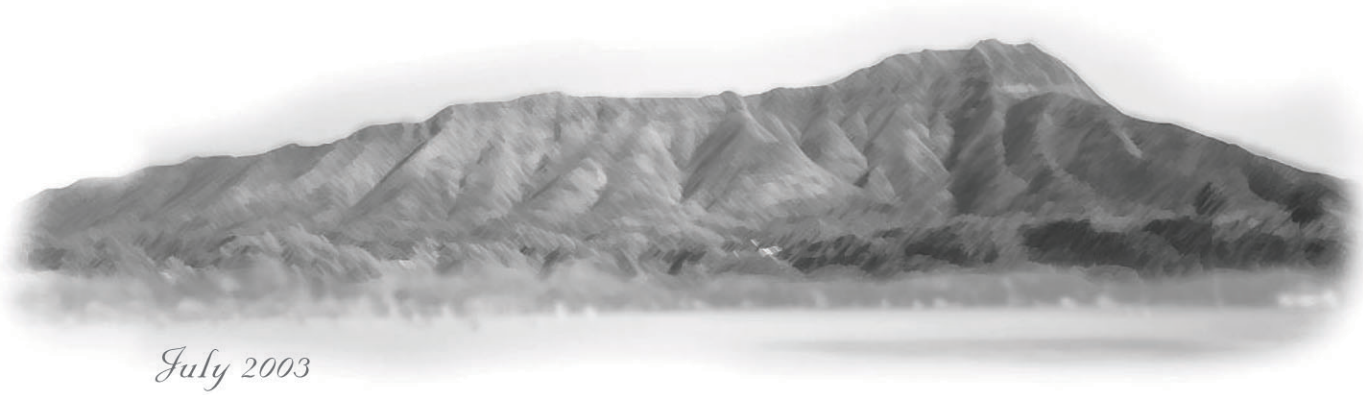
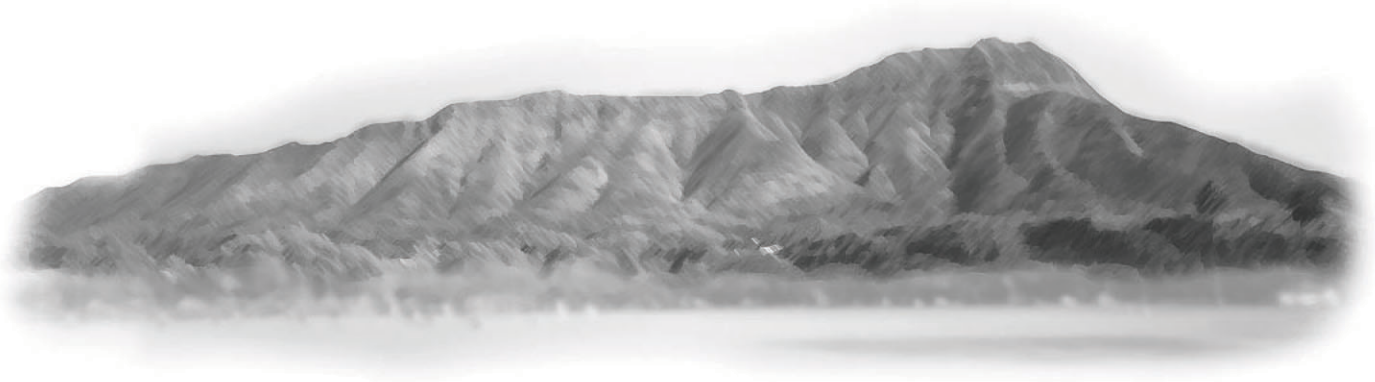
Diamond Head



July 2003

Master Plan Update

Diamond Head



Linda Lingle
Governor of Hawai'i

Board of Land and Natural Resources

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Timothy E. Johns, Member at Large
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Deputy Director

Ernest Y.W. Lau
Deputy Director

Division of State Parks

Daniel S. Quinn

Engineering Division

Eric T. Hirano, Chief Engineer

Master Plan Update

"On the seventh day out we saw a dim vast bulk standing up out of the wastes of the Pacific and knew that that spectral promontory was Diamond Head, a piece of this world which I had not seen before for twenty-nine years. So we were nearing Honolulu, the capital city of the Sandwich Islands-- those islands which to me were Paradise; a Paradise which I had been longing all those years to see again. Not any other thing in the world could have stirred me as the sight of that great rock did."

Mark Twain

Acknowledgments

PBR HAWAII wishes to extend its sincere appreciation to all those individuals listed below who contributed to the formulation of this Master Plan Update. We would also like to thank everyone who participated in the development of this plan, especially those who met with us, and/or provided suggestions and help. There are probably many others that we failed to mention; to those persons, we humbly apologize. To all, **Mahalo Nui Loa**.

Diamond Head Citizens Advisory Committee (1998-2003)
Nancy Bannick/Historic Hawai'i Foundation
Russell Chung/American Society of Landscape Architects
Rick Egged/Waikiki Improvement Association
Clark Hatch/East Diamond Head Comm. Assn.
Alison Kay/Save Diamond Head Association
Wes Kinder/Individual
Fred Madlener/Hawai'i's Thousand Friends
Cynthia Marnie/Individual
Michelle Matson/Individual
Luci Pfaltzgraff/Individual
Adeline Schutz/Save Diamond Head Association (*deceased, 2000*)
Sid Snyder/American Institute of Architects
Susan Spangler/The Outdoor Circle
Richard Turbin/Neighborhood Board #3
Allan Voronaeff/Kapi'olani Park Preservation Society
Juli Kimura Walters/Individual
Robert Wenkam/Sierra Club Hawai'i Chapter, Hawaiian Trail and Mountain Club (*deceased, 2000*)

Interested Parties
David Blaine/Department of Business, Economic Development and Tourism
Jane Hong/East Diamond Head Comm. Assn.
Lucinda Pyles/Individual
Barbara Marumoto/State Representative
Sam Slom/Senator
Scott Nishimoto/State Representative
Les Ihara/State Senator
Duke Bainum/Former City Councilmember
Mindy Jaffe/Former State Representative
Matt Matsunaga/Former State Senator
Brian Yamane/Former State Representative

Department of Land and Natural Resources
Michael Wilson (former Chairperson, 1994-1998)
Timothy Johns (former Chairