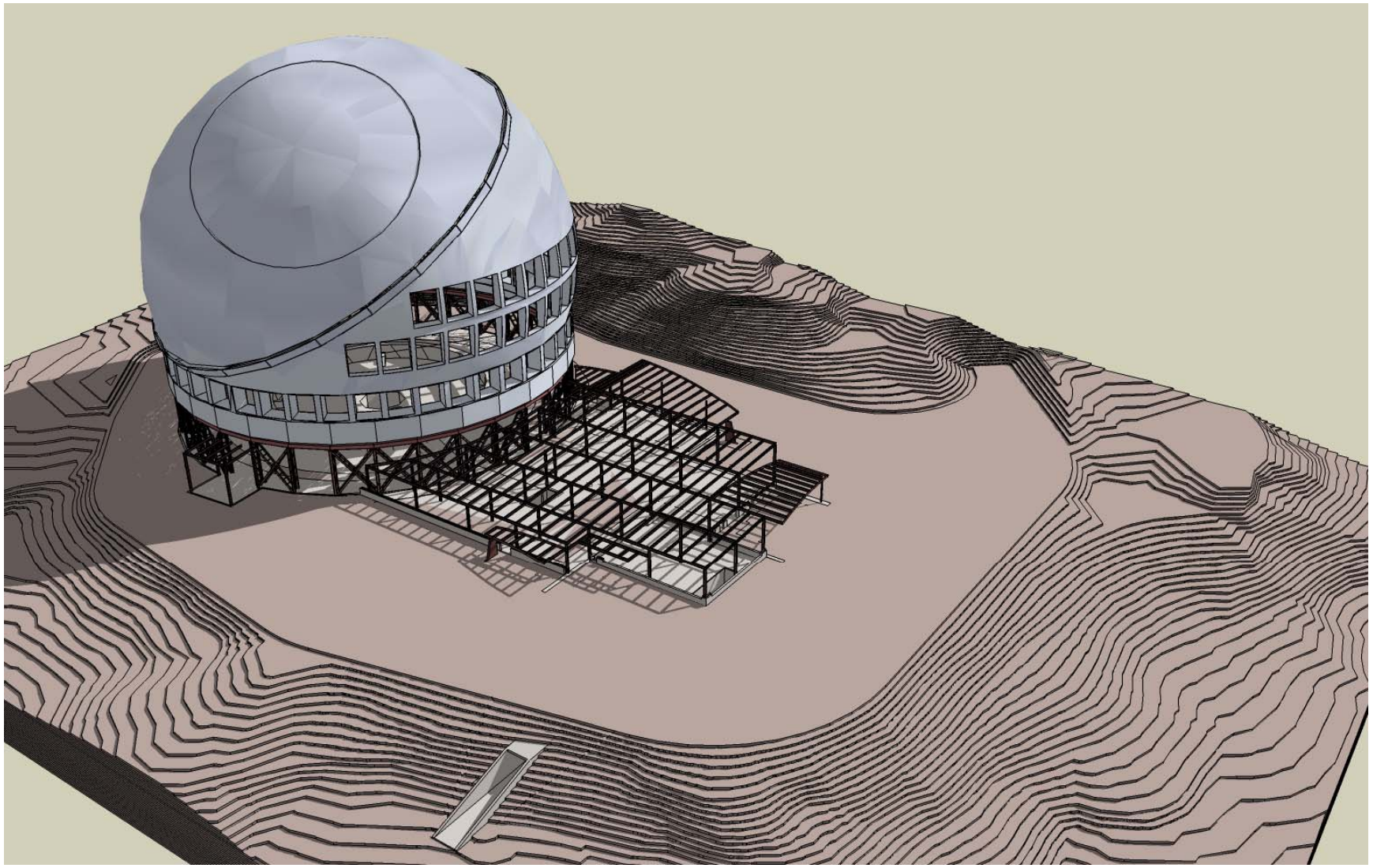
Construction Sequence
Summit Facility Concrete Slab & Backfill

2011				2012				2013				2014				2015				2016				2017				2018				2019			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4



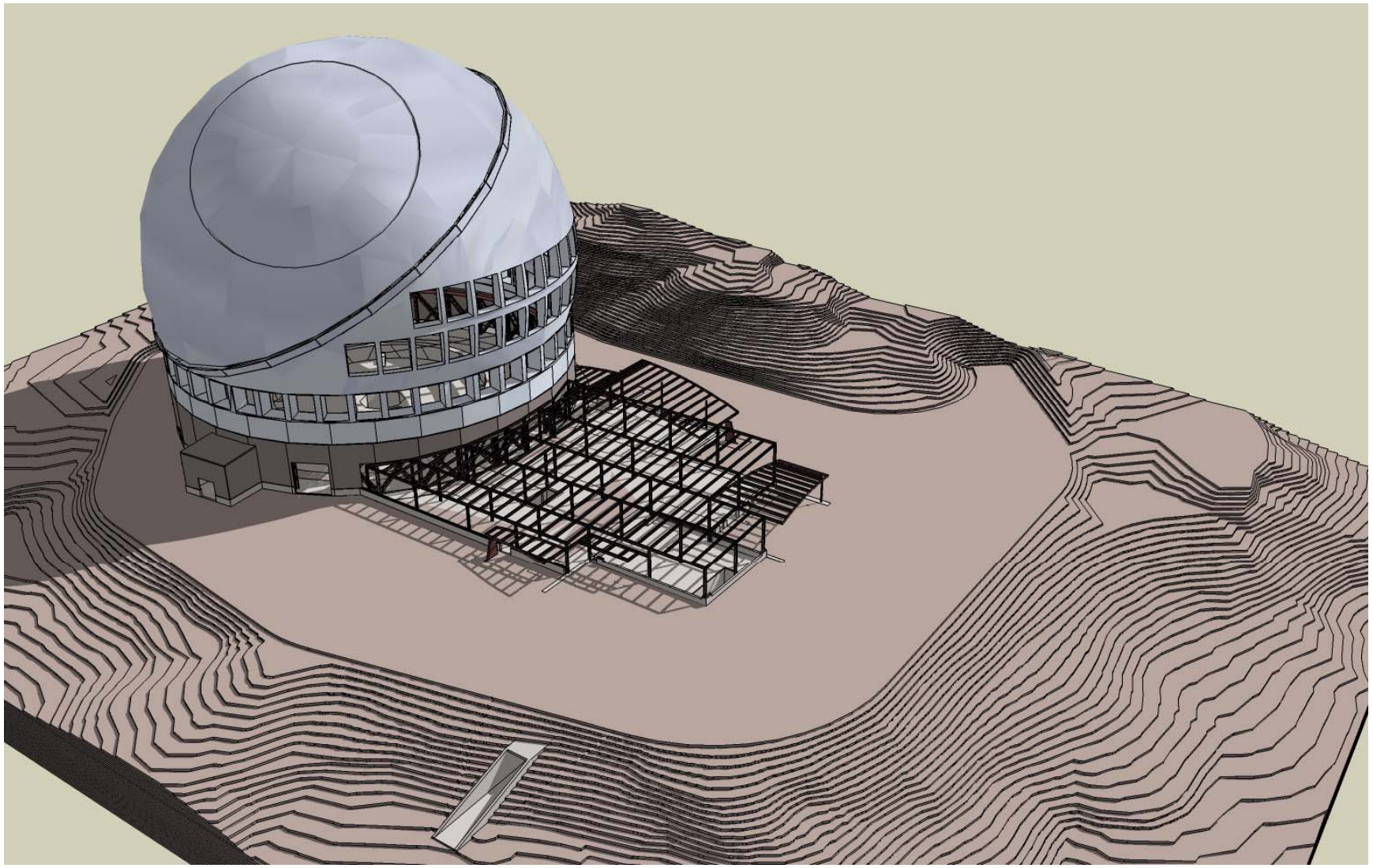
Construction Sequence
Summit Facility Steel

2011				2012				2013				2014				2015				2016				2017				2018				2019			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4



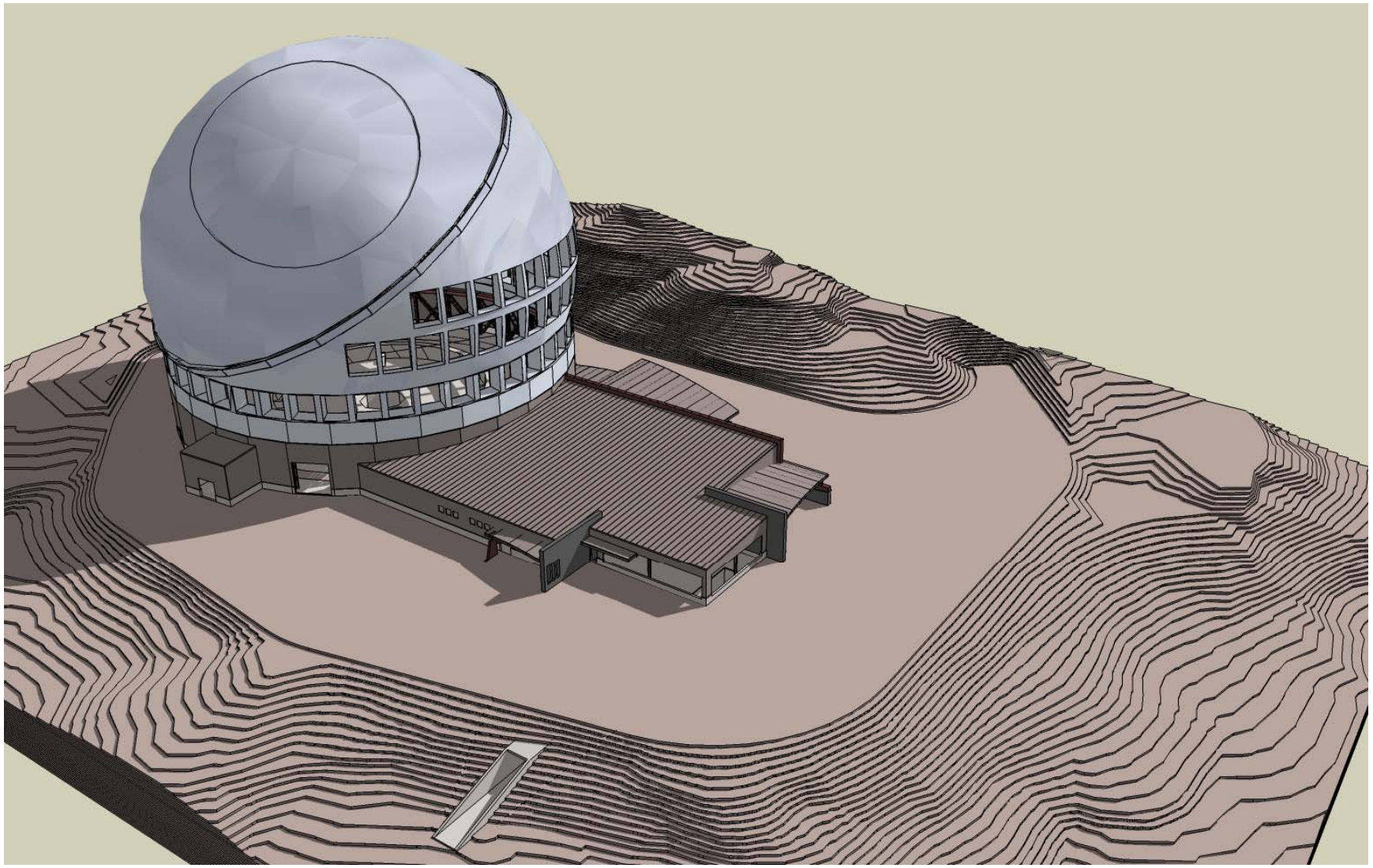
Construction Sequence
Fixed Enclosure Wall Panels

2011				2012				2013				2014				2015				2016				2017				2018				2019			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4



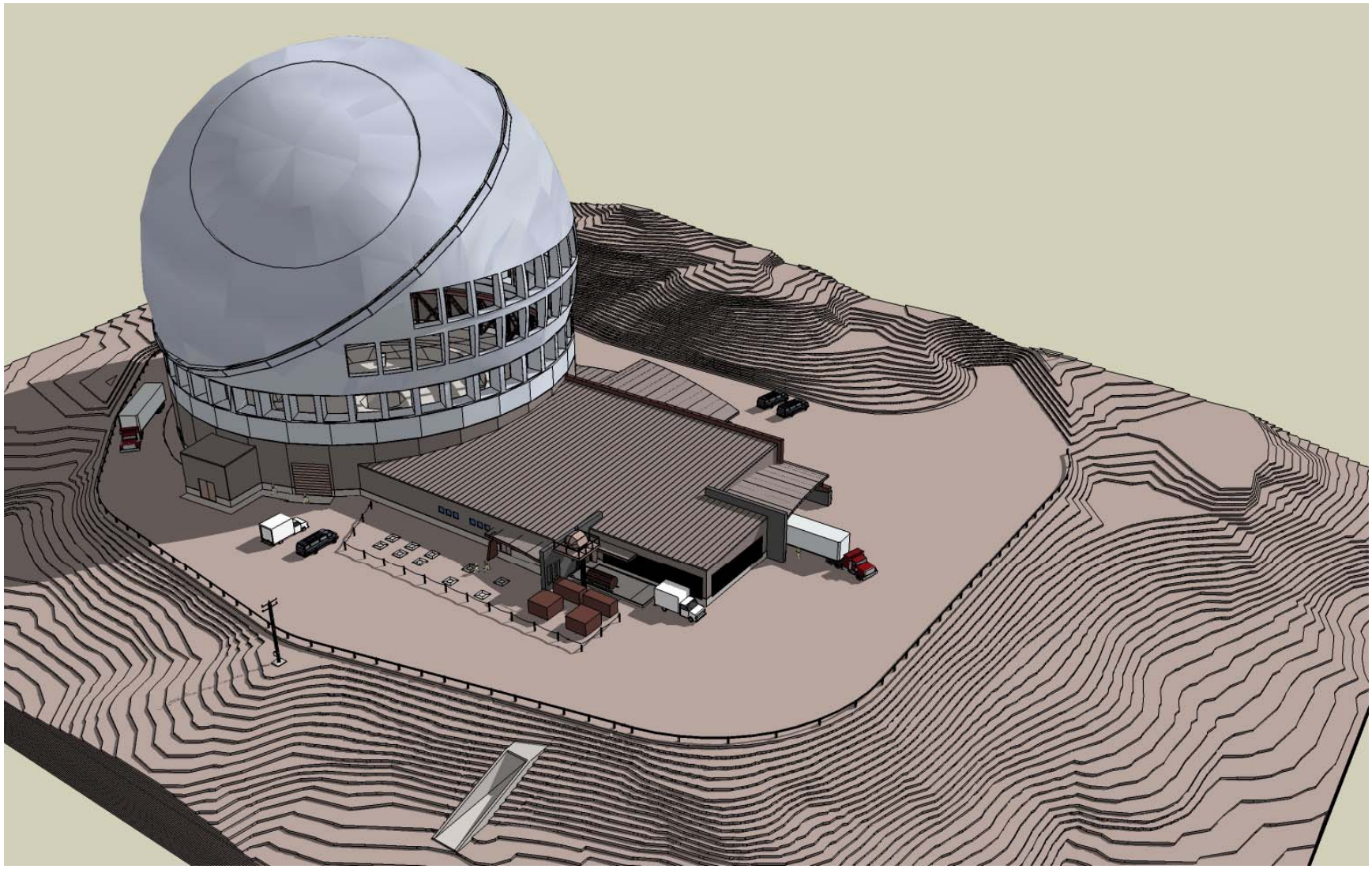
Construction Sequence
Summit Facility Shell, Utilities, & Site Work

2011				2012				2013				2014				2015				2016				2017				2018				2019			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4



Construction Sequence Completion

2011				2012				2013				2014				2015				2016				2017				2018				2019			
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4



Attachment B: Grading and Foundation Plans

THIRTY METER TELESCOPE

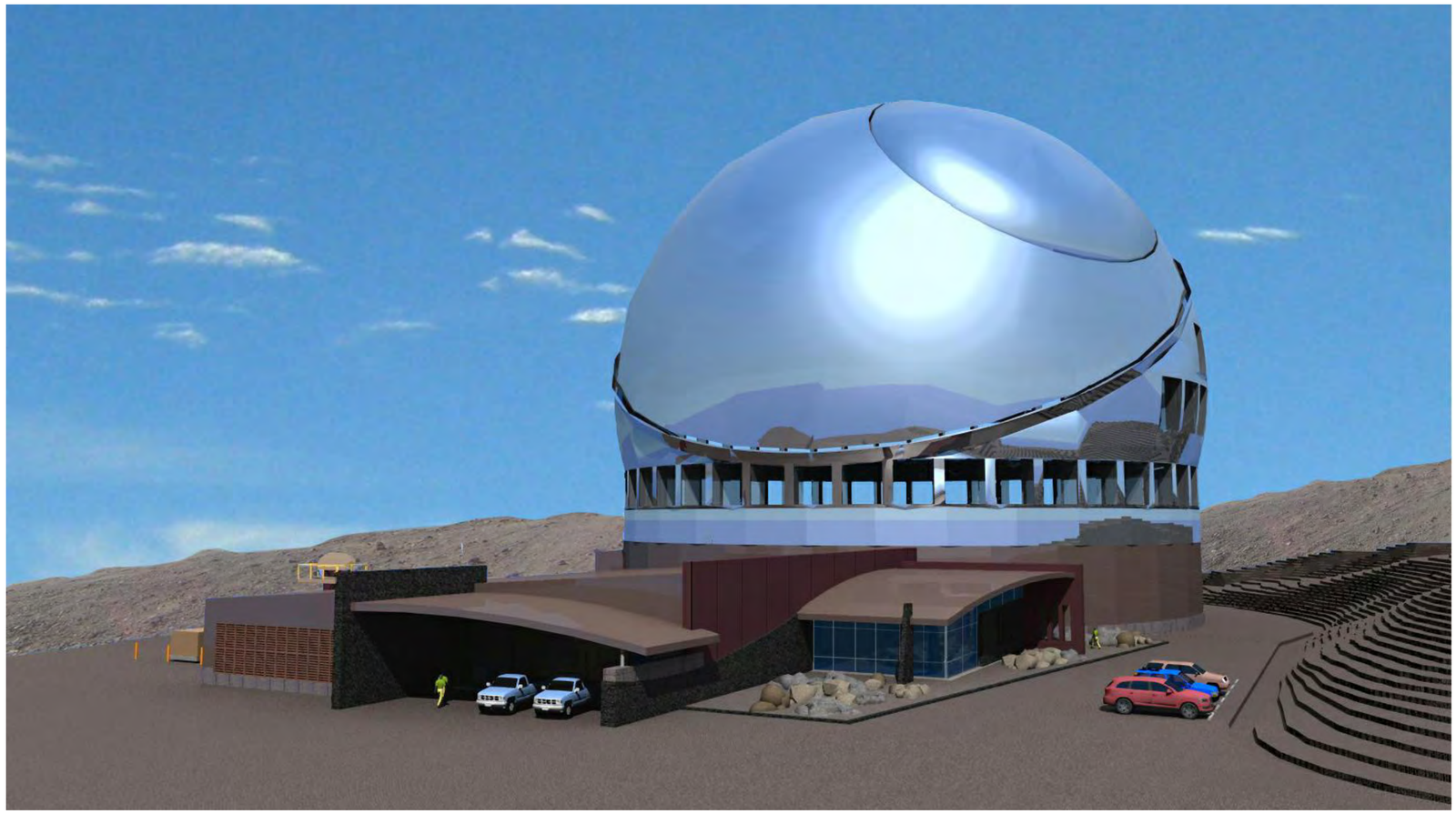
PHASE III - DESIGN DEVELOPMENT SUBMITTAL FOR THE OFFICE OF MAUNA KEA MANAGEMENT

ASSOCIATION OF CANADIAN UNIVERSITIES FOR RESEARCH IN ASTRONOMY - CALIFORNIA INSTITUTE OF TECHNOLOGY - UNIVERSITY OF CALIFORNIA

MAUNA KEA, HAWAII

APRIL 5, 2010

TMT.SUM.PDD.10.009.DRF01



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE
DESIGN DEVELOPMENT SUBMITTAL
FOR THE OFFICE OF MAUNA KEA MANAGEMENT
MAUNA KEA, HAWAII

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ARCHITECTURE
CONSTRUCTION MANAGEMENT

Revisions

	Description	Date
1		
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Drawn: E.J.G.
Checked: -
Issue Date: 4-5-10

Drawing Title

COVER SHEET

Sheet Number

GI001

M3PN 07131

Last Update: 3.26.2010

ABBREVIATIONS (NOT ALL ABBREVIATIONS SHOWN BELOW ARE USED IN THIS SET OF DRAWINGS)

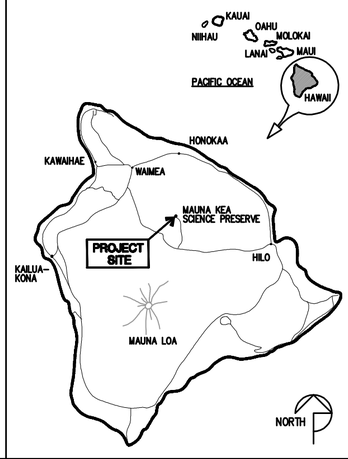
&	AND	F	FAHRENHEIT	OH	OVERHEAD
A.B.	ANCHOR BOLT	FD	FLOOR DRAIN	OPNG	OPENING
ABUT	ABUTMENT	FDN	FOUNDATION	OPP	OPPOSITE
ABC	AGGREGATE BASE COURSE	F.E.	FIRE EXTINGUISHER	ORN	ORNAMENTAL
ABV	ABOVE	FF	FINISH FLOOR		
AC	ACOUSTICAL SPRAY ON CEILING	FFE	FINISH FLOOR ELEVATION	PL	PLATE
ACI	AMERICAN CONCRETE INSTITUTE	F.G.	FINISHED GRADE	P.L., P	PROPERTY LINE
L	ANGLE (STRUCTURAL)	FIN	FINISH(ED)	PLF	POUNDS PER LINEAL FOOT
AFF	ABOVE FINISHED FLOOR	FLR	FLOOR	PLMB	PLUMBING
ALT	ALTERNATE	FLUOR	FLUORESCENT	PLS.LAM	PLASTIC LAMINATE
ALUM	ALUMINUM	FLG	FLANGE	PLYWD	PLYWOOD
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE	FLASH	FLASHING	PM	PRESSED METAL
		FOS	FACE OF STUD	PNL	PANEL
AP	ACOUSTICAL WALL PANEL	FT	FOOT, FEET	POLYISO	POLYISOCYANURATE
APPROX	APPROXIMATE	FTG	FOOTING		
ARCH	ARCHITECT(URAL)	FTR	FLUE THROUGH ROOF	REQ'D	REQUIRED
ARS	ARIZONA REVISED STATUTES	FURN	FURNITURE	REQ'MENT	REQUIREMENT
ASPH	ASPHALT			R	RESILIENT BASE
ASTM	AMERICAN SOCIETY FOR TESTING MATERIALS	G	GYPSUM BOARD	RA	REPAIR
		GALV	GALVANIZED	R	RADIUS
AVG	AVERAGE	G.B.	GRAB BAR	RE	REPLACE
AWG	AMERICAN WIRE GAGE	G.I.	GALVANIZED IRON	RR	RESTROOM(S)
AZ	AZIMUTH	GL	GLASS, GLAZING	ROW	RIGHT OF WAY
B	BRICK	GWB	GYPSUM WALL BOARD	S	STUCCO
B.BD	BULLETIN BOARD	GYP	GYPSUM	SC	SOLID CORE
BD	BOARD			SCHD	SCHEDULE
B.L.	BUILDING LINE	H	HEIGHT	S.D.	SOAP DISPENSER
BLDG	BUILDING	H.B.	HOSE BIBB	SECT	SECTION
BLK(G)	BLOCK(ING)	HC	HANDICAPPED	SF	SQUARE FOOT (FEET)
BLT	BOLT	HGT	HEIGHT	SHT	SHEET
BLW	BELOW	H.M.	HOLLOW METAL	SIM	SIMILAR
BM	BEAM	HORIZ	HORIZONTAL	SND	SANITARY NAPKIN DISPOSER
B.M.	BENCH MARK	H.P.S.	HIGH PRESSURE SODIUM		
BOF	BOTTOM OF FOOTING	HVAC	HEATING/VENTILATING/ AIR CONDITIONING	SNV	SANITARY NAPKIN VENDOR
BOT	BOTTOM				
BRG	BEARING			SOV	SHUT OFF VALVE
BUR	BUILT UP ROOFING	I.D.	INSIDE DIAMETER	SPECS	SPECIFICATIONS
		INCL	INCLUDE(D, ING)	SQ.	SQUARE
CAB	CABINET	INFO	INFORMATION	S.S.	SERVICE SINK
C/C	CENTER TO CENTER	INV. EL.	INVERT ELEVATION	STA	STATION
CF	CUBIC FOOT	INSUL	INSULATION	STD	STANDARD
CFCI	CONTRACTOR FURNISHED/ CONTRACTOR INSTALLED	INT	INTERIOR	STR	STORAGE
		IRRIG	IRRIGATION	STL	STEEL
CFM	CUBIC FEET PER MINUTE			STRUC	STRUCTURAL
CIP	CAST-IN-PLACE	JB	JUNCTION BOX	SURF	SURFACE
CJ	CONTROL JOINT	JCT	JUNCTION	SUSP	SUSPEND(ED)
CL	CENTER LINE	JT	JOINT	SYM	SYMMETRY(ICAL)
CLG	CEILING			SYS	SYSTEM
CLOS	CLOSET	L	LENGTH	SW	SWITCH
CLR	CLEAR(ANCE)	LAM	LAMINATE(D)	T&B	TOP AND BOTTOM
CO	CLEAN OUT	LAV	LAVATORY	TEL	TELEPHONE
COL	COLUMN	LB	POUND	T.O.	TOP OF
CONC	CONCRETE	LH	LEFT HAND	T.O.BM.	TOP OF BEAM
CONF	CONFERENCE	LT(G)	LIGHT(ING)	T.O.FTG	TOP OF FOOTING
CONN	CONNECTION	LT.WT	LIGHT WEIGHT	T.O.M.	TOP OF MASONRY
CONST	CONSTRUCTION	LVR	LOUVER	T.O.P.	TOP OF PARAPET
CONT	CONTINUOUS			T.O.S.	TOP OF STEEL
CONTR	CONTRACT(OR)	M	MOVABLE PARTITION	T.O.W.	TOP OF WALL
COT	CITY OF TUCSON	MACH	MACHINE	TPD	TOILET PAPER DISPENSER
CP	CARPET	MAINT	MAINTENANCE	TS	TUBE STEEL
CR	STAGE CURTAIN	MAS	MASONRY, MASON	TV	TELEVISION
CT	CERAMIC TILE	MATL	MATERIAL(S)	TYP	TYPICAL
CTR	CENTER	MAX	MAXIMUM		
CW	COLD WATER	MB	MACHINE BOLTS		
		MCJ	MASONRY CONTROL JOINT	UBC	UNIFORM BUILDING CODE
d	PENNY (NAIL SIZE)	MEAS	MEASURE	UG	UNDERGROUND
DBL	DOUBLE	MECH	MECHANICAL	UMC	UNIFORM MECHANICAL CODE
DEG	DEGREE	MED	MEDIUM	UNF	UNFINISHED
DEM	DEMOLISH, DEMOLITION	MEMB	MEMBRANE	UNG	UNDERGROUNDED
DESC.	DESCRIPTION	MFD	MANUFACTURED	UNO	UNLESS NOTED OTHERWISE
D.F.	DRINKING FOUNTAIN	MFG	MANUFACTURING	UPC	UNIFORM PLUMBING CODE
DIAG	DIAGONAL	MFR	MANUFACTURER	UR	URINAL
DIA.	DIAMETER	MH	MANHOLE	UTIL	UTILITY(TIES)
DIM	DIMENSION	MIN	MINIMUM, MINUTES		
DISP	DISPENSER	MIR	MIRROR	VAR	VARIES
DL	DEAD LOAD	MISC	MISCELLANEOUS	VGB	VERTICAL GRAB BAR
DN	DOWN	M.O.	MASONRY OPENING	VCR	VIDEO CASSETTE RECORDER
DO	DITTO	MT	MOSAIC TILE	VCT	VINYL COMPOSITION TILE
DR	DOOR	MTL	METAL	VER	VERIFY
D.S.	DOWNSPOUT			VERT	VERTICAL
DTR	DUCT THROUGH ROOF	#	NUMBER	VOL	VOLUME
DTW	DUCT THROUGH WALL	N	NEW	VTR	VENT THROUGH ROOF
DWG(S)	DRAWING(S)	N/A	NOT APPLICABLE		
		NAT	NATURAL	W	WIDTH
E, (E)	EXISTING TO REMAIN	NEC	NATIONAL ELECTRIC CODE	W/	WITH
EA	EACH	NEUT	NEUTRAL	WD	WOOD
ELEV	ELEVATION	NFPA	NATIONAL FIRE PROTECTION ASSOCIATION	WH	WALL HUNG
EIFS	EXTERIOR INSULATION FINISH SYSTEM			W/O	WITHOUT
		N.I.C.	NOT IN CONTRACT	WSCT	WAINSCOT
EOM	EDGE OF MASONRY	NOM	NOMINAL	WS	WAFFLE SLAB
EOS	EDGE OF STEM WALL	NTS	NOT TO SCALE	W/W	WALL TO WALL
EP	EPOXY PAINT			WWF	WELDED WIRE FABRIC
EQ	EQUAL	OA	OVERALL		
EQUIP	EQUIPMENT	O.C.	ON CENTER(S)	YD	YARD
ESMT	EASEMENT	O.D.	OUTSIDE DIAMETER		
EWC	ELECTRIC WATER COOLER	OFCI	OWNER FURNISHED/ CONTRACTOR INSTALLED	Z	GLAZING
EXIST	EXISTING				
EXP	EXPANSION, EXPOSED	OFOI	OWNER FURNISHED/ OWNER INSTALLED		
EXT	EXTERIOR				

SCOPE OF WORK

THE SCOPE OF WORK CONSISTS OF, BUT NOT LIMITED TO, THE CONSTRUCTION OF THE THIRTY METER TELESCOPE FIXED ENCLOSURE AND SUMMIT FACILITY WHICH INCLUDES ALL SITE WORK, ARCHITECTURAL, STRUCTURAL, PLUMBING, MECHANICAL, AND ELECTRICAL SYSTEMS AS NOTED IN THE DRAWINGS AND WRITTEN SPECIFICATIONS.

GENERAL NOTES

ISLAND MAP



DRAWING INDEX

GENERAL
- GI001 COVER SHEET
- GI002 DRAWING INDEX, ABBREVIATIONS, & SYMBOLS
- GI003 3-D MODEL RENDERINGS

ARCHITECTURAL
- AS101 ARCHITECTURAL SITE PLAN
- AR101 OVERALL FLOOR PLAN
- AR102 ENLARGED FLOOR PLAN
- AR103 ENLARGED FLOOR PLAN
- AR201 ELEVATIONS
- AR202 ELEVATIONS
- AR301 SECTIONS

OUTLINE OF WRITTEN SPECIFICATIONS

AIA MASTERSPEC – 16 DIVISION FORMAT

Division 1 – General Requirements
- 01000 – Special Provisions
- 01002 – Fire Plan
- 01010 – Summary of Work
- 01027 – Applications for Payment
- 01035 – Modification Procedures
- 01040 – Coordination
- 01045 – Cutting and Patching
- 01200 – Project Meetings
- 01300 – Submittals
- 01400 – Quality Control
- 01421 – Reference Standards and Definitions
- 01500 – Construction Facilities and Temporary Controls
- 01600 – Materials and Equipment
- 01631 – Substitutions
- 01700 – Contract Closeout
- 01740 – Warranties

Division 2 – Site Construction
- 02080 – Piped Utilities
- 02230 – Site Clearing
- 02300 – Earthwork
- 02361 – Termite Control
- 02510 – Water Distribution

Division 3 – Concrete
- 03300 – Cast-in-Place Concrete

Division 4 – Masonry
- 04200 – Unit Masonry

Division 5 – Metals
- 05120 – Structural Steel
- 05310 – Steel Deck
- 05400 – Cold-Formed Metal Framing
- 05510 – Metals Stairs and Handrails
- 05530 – Gratings
- 05550 – Corrugated Metal Pipe Exhaust Ducts

Division 6 – Woods & Plastics
- 06402 – Interior Architectural Woodwork

Division 7 – Thermal & Moisture Protection
- 07210 – Building Insulation
- 07412 – Manufactured Wall, Roof, and Soffit Systems
- 07620 – Sheet Metal Flashing and Trim
- 07841 – Through Penetration Firestop Systems
- 07920 – Joint Sealants

Division 8 – Doors and Windows
- 08110 – Steel Doors and Frames
- 08163 – Sliding Aluminum – Framed Glass Door
- 08211 – Flush Wood Doors
- 08305 – Access Doors
- 08331 – Overhead Coiling Doors
- 08410 – Aluminum Entrances
- 08420 – Aluminum Windows
- 08711 – Door Hardware
- 08800 – Glazing
- 08920 – Glazed Aluminum Curtain Walls

Division 9 – Finishes
- 09255 – Gypsum Board Assemblies
- 09511 – Acoustical Panel Ceilings
- 09651 – Resilient Tile Flooring
- 09652 – Sheet Vinyl Floor Coverings
- 09653 – Resilient Wall Base and Accessories
- 09680 – Carpet
- 09900 – Painting

Division 10 – Specialties
- 10155 – Toilet Compartments
- 10200 – Louvers and Vents
- 10505 – Metal Lockers
- 10520 – Fire-Protection Specialties
- 10521 – Fire Suppression Systems
- 10523 – Fire Extinguishers
- 10801 – Toilet and Bath Accessories

Division 11 – Equipment
- 11160 – Loading Dock Equipment

Division 12 – Furnishings
- 12500 – Black-Out Shades

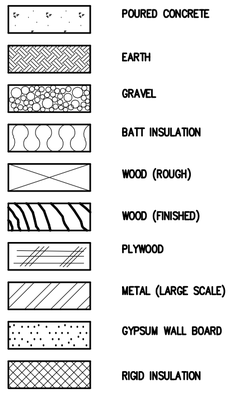
Division 13 – Special Construction
- 13100 – Lightning Protection
- 13852 – Fire Alarm Systems
- 13963 – Gaseous Fire Suppression Systems

Division 14 – Conveying Systems
- 14605 – Crane Rail
- 14620 – Trolley Hoist
- 14630 – Bridge Cranes
- 14650 – Jib Cranes

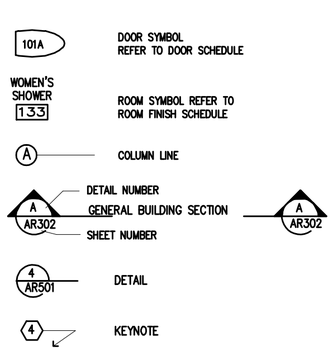
Division 15 – Mechanical
- 15010 – General Provisions
- 15050 – Basic Mechanical Materials and Methods
- 15060 – Hangers and Supports
- 15081 – Duct Insulation
- 15100 – Valves
- 15122 – Meters and Gages
- 15170 – Motors
- 15185 – Hydronic Pumps
- 15241 – Mechanical Vibration Controls and Seismic Restraints
- 15411 – Water Distribution Piping
- 15420 – Drainage and Vent Piping
- 15440 – Plumbing Fixtures
- 15450 – Fire Protection Water Storage Tanks
- 15461 – Electric Water Heaters
- 15465 – Compressed-Air Equipment
- 15545 – Chemical Water Treatment
- 15815 – Metal Ducts
- 15851 – Centrifugal Fans
- 15985 – Sequence of Operations
- 15590 – Testing, Adjusting, and Balancing

Division 16 – Electrical
- 16000 – General Requirements for Electrical Work
- 16100 – Raceways, Boxes, and Cabinets
- 16114 – Cable Trays
- 16124 – Medium Voltage Cable – Single Conductor Cable
- 16140 – Wiring Devices
- 16170 – Motor and Circuit Disconnects
- 16180 – Overcurrent Protective Devices
- 16230 – Generator Assemblies
- 16425 – Distribution Switchboards
- 16450 – Electrical Grounding System
- 16460 – Dry Type Transformers
- 16470 – Panelboards
- 16473 – Transient Voltage Surge Protection
- 16481 – Motor Starters and Control Centers
- 16483 – Adjustable Frequency Motor Controller
- 16500 – Lighting Fixtures
- 16610 – Uninterruptable Power Supply (UPS)
- 16670 – Lighting Protection System
- 16720 – Fire Alarm System
- 16990 – Testing

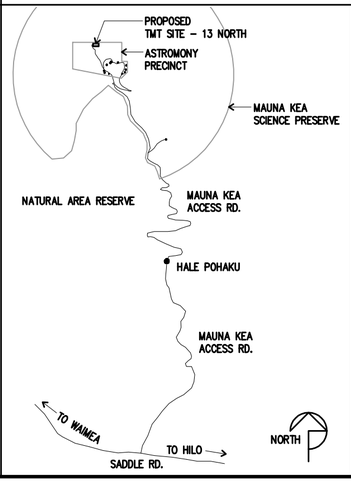
MATERIAL SYMBOLS (NOT ALL SYMBOLS ARE USED IN THIS SET OF DRAWINGS)



KEYING SYMBOLS



LOCATION MAP



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

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MAUNA KEA, HAWAII

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ARCHITECTURE
CONSTRUCTION MANAGEMENT

Revisions

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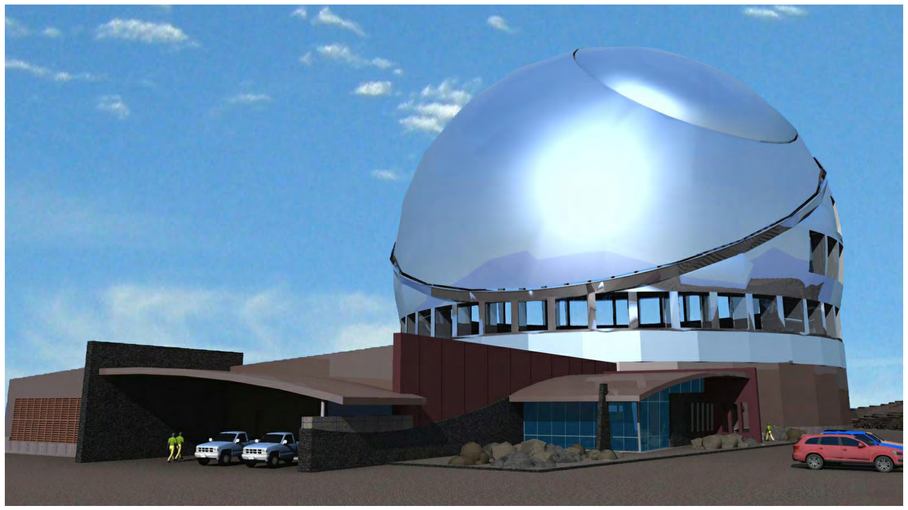
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Issue Date: 4-5-10

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DRAWING INDEX, ABBREVIATIONS, AND SYMBOLS

Sheet Number
GI002

M3PN 07131

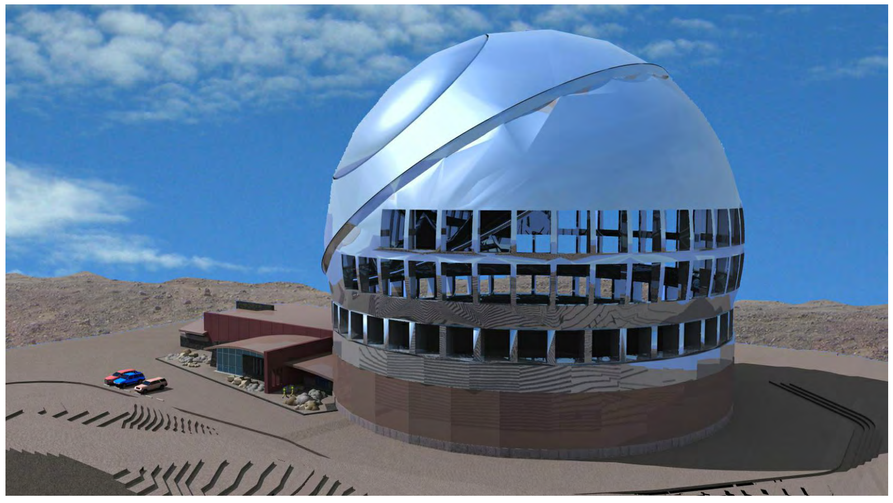
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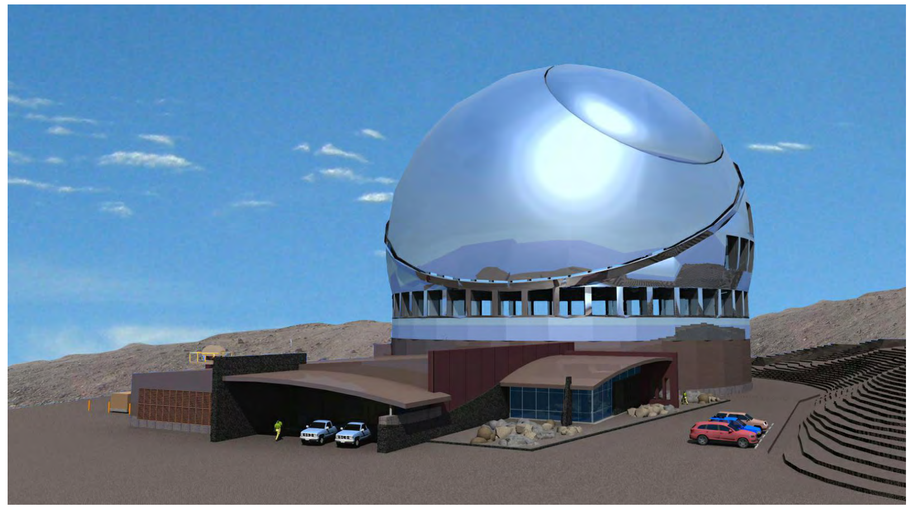
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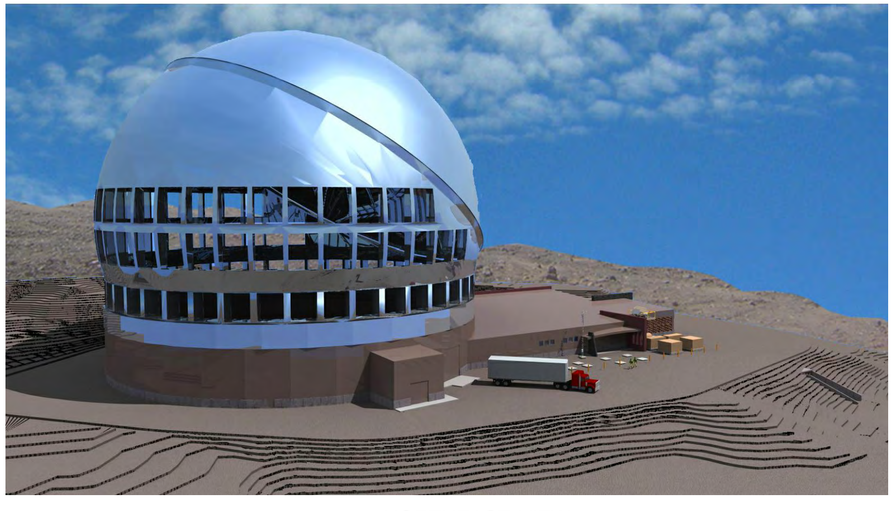
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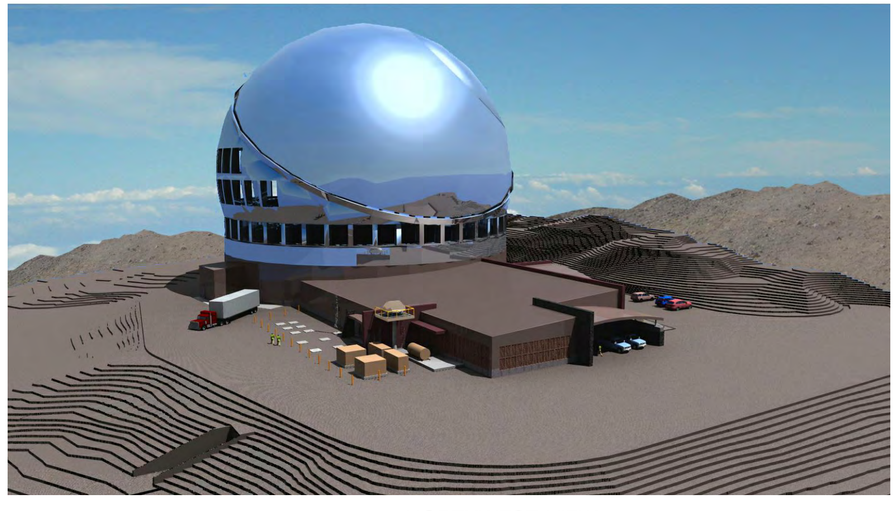
SOUTHEAST VIEW



SOUTHWEST VIEW



NORTHEAST VIEW



NORTHWEST VIEW

PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

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ARCHITECTURE
ENGINEERING
CONSTRUCTION MANAGEMENT

Revisions

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1		
2		
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4		
5		
6		

Drawn: EJC
Checked: –
Issue Date: 4–5–10

Drawing Title

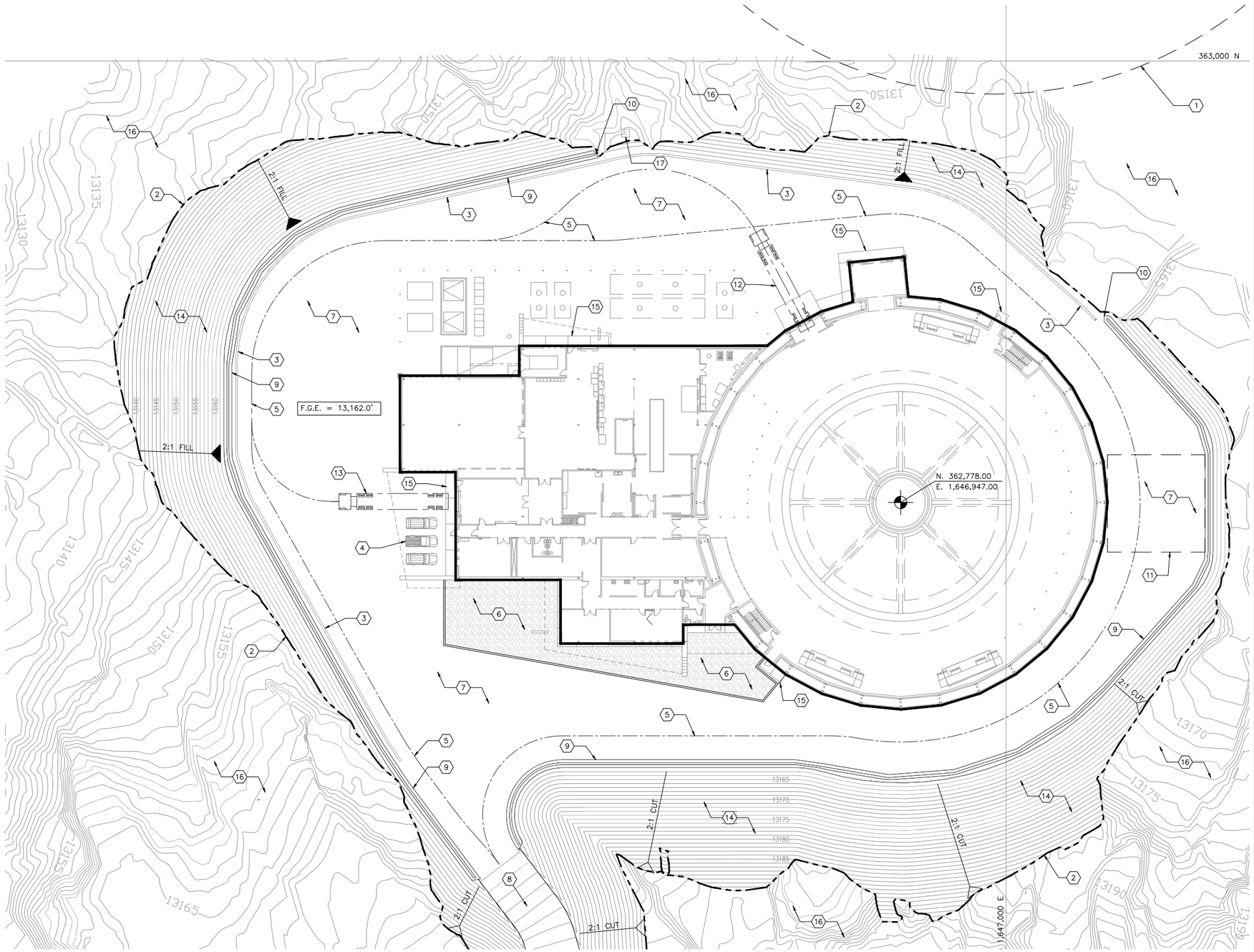
3-D MODEL RENDERINGS

Sheet Number

GI003

M3PN 07131

Last Update: 3.26.2010



ARCHITECTURAL SITE PLAN

20' 10' 0' 20' 40'
1"=20'-0"

NORTH

KEY NOTES

1. 200'-0" ENVIRONMENTAL AREA RADIUS
2. PROPOSED DISTURBED SITE AREA LIMITS
3. VEHICULAR GUARDRAIL
4. TMT STAFF PARKING
5. CIRCULATION PATH (CENTERLINE)
6. NATURAL LANDSCAPING
7. 2" DECOMPOSED GRANITE OR CRUSHED BASALT
8. TMT ACCESS ROAD
9. SITE DRAINAGE SWALE
10. SITE DRAINAGE SWALE OUTLET
11. 49'-0" x 49'-0" DOME CRANE ACCESS
12. TRUCK ACCESS TO FIXED ENCLOSURE & DOME
13. TRUCK ACCESS TO SUMMIT FACILITIES
14. DISTURBED AREA TO BE GRADED SIMILAR TO THE EXISTING SITE CONTOURS TO CREATE A MORE NATURAL SURFACE
15. CONCRETE WALK
16. UNDISTURBED AREA
17. WEATHER STATION TOWER (TMT)

GENERAL INFORMATION

PROPOSED LOCATION:
MAUNA KEA SCIENCE PRESERVE
ASTRONOMY PRECINCT
AREA 'E' – 13 NORTH

PROPOSED SITE ELEVATION
F.G.E. 13,162.0'

PROPOSED DISTURBED SITE AREA
AREA: APPROX. 4.5 ACRES
(3.9 ACRES BEFORE 'RE-CONTOURING')

PROPOSED SITE GRADING
CUT: 36,881 CUBIC YARDS
FILL: 22,356 CUBIC YARDS

PROPOSED BUILDING SIZE:
52,679 GROSS SQUARE FEET
SINGLE LEVEL FACILITY
(OVERALL FOOTPRINT OF THE FIXED ENCLOSURE AND SUMMIT FACILITY)

PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE
SCHEMATIC DESIGN PACKAGE
MAUNA KEA, HAWAII

TMT

2901 W. SUNSET ROAD
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TUCSON, ARIZONA 85742
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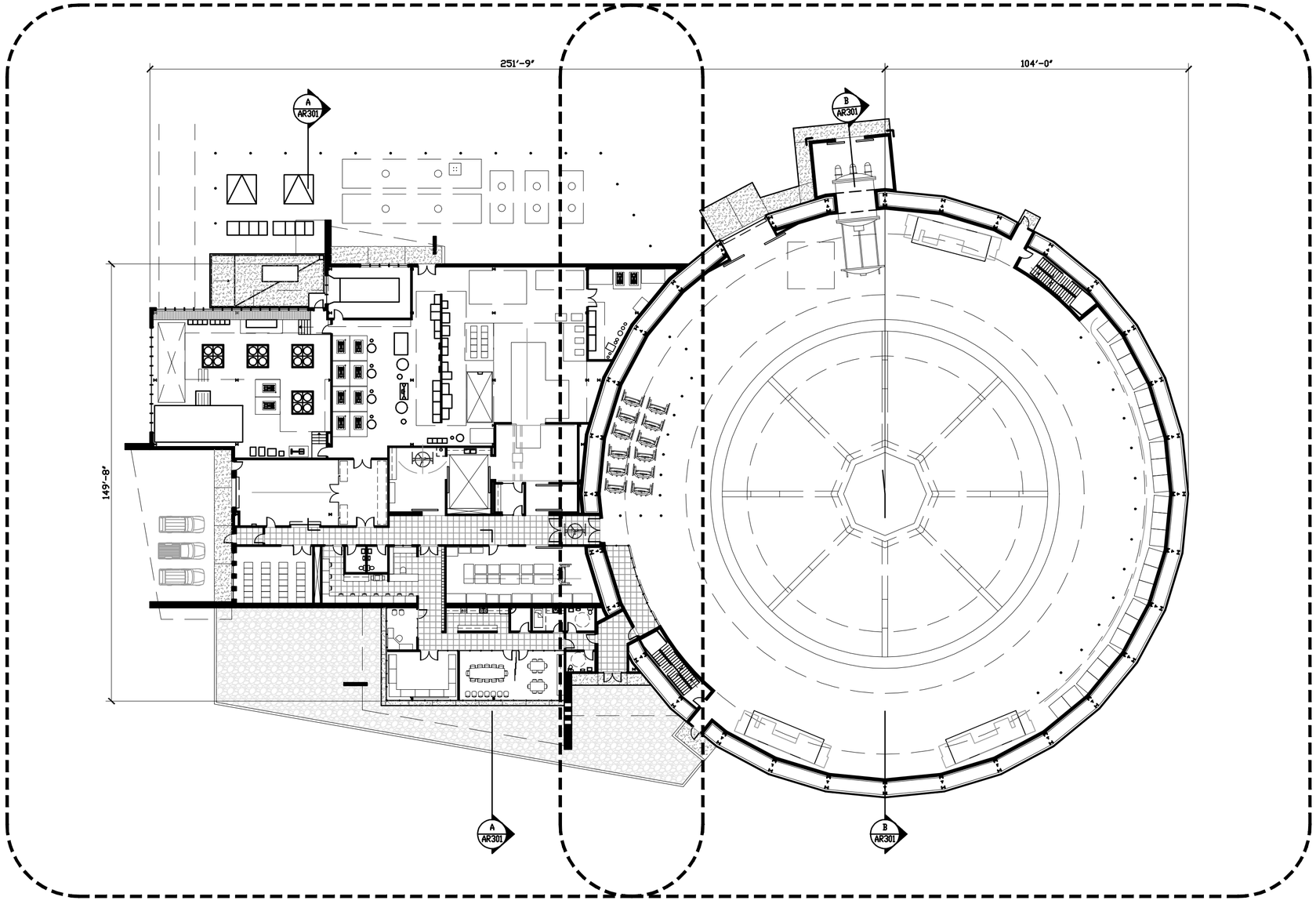
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Issue Date: 9-1-10

Drawing Title
ARCHITECTURAL SITE PLAN

Sheet Number
AS101

M3PN 07131

Last Update: 8.19.2010



SEE SHEET AR103 FOR
FLOOR PLAN OF THIS AREA

SEE SHEET AR102 FOR
FLOOR PLAN OF THIS AREA

OVERALL FLOOR PLAN

16' 8' 0' 16' 32'

1/16"=1'-0"

NORTH

KEY NOTES

PRELIMINARY
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THIRTY METER TELESCOPE

DESIGN DEVELOPMENT SUBMITTAL
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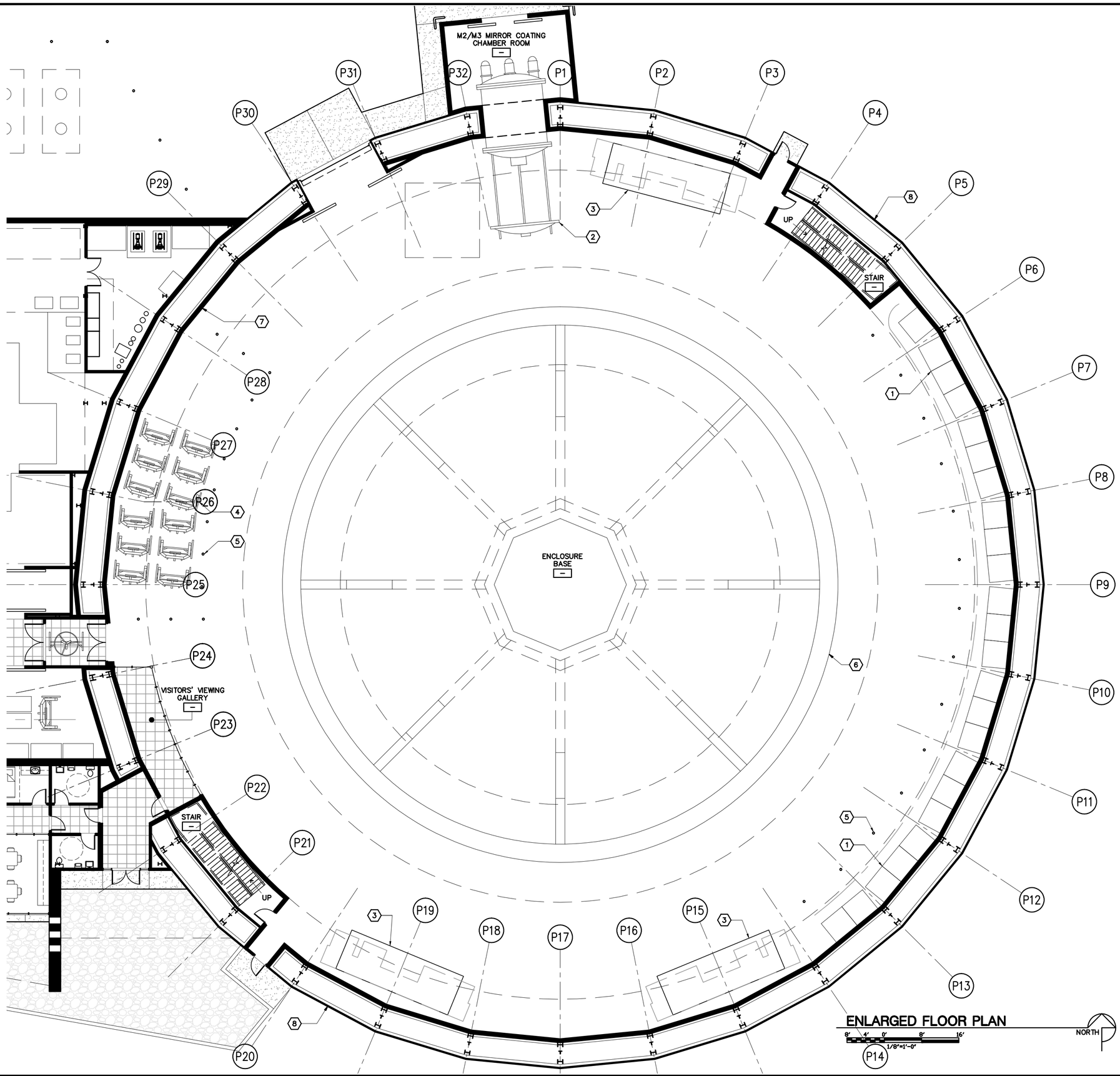
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Issue Date: 4-5-10

Drawing Title
OVERALL
FLOOR PLAN

Sheet Number
AR101

M3PN 07131

Last Update: 3.26.2010



ENLARGED FLOOR PLAN

8' 4' 0' 8' 16'

1/8"=1'-0"

NORTH

KEY NOTES

1. M1 MIRROR STORAGE CABINETS
2. M2/M3 COATING CHAMBER
3. DOME COOLING AIR HANDLER UNITS (TYPICAL OF 3)
4. M1 SEGMENT STAGING AREA
5. BOLLARD, TYP.
6. CONCRETE PIER
7. 10" INSULATED METAL WALL PANEL
8. EXTERIOR METAL PANEL

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THIRTY METER TELESCOPE

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Issue Date: 4–5–10

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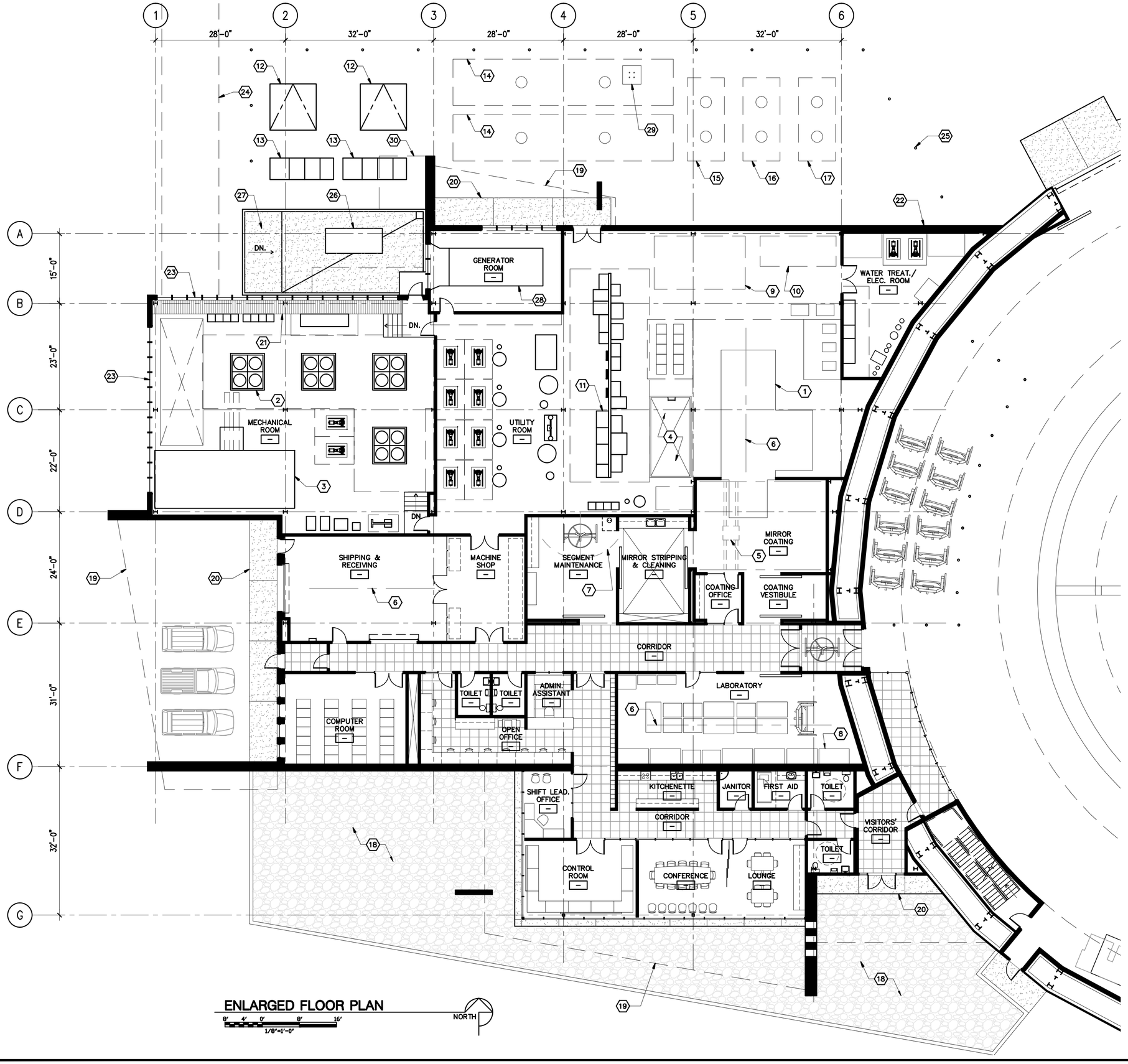
ENLARGED FLOOR PLAN

Sheet Number

AR102

M3PN 07131

Last Update: 3.24.2010



ENLARGED FLOOR PLAN

8' 4' 0' 8' 16'

1/8"=1'-0"

NORTH

KEY NOTES

1. M1 COATING CHAMBER
2. MECHANICAL CHILLERS (TYPICAL OF 4)
3. AIR ECONOMIZER
4. UTILITY CHASE
5. BRIDGE CRANE ABOVE
6. MONORAIL CRANE ABOVE
7. JIB CRANE
8. LABORATORY EQUIPMENT
9. HYDROSTATIC OIL EQUIPMENT
10. HYDROSTATIC OIL TANK
11. ELECTRICAL EQUIPMENT
12. HELCO SERVICE TRANSFORMER
13. ELECTRICAL SERVICE ENTRANCE SWITCHBOARD
14. UNDERGROUND FIRE WATER STORAGE TANK
15. UNDERGROUND 5,000 GALLON WATER STORAGE TANK
16. UNDERGROUND 5,000 GALLON WASTE STORAGE TANK
17. UNDERGROUND 5,000 GALLON DOUBLE CONTAINED CHEMICAL WASTE STORAGE TANK
18. NATIVE LANDSCAPING
19. ROOF ABOVE
20. CONCRETE WALK
21. DUCT SILENCER
22. EXTERIOR METAL PANEL
23. ACOUSTICAL LOUVER
24. UNDERGROUND EXHAUST TUNNEL
25. BOLLARD, TYP.
26. 2,000 GALLON ABOVE-GROUND DIESEL FUEL TANK
27. CONCRETE CONTAINMENT PAD AND FILL STATION
28. EMERGENCY GENERATOR
29. WEATHER STATION TOWER
30. ATMOSPHERIC TURBULENCE MONITOR ABOVE

PRELIMINARY
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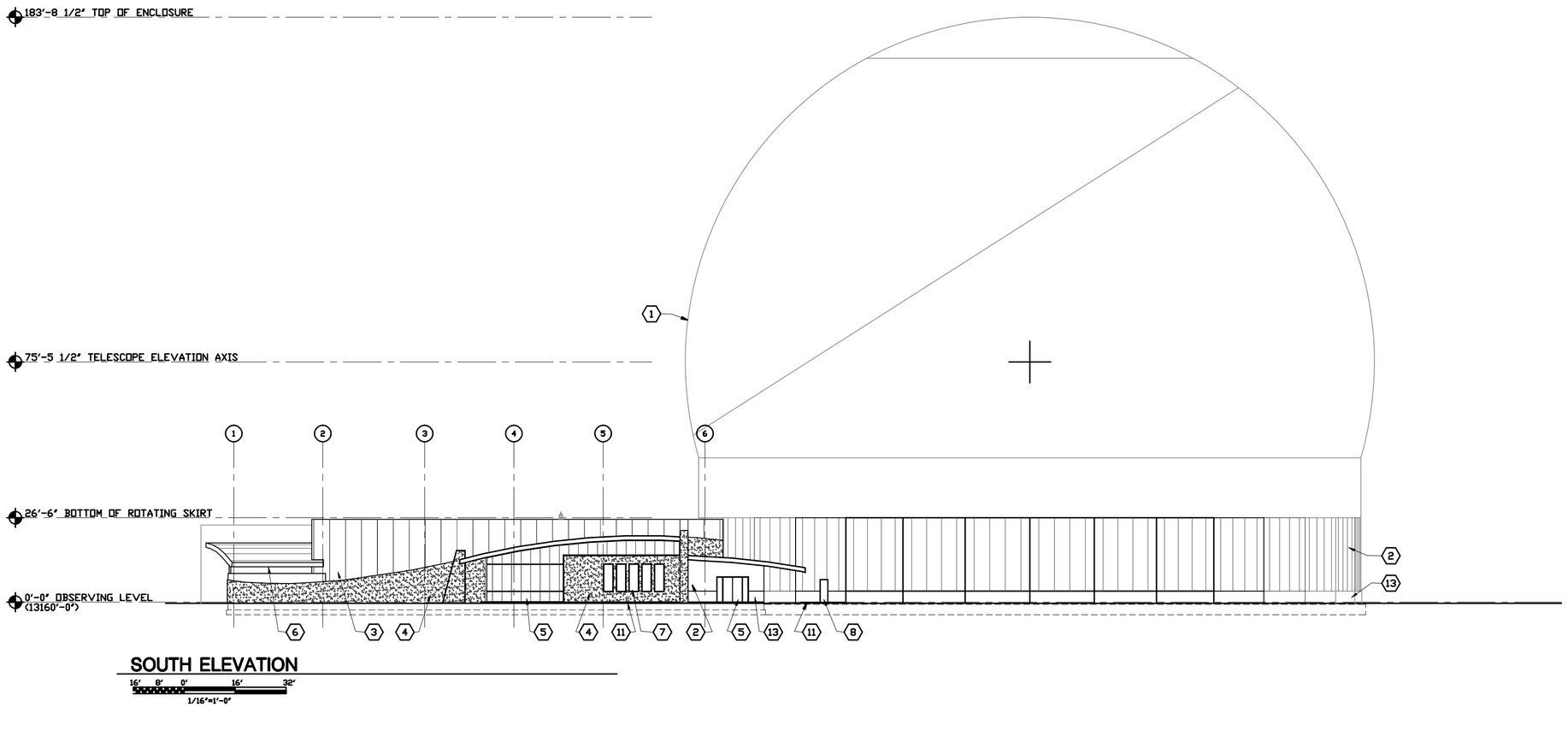
ENLARGED FLOOR PLAN

Sheet Number

AR103

M3PN 07131

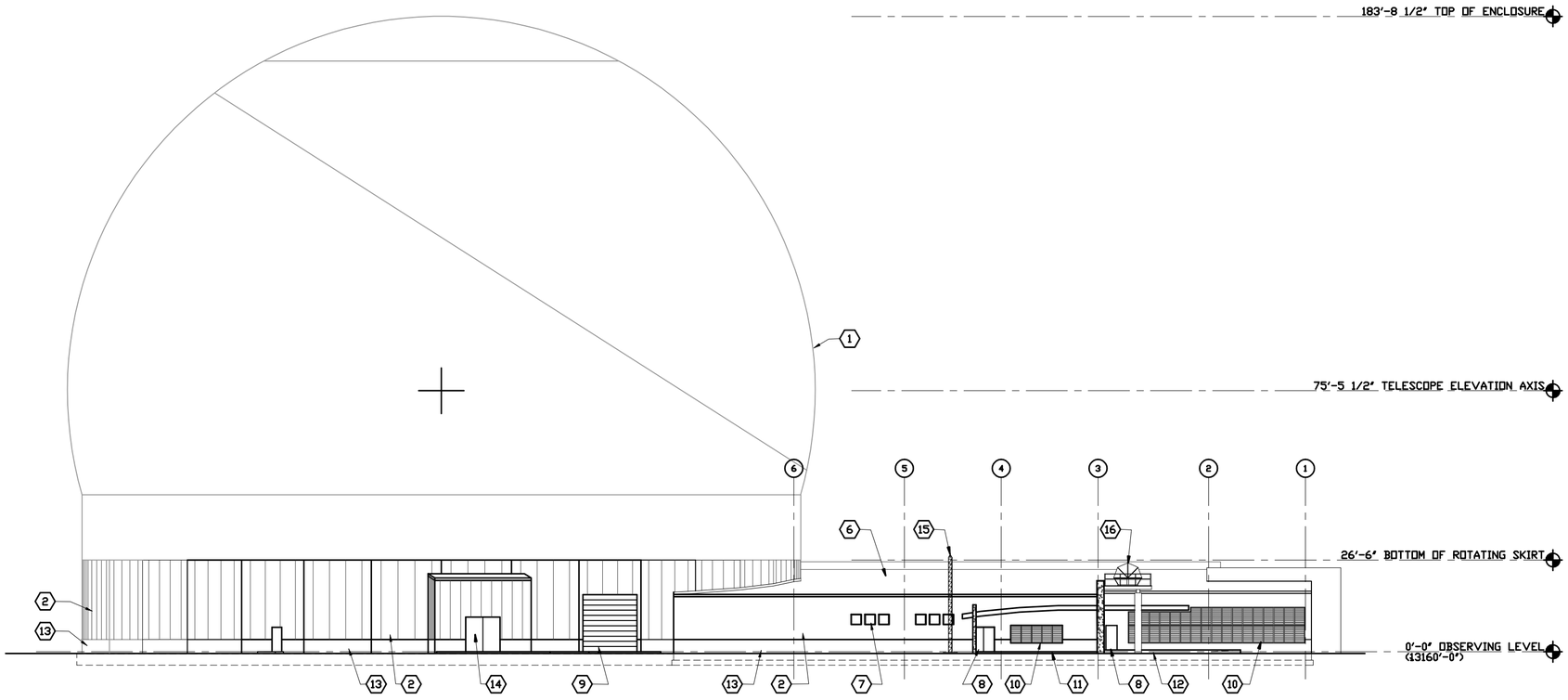
Last Update: 3.26.2010



SOUTH ELEVATION

16' 8' 0' 16' 32'

1/16"=1'-0"



NORTH ELEVATION

16' 8' 0' 16' 32'

1/16"=1'-0"

KEY NOTES

1. DOME STRUCTURE N.I.C.
2. METAL SIDING
3. SMOOTH METAL SIDING
4. LAVA ROCK VENEER
5. ALUMINUM STOREFRONT WITH INSULATED GLAZING
6. METAL ROOF
7. ALUMINUM WINDOWS WITH INSULATED GLAZING
8. HOLLOW METAL DOORS AND FRAME (PAINT)
9. INSULATED COILING ROLL UP DOOR
10. ACOUSTICAL LOUVER
11. CONCRETE WALK OR STOOP
12. CONCRETE UTILITY PAD
13. CONCRETE WAINSCOT
14. INSULATED SLIDING DOOR
15. WEATHER STATION TOWER
16. ATMOSPHERIC TURBULENCE MONITOR

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THIRTY METER TELESCOPE

DESIGN DEVELOPMENT SUBMITTAL
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Issue Date: 4-5-10

Drawing Title

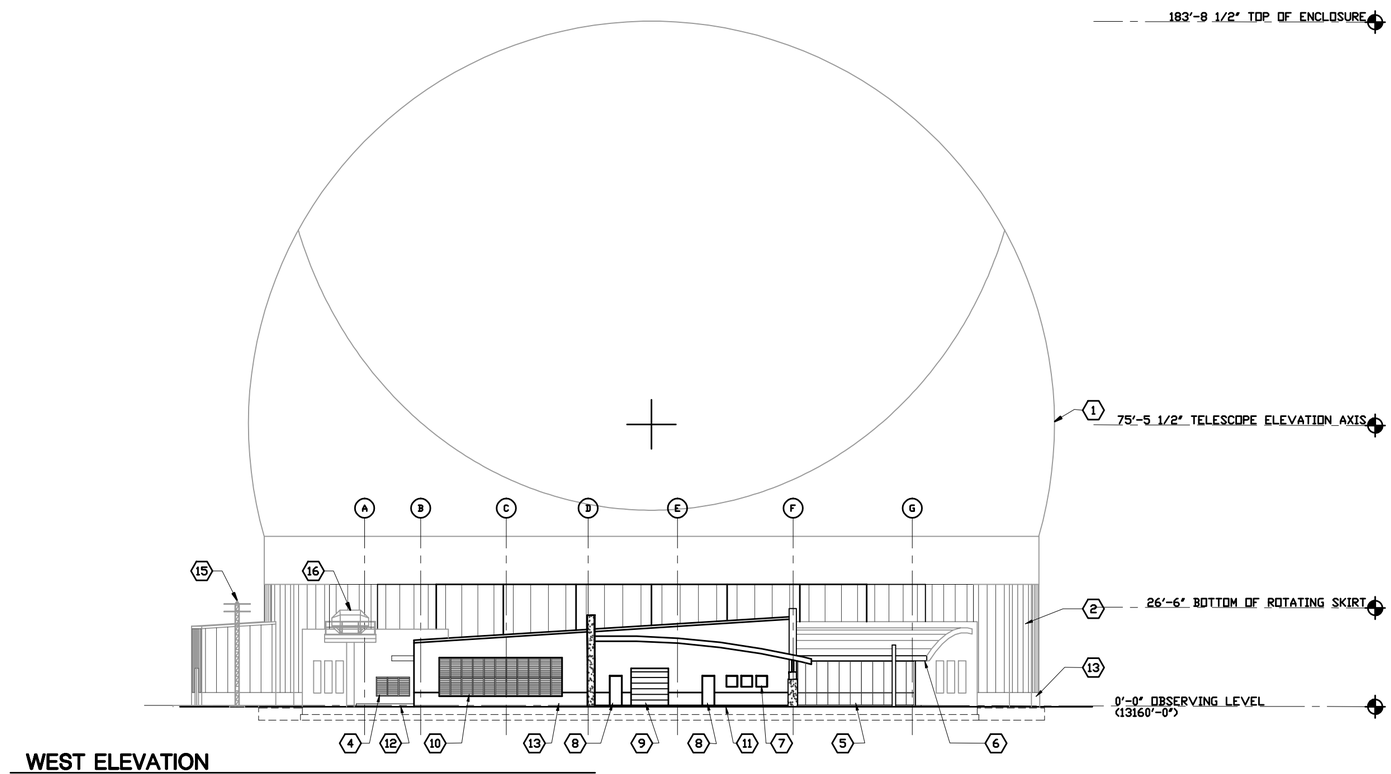
BUILDING ELEVATIONS

Sheet Number

AR201

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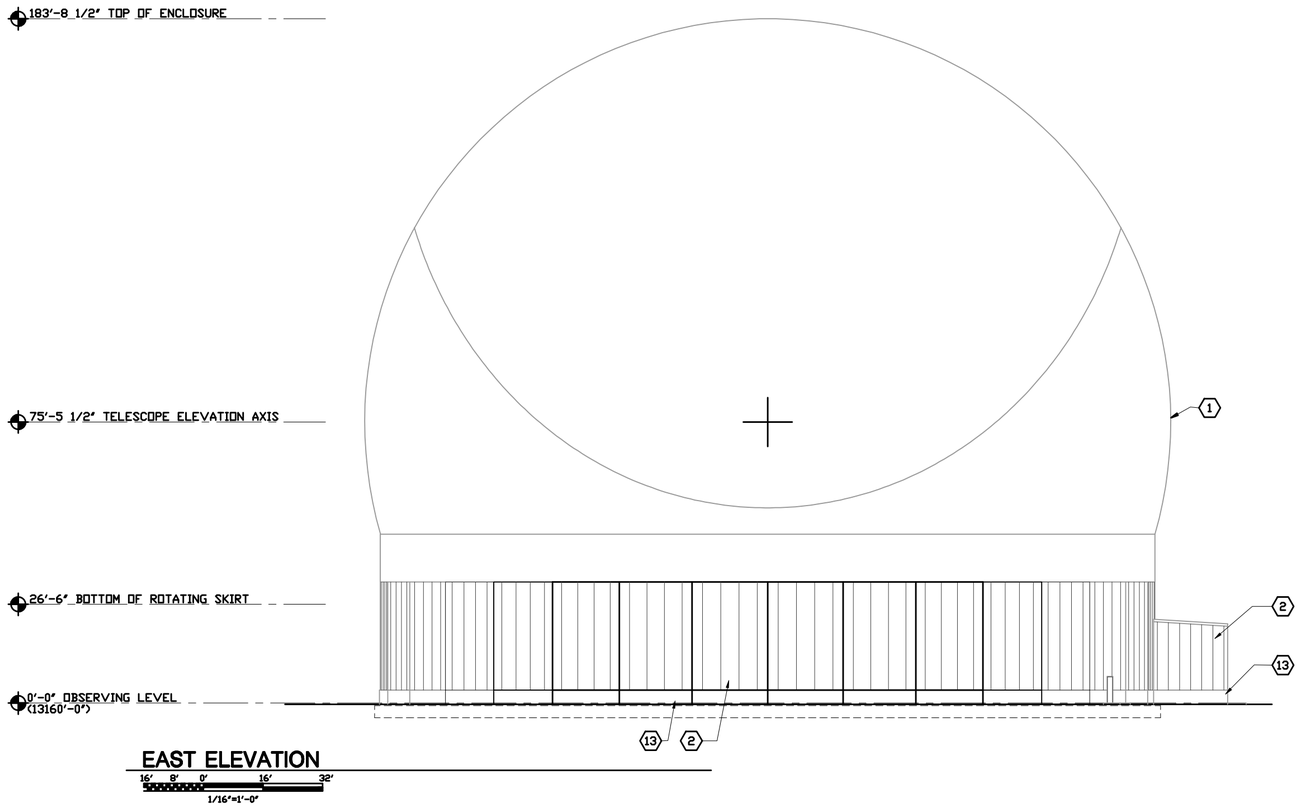
Last Update: 3.26.2010



WEST ELEVATION

16' 8' 0' 16' 32'

1/16"=1'-0"



EAST ELEVATION

16' 8' 0' 16' 32'

1/16"=1'-0"

KEY NOTES

1. DOME STRUCTURE N.I.C.
2. METAL SIDING
3. SMOOTH METAL SIDING
4. LAVA ROCK VENEER
5. ALUMINUM STOREFRONT WITH INSULATED GLAZING
6. METAL ROOF
7. ALUMINUM WINDOWS WITH INSULATED GLAZING
8. HOLLOW METAL DOORS AND FRAME (PAINT)
9. INSULATED COILING ROLL UP DOOR
10. ACOUSTICAL LOUVER
11. CONCRETE WALK OR STOOP
12. CONCRETE UTILITY PAD
13. CONCRETE WAINSCOT
14. INSULATED SLIDING DOOR
15. WEATHER STATION TOWER
16. ATMOSPHERIC TURBULENCE MONITOR

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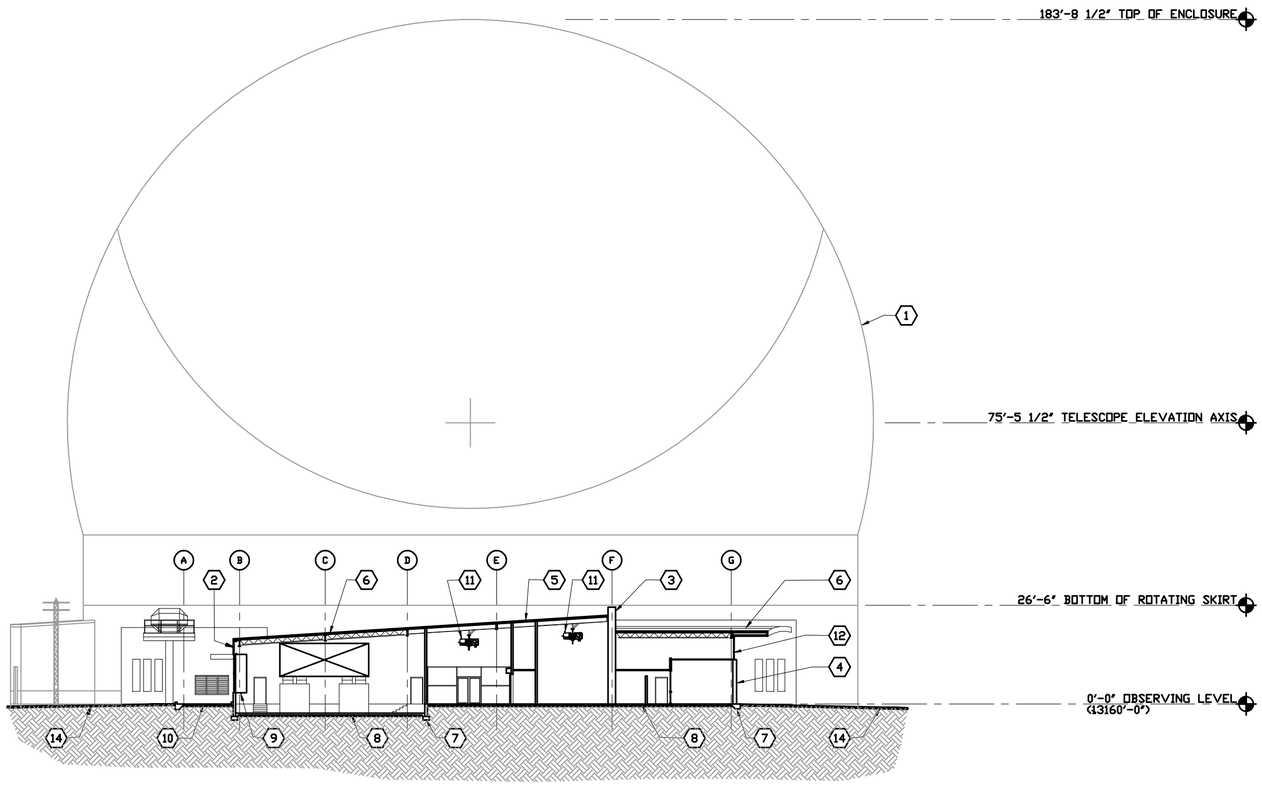
BUILDING ELEVATIONS

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AR202

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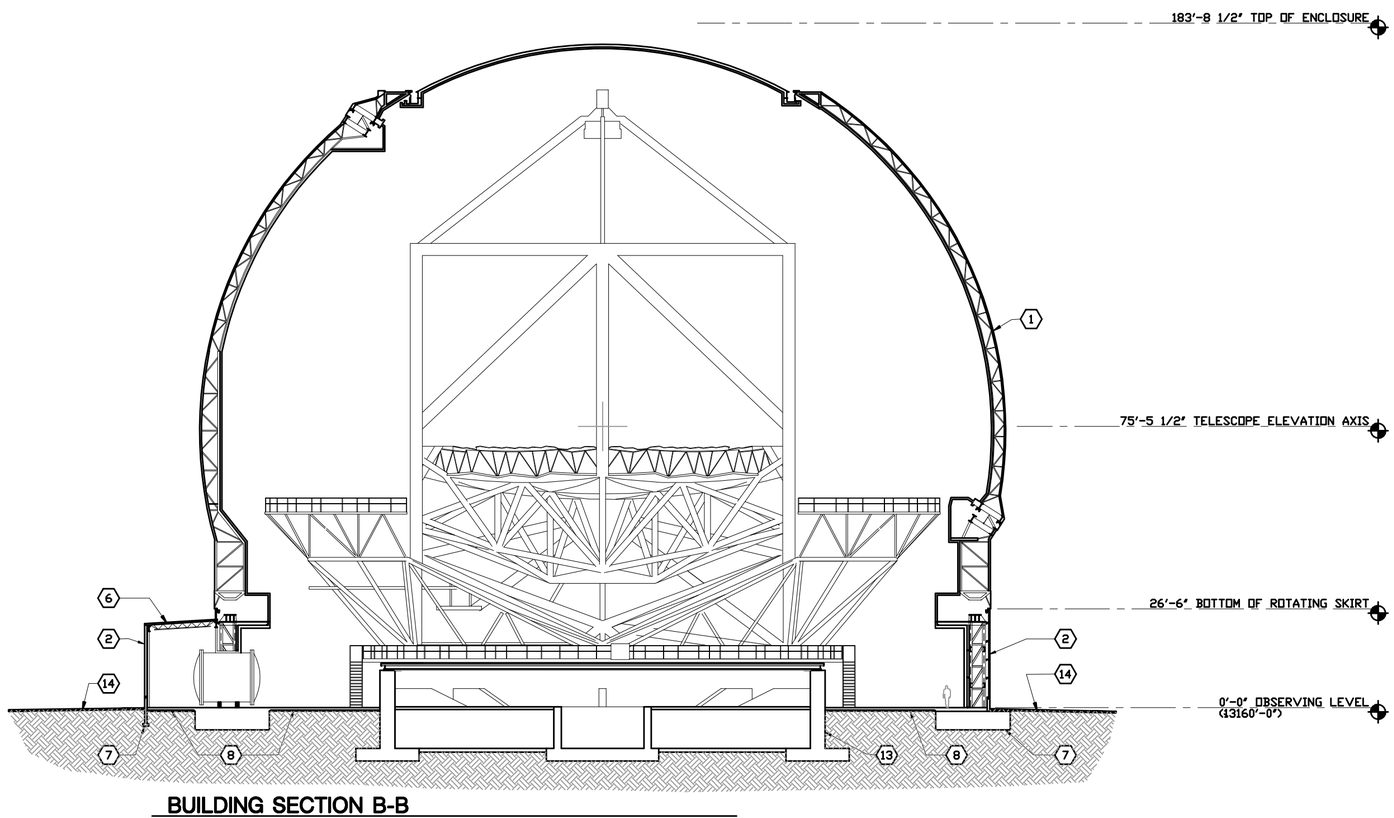
Last Update: 3.26.2010



BUILDING SECTION A-A

16' 8' 0' 16' 32'

1/16"=1'-0"



BUILDING SECTION B-B

16' 8' 0' 16' 32'

1/16"=1'-0"

KEY NOTES

1. DOME STRUCTURE N.I.C.
2. METAL SIDING ON GIRTS
3. SMOOTH METAL SIDING ON GIRTS
4. LAVA ROCK VENEER ON STRUCTURAL STEEL STUDS
5. METAL ROOF ON METAL DECK OVER STEEL BEAMS
6. METAL ROOF ON METAL DECK OVER METAL JOISTS
7. CONCRETE FOOTING – SEE STRUCTURAL DRAWINGS
8. CONCRETE FLOOR – SEE STRUCTURAL DRAWINGS
9. ACOUSTICAL LOUVER AND DUCT SILENCER
10. CONCRETE UTILITY PAD
11. MONORAIL HOIST
12. ALUMINUM STOREFRONT WITH INSULATED GLAZING
13. CONCRETE PIER – SEE STRUCTURAL DRAWINGS
14. FINISH GRADE

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THIRTY METER TELESCOPE

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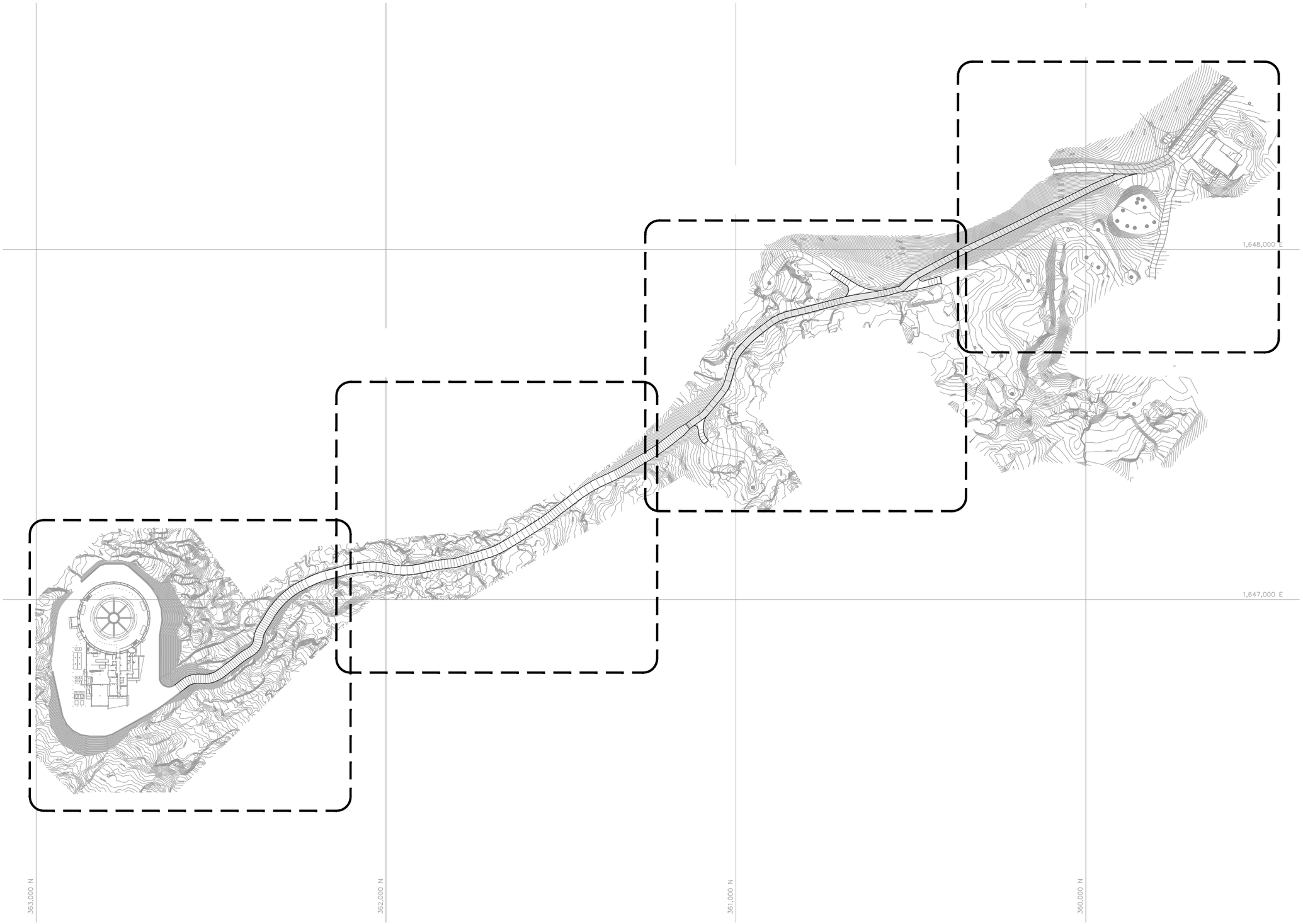
BUILDING SECTIONS

Sheet Number

AR301

M3PN 07131

Last Update: 3.26.2010



CIVIL OVERALL SITE PLAN

100' 50' 0' 100' 200'

1" = 100'

NORTH

PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE SCHEMATIC DESIGN PACKAGE

MAUNA KEA, HAWAII

TMT

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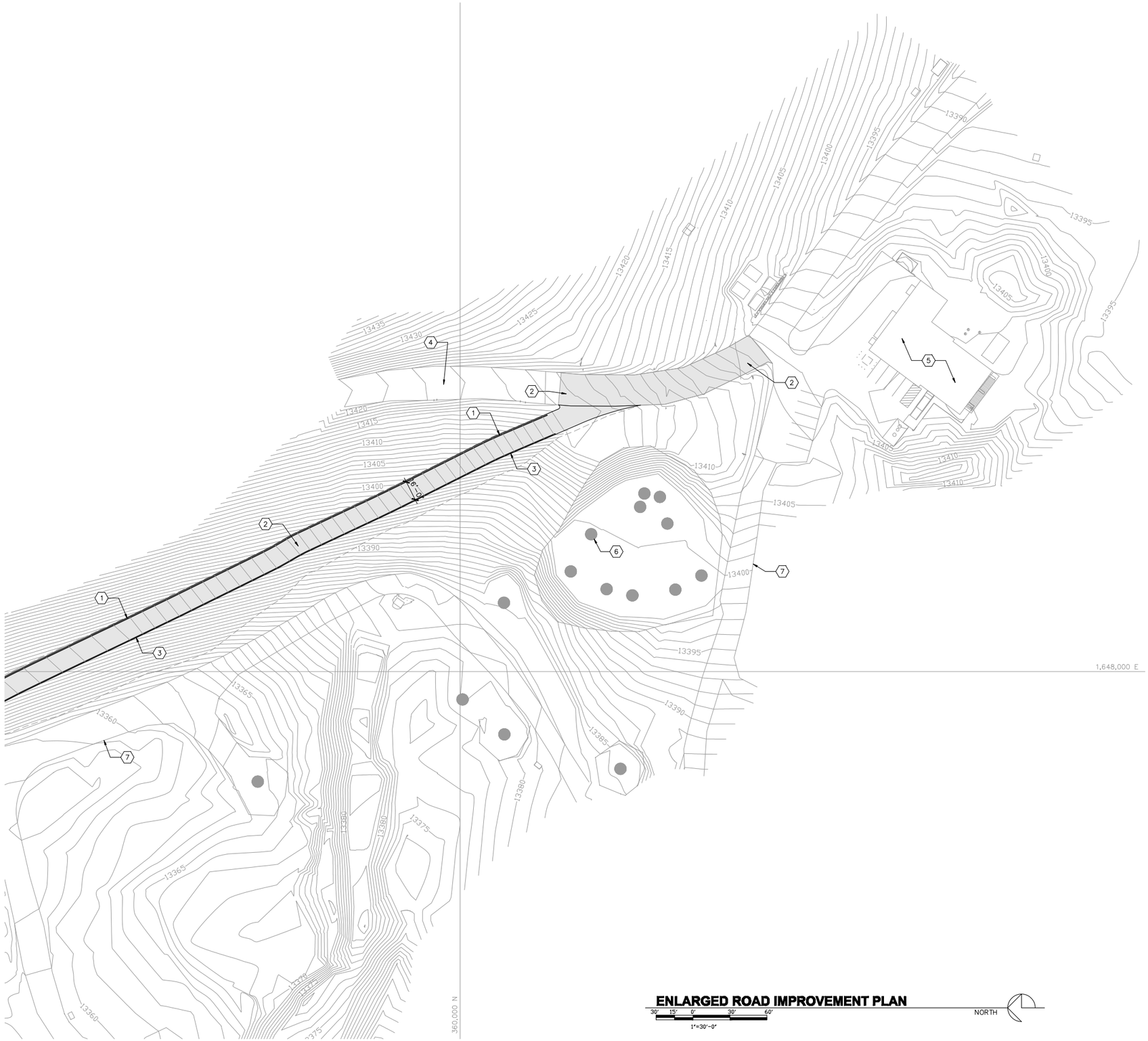
CIVIL OVERALL SITE PLAN

Sheet Number

CS101

M3PN 07131

Last Update: 8.30.2010



KEY NOTES

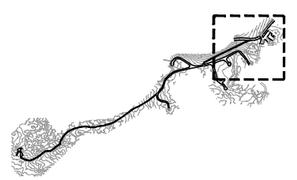
1. 6" VERTICAL CONCRETE CURB
2. 3" ASPHALT OVER 4" ABC
3. VEHICULAR GUARDRAIL
4. EXISTING MAUNA KEA LOOP ROAD (DIRT)
5. SMA ARRAY FACILITY
6. SMA CONCRETE ANTENNA PAD, TYP.
7. EXISTING SMA ACCESS ROAD (DIRT)

ENLARGED ROAD IMPROVEMENT PLAN

30' 15' 0' 30' 60'
1"=30'-0"

NORTH

KEY PLAN



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE
SCHEMATIC DESIGN PACKAGE
MAUNA KEA, HAWAII

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Drawing Title
ENLARGED ROAD IMPROVEMENT PLAN

Sheet Number
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M3PN 07131

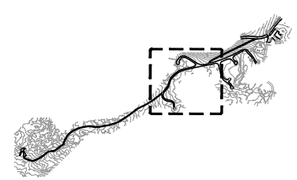
Last Update: 8.30.2010



KEY NOTES

1. 6" VERTICAL CONCRETE CURB
2. 3" ASPHALT OVER 4" ABC
3. VEHICULAR GUARDRAIL
4. EDGE OF ASPHALT
5. TMT ACCESS ROAD – DIRT
6. –

KEY PLAN



PRELIMINARY
NOT FOR CONSTRUCTION

ENLARGED IMPROVEMENT PLAN

30' 15' 0' 30' 60'
1"=30'-0"

NORTH

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE
SCHEMATIC DESIGN PACKAGE
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Drawing Title
ENLARGED IMPROVEMENT PLAN

Sheet Number
CI402

M3PN 07131

Last Update: 8.17.2010



ENLARGED IMPROVEMENT PLAN

30' 15' 0' 30' 60'

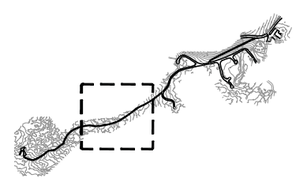
1"=30'-0"

NORTH

KEY NOTES

1. TMT ACCESS ROAD – DIRT
2. –

KEY PLAN



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE

SCHEMATIC DESIGN PACKAGE

MAUNA KEA, HAWAII

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Drawing Title

ENLARGED IMPROVEMENT PLAN

Sheet Number

CI403

M3PN 07131

Last Update: 8.17.2010



ENLARGED IMPROVEMENT PLAN

30' 15' 0' 30' 60'

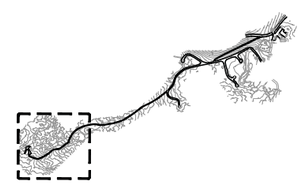
1"=30'-0"

NORTH

KEY NOTES

1. VEHICULAR GUARDRAIL
2. SITE DRAINAGE SWALE
3. 2" DECOMPOSED GRANITE
4. –
5. –
6. –

KEY PLAN



PRELIMINARY
NOT FOR CONSTRUCTION

THIRTY METER TELESCOPE

CIVIL, SUMMIT FACILITIES, AND FIXED ENCLOSURE

SCHEMATIC DESIGN PACKAGE

MAUNA KEA, HAWAII

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Issue Date: 9-1-10

Drawing Title

ENLARGED IMPROVEMENT PLAN

Sheet Number

CI404

M3PN 07131

Last Update: 8.17.2010

Appendix C. Historical & Archaeological Site Plan

This appendix summarizes information concerning archaeological sites and historic properties within the Mauna Kea Science Reserve (MKSR). The information presented here was reported by McCoy and Nees (2010)[22] as part of an Archaeological Inventory Survey of the MKSR conducted on behalf of the University of Hawai‘i between 2005 and 2009.

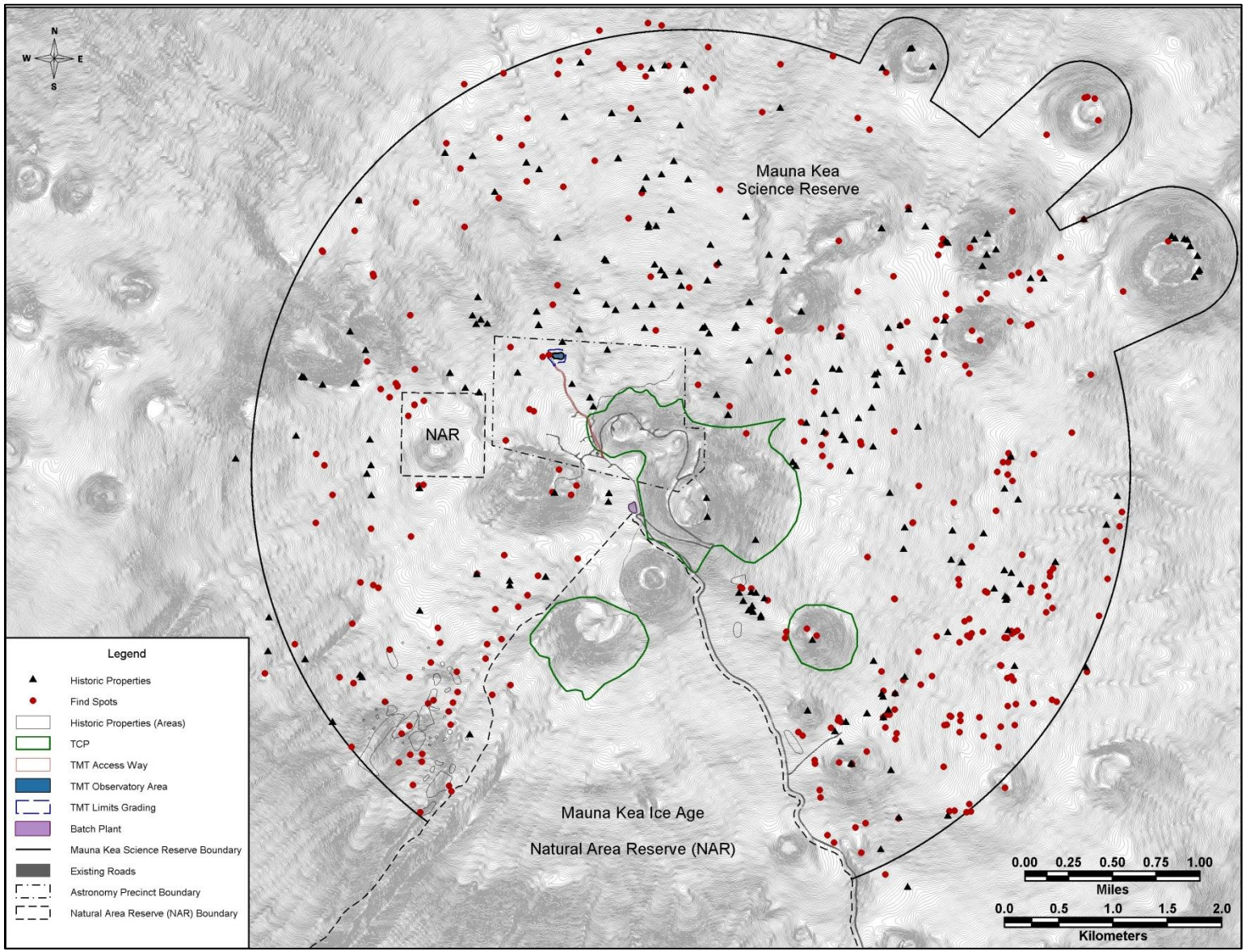
The inventory survey recorded a total of 263 sites. This number includes 95 previously identified sites and 168 new sites. Figure C.1 shows the general distribution of historic properties. Table C.1 summarizes the number and variety of historic property types found in the MKSR. The historic properties include two previously identified traditional cultural properties, and 261 examples of what are commonly called archaeological sites. Shrines are the most common functional site type. The next most common category are sites located in the Mauna Kea Adze Quarry Complex which consists of: (1) the quarry proper, which is defined as the source areas of tool-quality basalt, and (2) diverse activity remains located outside of the quarry proper as just defined, but which are directly linked to the quarry because of the presence of adze manufacturing by-products (e.g., cores, flakes), hammerstones and unfinished adzes in various stages of completion. Approximately 11 percent of the sites (29) were classified as burials or possible burials. Two possible burial sites have associated lithic scatters comprised of adze manufacturing by-products that suggest the possibility of adze maker interments. They are included in the list of sites that make up the Mauna Kea Adze Quarry Complex. The remainder of the historic property inventory is represented by small numbers of diverse site types.

Table C-1: Historic Property Types in the Mauna Kea Science Reserve

Functional Site Type	Number	Percent Total (%)
Traditional Cultural Properties	2	0.76
Shrines	141	53.61
Mauna Kea Adze Quarry Complex Sites	67	25.47
Burials and Possible Burials	29	11.03
Stone Markers/Memorials	15	5.70
Temporary Shelters	3	1.14
Historic Campsites	2	0.76
Historic Transportation Route	1	0.38
Unknown Function	3	1.14
TOTAL	263	99.99

[22] McCoy, Patrick, Nees, Richard, Final Report, Archaeological Inventory Survey of the Mauna Kea Science Reserve, August 2010.

Figure C-1: Historic Properties and Find Spots within the Mauna Kea Science Reserve



Source: McCoy& Nees (2010)

Traditional Cultural Properties

In 1999, SHPD identified three areas on Mauna Kea as traditional cultural properties (TCPs). Two of the three, Kūkahauʻula and Puʻu Līlīnoe are located in the Science Reserve, the third, Puʻu Waiau, is located in the Natural Area Reserve (NAR). The boundaries of the three TCPs on Mauna Kea were drawn based on geological boundaries of the cinder cones and, in the case of the summit, a series of overlapping, contiguous cinder cones which include Puʻu Wēkiu, Puʻu Kea, Puʻu Hauʻoki and at least one other unnamed cone. In the case of Kūkahauʻula, the boundaries are also based in part on the near total absence of archaeological sites on the summit. The summit thus stands out from the rest of the cultural landscape which is dotted with shrines and other cultural remains.

Shrines and Possible Shrines

Shrines are by far the most common site type in the UH Management Areas. A total of 141, or 54 percent, of the 263 historic properties are shrines that, based on present evidence, are non-occupational religious structures unrelated to the adze quarry. This number includes possible shrines, where some doubt exists about the presence of uprights because none were found in a standing position. It is possible that the construction of some shrines was never completed or the uprights were removed at a later date.

The quintessential characteristic of all of the sites on Mauna Kea that have been interpreted as shrines is the presence of one or more upright stones that the Hawaiians called ʻ*eho* or *pohaku* ʻ*eho*, which translates as "god-stone". The conventional view of these and other kinds of Polynesian "god-stones" is that they were "places for the gods to inhabit," or "abodes of the gods," as opposed to icons or actual representations of the gods.

Mauna Kea Adze Quarry Complex

The Mauna Kea Adze Quarry Complex consists of two physically discrete but functionally interrelated parts: (1) the quarry proper, which is defined as the source areas of tool-quality basalt, and (2) diverse activity remains located outside of the quarry proper. Sites located outside of the quarry proper include isolated adze manufacturing by-products (e.g., cores, flakes), hammerstones and unfinished adzes in various stages of completion found by themselves and also found with shrines and possible burials. One of the most important sites is a ritual complex that consists of multiple shrines, enclosures and a lithic scatter.

Burials and Possible Burials

The survey identified 29 sites with a total of 48 features in the MKSR that have been interpreted as burials or possible burials. Of the 48 features, five are confirmed burials and 43 are possible burials. For the sites classified as possible burials there are compelling reasons, such as the topographic location and morphological characteristics of the structures, to believe that these sites are indeed burials, but because human remains were not seen at the time they were recorded they are classified as possible burials.

Stone Markers/Memorials

One of the more ambiguous classes of sites are piles or stacks of rocks believed to be markers of some kind or memorials to a person or event. In all but a couple of cases the actual function is unclear. There are 15 sites that may have been survey markers, piles of stones left by unknown visitors as memorials of their visit to the top of a cinder cone or way-markers along an unmarked trail.

Temporary Shelters

The evidence for "habitation" in the most general sense of the word in the MKSR is sparse. Crude stone walls were found at various localities in the MKSR, usually in association with other features, such as lithic scatters. Three sites consist of walls without associated artifacts. Two to a maximum of four walls were found at three sites. Some are linear, while others are roughly C-shape in plan-view. A walled overhang shelter was found directly below a ridge-top shrine at one site. All of these remains are interpreted as temporary shelters based on their morphology and environmental setting.

With the possible exception of one walled rockshelter, there is no evidence that any of the shelters were occupied overnight. At least there is no evidence of a fire pit, although the evidence could be buried beneath the surface. With the possible exception of the walled overhang shelter there is no means of dating any of these sites, which are probably either late prehistoric or historic in age.

Historic Camp Sites

One and possibly two of the camps occupied by the United States Geological Survey (USGS) survey team in 1925 were found on the northern and northeastern slope of the mountain near Puʻu Māhoe and Puʻu Mākanaka.

Historic Transportation Routes

The survey identified direct evidence of the Umi Koa Trail in close proximity to the route shown on the USGS Mauna Kea Quadrangle maps. How long the trail was used to transport visitors from the Hāmākua coast is unknown.

Unknown Function

There are three sites with a total six features whose function could not be determined. A large number of these features are stone mounds and rock piles, which is one of the most common formal feature types found in the project area.

Other Cultural Resources

Cultural resources in the MKSR include a large number of remains that at present cannot be classified as historic properties or sites, as normally defined in State and Federal laws, but which nevertheless need to be considered in developing appropriate management strategies. These sites, referred to as "find spots," are cultural resources that are either obviously modern features (e.g.,

camp sites with tin cans, pieces of glass and other modern material culture items), or features that cannot be classified with any level of confidence as historic sites because of their uncertain age and function (e.g., a pile of stones on a boulder). A total of 339 find spots were found in the 2005-2009 survey. Figure H.1 includes the location of find spots within the Science Reserve.

Mauna Kea Summit Region Historic District

The Science Reserve is situated 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 the site types described above. All of these types of historic sites are contributing properties to the Historic District (McCoy & Nees 2010). 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 Hawaii Administrative Rules §13-275 -6. The exact boundaries of the Historic District have not been formally established.

Appendix D. Maintenance Plan

Power Transmission

The proposed project and use does not involve power transmission other than power service to be provided from the current electrical box to the TMT Observatory. This power service will be installed and maintained by HELCO. HELCO will be granted an easement for the electrical conducting cable providing power to the TMT Observatory. Maintenance of the power service will be the responsibility of HELCO and could include periodic upgrades or replacement of the electrical conducting cable.

Fuel Lines

The proposed project and use does not involve fuel lines other than minor fuel lines connecting the 2,000-gallon above ground storage tank (AST), which will store diesel fuel, and the emergency generator. The AST and emergency generator are located roughly 20 feet away from each other, with the AST located outside the TMT Observatory support building in a concrete containment pad and fill station and the emergency generator located inside the TMT Observatory support building adjacent the AST. All fuel lines will be double walled and designed and maintained per regulatory requirements. The emergency generator system is discussed below.

Drainage Systems

The proposed project and use does not involve a drainage system. All drainage will occur by ground surface flow and there will be no underground drainage system.

Unmanned Communication Facilities

The proposed project and use does not involve an unmanned communication facility.

Roadways

The proposed project and use includes the upgrade of an existing 4-wheel drive road in order to access the TMT Observatory. The road will be paved for a length of roughly 1,600 feet (the southern portion of the road) and will otherwise be a gravel road. The road will be maintained by MKSS, including grading and snow removal, using the same methods and on the same schedule as other roads within the MKSR.

Other Systems

Zero-Discharge Wastewater and Water Treatment Systems

The Project includes a zero-discharge wastewater system and a water treatment system. The zero-discharge system includes a 5,000-gallon underground storage tank (UST) for the storage of domestic wastewater and a 5,000-gallon double-walled UST for the storage of wastewater potentially containing chemicals from the mirror washing and recoating process. These USTs will be connected to waste generation locations (i.e. restrooms and mirror cleaning drains) via pipes, with pipes draining wastewater potentially containing chemicals being double walled. The USTs will be pumped out as needed and the accumulated wastewater transported to the Hilo Wastewater Treatment Plant (or other permitted treatment facility) for treatment and disposal.

The Project also includes a water treatment facility within the TMT Observatory support building. The water treatment facility is not for the treatment of wastewater; the facility will treat potable water to generate pure water for use in the mirror cleaning process.

Maintenance related to these systems will follow guidelines supplied by the manufacturer of the equipment ultimately acquired and installed. Monitoring is anticipated to include items such as the following:

- Monthly inspections for leaks in pipe work, valves, and containment systems.
- Periodic six month maintenance (lubrication, seal replacement, etc.) of pumps and valves (contracted service to local company).
- Routine testing every three months for potable water quality and periodic six month cleaning/flushing of tanks and supply lines.

Emergency Generator

The Project includes an emergency generator as a backup should the HELCO-supplied power go out. Maintenance of the emergency generator will follow guidelines supplied by the manufacturer of the equipment ultimately acquired and installed. Monitoring is anticipated to include items such as the following:

- Weekly:
    a. Inspect fuel storage tank, supply line, and containment systems.
    b. Inspect air intake system with checks for leaks, holes, and loose connections.
    c. Check fuel system and radiator air restriction, hoses, connections, fluid concentration, belts and louver operation.
- Regular monitoring of fuel levels and fuel pump operation.
- Exhaust system checks for leaks, restrictions and flush condensation cap.
- Annual, semi-annual, and quarterly checks of electrical system with monitoring of meters and battery fluid. Recharge batteries if needed.
- Check cooling system radiator for air restriction. Inspect hoses, connections, fluid concentration, belts and louver operation.

- Annual engine maintenance including changing of engine oil and filters. Refill oil and coolant levels and inspect for leaks, holes and loose connections.
- Battery and charger (semi-annual) maintenance. Check gravity and adjust charger output and corrosion cleaning.
- Fuel system inspection. Leaks, water, sediment checks. Day tank – float switch pump. Check governor linkage.
- Coolant system (check only). Antifreeze, radiator and cap. Leaks, hoses, belts and tension.
- Intake and exhaust (check only). Inspect and replace if required air cleaner, turbocharger, muffler and traps. Check for leaks in breather, flex pipe and rain cap.
- Generator maintenance. Inspect and replace the following if required: (1) diodes; (2) end bearings; (3) brushes; and (4) folder. Check condition of A.C. wiring, exciter stator, over speed switch and breakers.
- Generator controls check. Inspect voltage regulator, wiring relays, monitors and bulbs. Check operation of transfer switch, measure time delays, and exerciser clocks (adjust or reset as necessary). General cleaning of cabinet.
- Generator testing with engine running under load. Record A.C. output, frequency and amps.

HVAC System

The Project includes an HVAC system to control the environment in the TMT Observatory dome and support building plus maintain the required temperature for certain instruments. Maintenance of the HVAC system will follow guidelines supplied by the manufacturer of the equipment ultimately acquired and installed. Monitoring is anticipated to include items such as the following:

- Visually inspect equipment for refrigerant leaks and check for clogged condenser coil.
- Check contacts and tighten electrical connections. Adjust tension on belt and replace periodically as required.
- Lubricate all motors.
- Replace air filters or chemically clean electronic air cleaner.
- Clean and vacuum motor and blower compartment. Visually inspect evaporator, if accessible.
- Clean out condensate drain line and test operation for condensate pump.
- Cycle A/C on and check charge in unit.
- Check and record all voltage and amperages on all motors and compressors.

Mirror Cleaning and Recoating

The Project includes a mirror cleaning and recoating system. TMT's 492 M1 mirror segments require a new metallic coating every two years. A smaller number of spare mirror segments with fresh coatings are provided so that the mirrors can be swapped out in batches of 6-8 every 1-2 weeks. This continuous weekly process, done during daytime to avoid loss of observing time, will result in all mirrors being replaced every two years. The old mirror coatings are cleaned and chemically stripped to remove the old metal layer with all wastewater collected by the zero-discharge wastewater system discussed above. A new metallic reflective layer is applied using a vacuum deposition chamber to recoat the mirrors. Maintenance items related to the mirror cleaning and recoating process include:

- The smaller secondary M2 mirror and tertiary M3 mirror will be completely removed from the telescope every two years for recoating of the reflective surface. This process is expected to take 3-4 days at least and requires the entire telescope to be stopped from observing for this duration. The same technique is used to clean and chemically strip the reflective surface and a new coating applied in a vacuum tank deposition system.
- In addition, on a weekly basis, all mirror segments of the entire M1 primary mirror will be cleaned in-situ in the telescope using a spray of frozen carbon dioxide CO_2 "snow". A similar weekly process with CO_2 snow will be used to clean the M2 and M3 mirrors while they are installed in the telescope. In addition, every 6-12 months, the M2 and M3 mirrors will undergo a more thorough cleaning using a mild detergent- based water washing or peelable soft plastic layer.

Rotating Dome and Shutter

The system responsible for rotating the dome and opening the shutter will require the following maintenance:

- Azimuth Rail: Visual inspection of rail wear, bolt torque stripes.
- Azimuth Bogies/Lateral Guides: Check bogie load and adjust. Coil springs – visual inspection for wear or damage. Bearings – visual inspection, check noise/vibration and lubricate. Bushings (articulating frame & lateral pivot) – check smoothness/tightness. Wheels – visual inspection of wear. Replace items as required.
- Azimuth Drives: Motor – visual/noise inspection, seals, brake settings. Gearbox – visual/noise inspection, check oil level. Replace items as required.
- Azimuth Seals: Visual inspection of seal gap and signs of wear (exterior and interior seals). Check wear of internal surfaces (exterior and interior seals, requires partial disassembly at sampled points. Replace worn components as required.
- Cap Rail: Visual inspection of rail wear, bolt torque stripes. Visual inspection of rail wear, bolt torque stripes. Replace worn components as required.
- Cap Bogies: Check gas pressure and adjust, gas spring visual inspection. Bearings – visual inspection, check noise/vibration & lubricate. Bushings (at pivots) – check smoothness/tightness. Wheels – visual inspection of wear. Motor – visual/noise inspection, seals, brake settings. Gearbox – visual/noise inspection, check oil level.

Pinion – visual inspection or wear, check bushing functionality. Linear guides – visual inspection, lubrication. Preload spring – visual inspection. Preload wheel - visual inspection. Replace worn components as required.

- Cap Seals: Visual inspection of seal gap and signs of wear (external and internal seals). Check wear of internal surfaces (external and internal seals, requires partial disassembly at sampled points). Replace worn components.
- Shutter Rail: Visual inspection of rail wear, bolt torque stripes.
- Shutter Bogies: Bearings – visual inspection, check noise/vibration & lubricate. Bushings (at pivots & suspension points) – check smoothness/tightness. Wheels - visual inspection of wear. Replace worn components as required.
- Shutter Drives: Motor – visual/noise inspection, seals, brake settings. Gearbox – visual/noise inspection, check oil level. Pinion – visual inspection or wear, check bushing functionality. Linear guides – visual inspection, lubrication. Preload spring – visual inspection Preload wheel – visual inspection. Replace worn components as required.
- Shutter Seals & Lock: Actuator – visual inspection, lubrication. Bearings (pivot & locking shaft) – visual inspection & lubrication. Linear guides – visual inspection, lubrication. Seals – visual inspection of seal alignment and signs of wear or damage. Gutter – check and clean debris. Replace worn components as required.
- Aperture Flaps: Actuator – visual inspection, lubrication. Bearings (pivot & locking shaft) – visual inspection & lubrication. Seals – visual inspection of seal alignment and signs of wear or damage. Replace worn components as required.
- Vent Doors: Visual inspection (check seals, guide rail/roller wear, gearbox/motor, seals, hinges, door openers, and locks). Replace worn components, such as guiderails, seals, motor/gearbox, magnetic locks, and door opener, as required.
- Cranes: the three cranes (Nasmyth (20t), Top-End (10t), and Shutter (10t), will be maintained follow guidelines supplied by the manufacturer of the equipment ultimately acquired and installed. A contracted licensed crane inspection contractor will perform the maintenance and inspection.

Recoating (Repainting) of Dome

In order to maintain the TMT Observatory dome finish, it will be recoated (repainted) as follows:

- Refinishing the TMT enclosure exterior will be required every 10-20 years depending on the surface treatment used to obtain the reflective aluminum-like finish of the TMT enclosure.
- For a painted exterior finish, the paint will be replaced after approximately 20 years, depending on wear, and will require an exterior scaffolding to prepare and clean the dome surface and repaint the exterior. This has been estimated to take approximately 2-3 weeks and would be done so as not to significantly disturb observing.

- If adhesive backed aluminum film coating is used (e.g. 3M™ Aluminum Foil Tape 431), then it will need replacement after approximately 10 years. This process will require a scaffolding access to either replace the existing film, clean and prepare the surface and apply a new layer of aluminum film. Alternatively the new film layer may be applied directly over the old surface after cleaning.

Fire Safety System

The Project includes a fire safety system (alarm, water, and gas) that will be maintained following guidelines supplied by the manufacturer of the equipment ultimately acquired and installed. Maintenance is anticipated to including the following:

- Sprinkler and Standpipe Systems: Periodic maintenance and inspections and service test by a licensed contractor will be performed every five years.
- Fire alarm system will be tested annually in accordance with State of Hawai'i Fire Code.
- Supervisory valve switches (including those which are part of a sprinkler or standpipe system), and the water flow (i.e. main drain test) and Inspector's Test which are part of a sprinkler system, will be tested semi-annually.

Chemical waste system maintenance (may include part of the mirror cleaning and recoating)

The TMT Observatory will generate chemical wastes, including mirror cleaning and recoating wash water and other wastes. The mirror cleaning and recoating wash water will flow into a 5,000-gallon double-walled UST in the outdoor equipment area. Some other wastes will be stored in a designated storage area within the TMT Observatory support building.

The 5,000-gallon double-walled UST will be maintained following guidelines supplied by the manufacturer of the equipment ultimately acquired and installed. This includes maintenance and periodic testing of the tank and piping leak detector system. The tank will be emptied periodically by a licensed contractor and the waste managed appropriate depending on results of testing performed on the waste.

The following maintenance measures will be implemented regarding the wastes stored in the designed indoor storage area:

- Periodic inspections of waste storage containers for leakage, bulging, rusting, damage, or dents. Check that containers compatible with the waste in them and are kept closed except when waste is actually being added.
- Weekly inspections will be conducted of the 180 day waste storage area. Inspections will check that all containers of hazardous waste are marked with the words "HAZARDOUS WASTE" and indicate the date accumulation began. Regular verification of documentation to ensure waste leaving the facility is ready for disposal, treatment, or recycling and is being managed appropriately.
- Periodic inspections to verify there is sufficient aisle space in the waste containment area to allow unobstructed movement of personnel, fire protection equipment, spill control

equipment, and decontamination equipment to any area of the operation. Check that the required equipment is easily accessible and in working condition.

- Periodic inspections to confirm the internal communications or alarm system capable of providing immediate emergency instruction to personnel is working, and there are portable fire extinguishers and fire control equipment, including special extinguishing equipment (foam, inert gas, or dry chemicals), as well as spill control equipment and decontamination equipment available.
- Maintain records of regular training for personnel in waste handling and emergency procedures relevant to their responsibilities during normal facility operation and emergencies.
- Regular inspection and updating of manifest documentation archive for waste taken offsite for disposal or recycling, including records of waste analyses, tests, and waste determinations for 3 years. Documentation of the weekly inspection of the waste storage area.

Utility System

The power system is discussed above.

TMT will use the services of Mauna Kea Support Services (MKSS) to contract with a trucking company to deliver potable water from Hilo to the TMT Observatory in 5,000-gallon-capacity tank trailers that are owned by MKSS. TMT will be responsible for the maintenance of its water tanks.

Wastewater is discussed above as part of the zero-discharge system.

Communications utilities will be provided by HawaiianTel. Maintenance of the system may include periodic upgrade of the communication lines serving the TMT Observatory.

Weather/seeing Tower

The Project includes a weather/seeing tower located on the north side of the support building. Maintenance of this system will follow guidelines supplied by the manufacturer of the equipment ultimately acquired and installed. It is anticipated that maintenance will include the following:

- Routine local maintenance checks of weather station systems at least once every 12 months and preferably every six months.
- Sensor readings re-calibration periodically and humidity sensors replacement about every six months.
- Anemometer bearings replaced at least every 18 months and preferably every 12 months to ensure proper measurement of wind speed.
- Temperature sensors will be examined regularly by a trained technician. Remove any accumulated dirt and debris on the thermometer hygrometer solar radiation shield. During the winter, remove snow and ice that will affect temperature and humidity readings.

- If an external DIMM/MASS telescope is installed, it will need optical cleaning and regular checks of alignment, as well as telescope drive maintenance.

Compressed Air System

The Project includes a compressed air system. Maintenance of this system will follow guidelines supplied by the manufacturer of the equipment ultimately acquired and installed. It is anticipated maintenance will include the following:

- Monitor compressor oil and oil cleanliness. Change the oil according to manufacturer's recommendations. Maintain oil level and sample the oil every month. Note compressor lubricant level, color, and pressure. Compare with trended values. Depending on use and compressor size, develop periodic oil sampling to monitor moisture, particulate levels, and other contamination. Replace oil as required.
- Monitor condensate control. Drain fluid traps regularly or automatically. Drain receiving tanks regularly or automatically. Service air-drying systems according to manufacturer's recommendations.
- Keep air inlet filters clean. Replace particulate and lubricant removal elements when pressure drop exceeds 2-3 psid. Minimize system leaks. Verify all pressure relief valves are functioning properly. All air-consuming devices inspected on a regular basis for leakage. Leakage will typically occur in: worn, cracked, or frayed hoses, sticking air valves and cylinder packing.
- Tighten motor belts tight. Check belt tension and alignment for proper settings.
- Complete overall visual inspection to be sure all equipment is operating and that safety systems are in place.
- Make sure proper compressor ventilation is available for compressor and inlet. Verify operating temperature is per manufacturer's specification.
- Lubricate motor bearings to manufacturer's specification.

Appendix E. Arthropod Access Way Monitoring Plan

The Final Environmental Impact Statement, Thirty Meter Telescope Project, dated May 8, 2009, (page 3-76 and page 3-195) commits the TMT Observatory Corporation to monitoring arthropods in the area of the Access Way on the alpine cinder cone habitat before, during, and for two years after construction of that portion of the Access Way. The purpose of monitoring in that area of the Access Way is to provide baseline data regarding the presence of arthropods, including wēkiu bugs and potential invasive species prior to, during, and after construction. The proposed monitoring plan laid out below is subject to modification by OMKM and DLNR.

The extent of Access Way construction activities within the alpine cinder cone habitat extend from the southern end of the Access Way (at the existing electrical panel across from the SMA building) and extends roughly 760 feet to the north (Figure E-1) where the Access Way enters a lava flow habitat.

Biologists will be hired to conduct arthropod surveys in the vicinity of the Access Way construction activities and nearby areas relatively undisturbed by Access Way construction.

Monitoring Tasks, Locations, and Schedule

This section generally describes the tasks to be performed during the monitoring, the locations n the field where monitoring will occur, and the schedule for monitoring activities. The monitoring methods, the methods to be used in the field at each monitoring location, are detailed in a separate section below. Access Way monitoring will consist of the following tasks:

- Perform a single arthropod monitoring event prior to the start of construction activities. Timing of monitoring will be coordinated with OMKM's ongoing survey schedule. Monitoring will take place at the following general locations:
    - Three locations above the 4-wheel drive road, the alignment of the proposed TMT Access Way, and electrical boxes across from the SMA building (Figure E-1: Extent of Access Way Work on Cinder Cone Habitat
    - Figure E-2). The elevation of these monitoring points varies, but average roughly 13,400 feet.
    - Three locations between the 4-wheel drive road, the alignment of the proposed TMT Access Way, and the lower SMA road (Figure E-1: Extent of Access Way Work on Cinder Cone Habitat
    - Figure E-2). The elevation of these monitoring points varies, but average roughly 13,375 feet.
    - Three nearby locations:

A location between the Mauna Kea Loop Road to Subaru and Keck observatories and the Subaru Observatory, at an elevation of roughly 13,500 feet (Figure E-1: Extent of Access Way Work on Cinder Cone Habitat

- Figure E-2). This location is roughly 300 feet from the Access Way construction area.

A location on the lower, northern slope of Puʻu Poliʻahu. This location is at an elevation of roughly 13,350 feet and roughly 1,000 feet from the Access Way construction area (Figure E-1: Extent of Access Way Work on Cinder Cone Habitat

- Figure E-2).

Figure E-1: Extent of Access Way Work on Cinder Cone Habitat

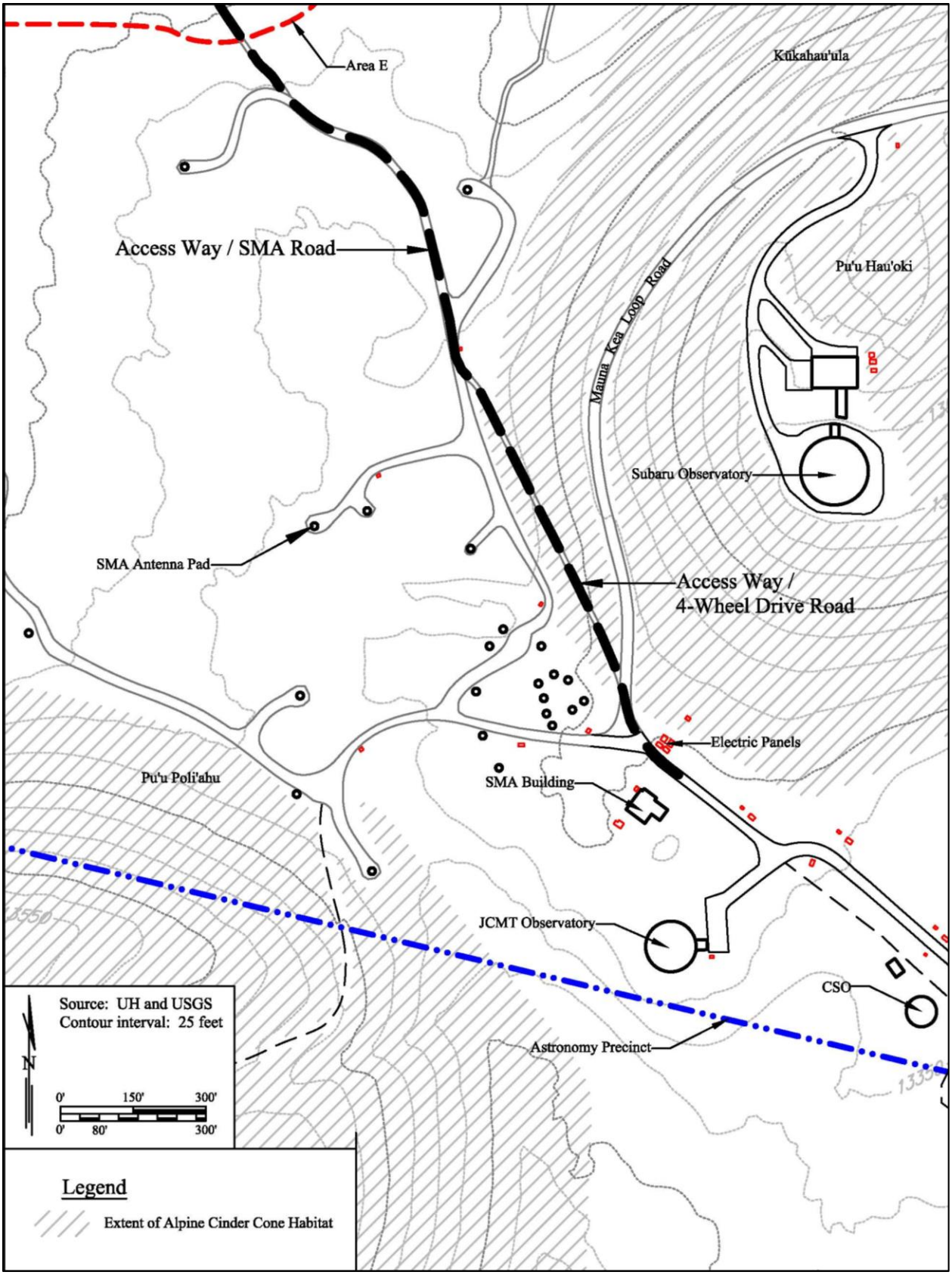
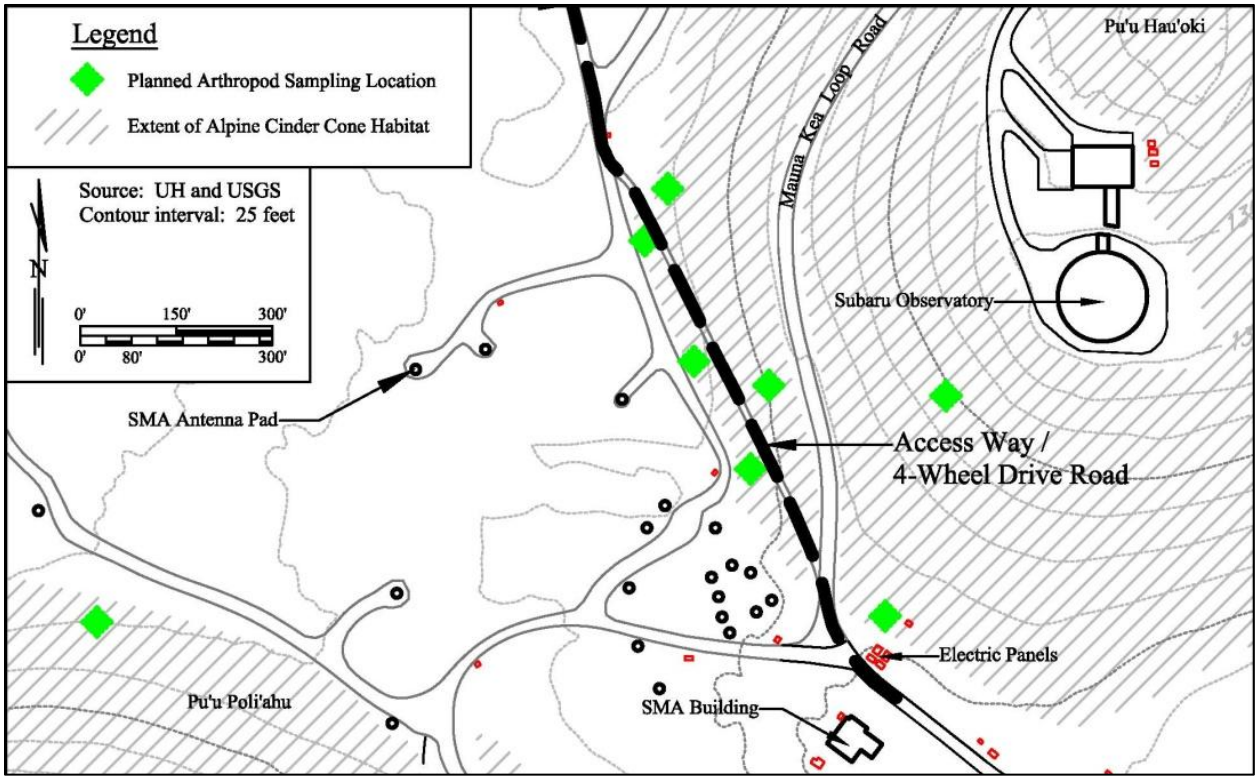


Figure E-2: Arthropod Monitoring Locations in Vicinity of Access Way



A brief report summarizing the results of the monitoring will be produced and shared with OMKM, the wēkiu bug working group, DLNR, and USFWS.

- Perform arthropod monitoring according to a schedule approved by OMKM, during the period of construction within the alpine cinder cone habitat. Monitoring will take place at the general locations outlined above with two traps deployed per location.

  Brief reports summarizing the results of each monitoring event will be produced and shared with OMKM, the wēkiu bug working group, DLNR, and USFWS. The reports will include the results of all previous monitoring events.

- Perform arthropod monitoring twice a year according to a schedule approved by OMKM, for a period of two years after completion of construction in that area. Monitoring will take place at the general locations outlined above with two traps deployed per location.

  Brief reports summarizing the results of each monitoring event will be produced and shared with OMKM, the wēkiu bug working group, DLNR, and USFWS. The reports will include the results of all previous monitoring events.

- Prepare a final report that (a) summarizes the results of the surveys, and (b) discusses the presence/introduction of new arthropod species (invasive or otherwise) during the monitoring period.

The following provides an example of a possible monitoring schedule, if construction were to start in the beginning of the summer:

Table E-2: Example Monitoring Schedule

Task	Event Date							
Construction in Alpine Cinder Cone Habitat		Start Jul-Y1		Finish Nov-Y1				
Before Construction Monitoring Event	June-Y1							
During Construction Monitoring Events		June, Jul, Aug, Sep, Oct (monthly until first significant snow)-Y1						
After Construction Monitoring Events					Apr-Y2	Sept-Y2	Apr-Y3	Sep-Y3
Report Distributed	July-Y1	Aug, Sep, Oct, Nov-Y1			May-Y2	Oct-Y2	May-Y3	Oct-Y3

Y1 = Year 1.

Monitoring Methods

At each monitoring location, two pitfall live-traps will be placed within roughly 10 feet of each other. The two traps will be placed in different microhabitat types (ex. large rock jumble vs. ash layer near the surface) to attempt to sample the diversity of the habitat at each location. A live-trap design very similar to that employed by Jesse Eiben in 2007 and 2008 and Mr. Eiben and Greg Brenner in 2008 and 2009 for the TMT Project will be used to trap wēkiu bugs and other arthropods. The trap was successful during those studies and is described in the "Arthropod and Botanical Inventory and Assessment" included as Appendix K of the Final Environmental Impact Statement, Thirty Meter Telescope Project (dated May 8, 2009).

The trap includes two 10-ounce clear plastic cups with the upper cup punctured with one small hole in the bottom center through which a small absorbent wick made of tissue is pushed. A small amount of water is placed in the bottom of the lower reservoir cup. Attractant shrimp paste is placed in the upper cup contacting the wick, on a few small pieces of rock in the cup, smeared on the side of the cup, and on a cap rock.

The traps are dug into the available ground substrate with a goal of achieving a depth where moisture was present (if moisture is available) in the ash layer. The lip of the cup needs to be placed flush with the ash layer, but there does not have to be wire mesh surround to provide structure surrounding the cups. A cap rock is placed over the traps and elevated above the ground approximately 0.5-inch with smaller rocks.

The traps will be checked daily for three consecutive days after installation. Wēkiu bugs and other arthropods captured will be removed for the duration of the sampling period to prevent recounts. Wēkiu bugs and other native species will be held for up to three days in captivity with food and water sources. Any introduced species will be euthanized so as to prevent introduction to another habitat. After sampling is complete, all wēkiu bugs and other native species will be released near the trap in which they were captured. Non-native species will be catalogued for future reference.

In addition to the pitfall live-traps, each day the traps are maintained there will be a 20 minute visual search for native and non-native arthropods at each monitoring location. The search will be conducted in a way to minimize impact of the substrate by visually searching the substrate surface, and by occasionally lifting rocks and searching below the surface for arthropods. Cinder

rocks will be placed back in their original positions. The biologist will have an aspirator and aerial net available for collecting arthropods observed either on the ground or in the air. Other types of traps may be employed in an effort to survey other kinds of arthropods that do not respond to or get trapped in the live pitfall traps; examples of potential traps include peanut butter covered sticks for surveying for ants. Arthropods encountered will be field identified and recorded, or if the identity is undetermined, one to five individuals of that morphospecies will be collected for identification purposes.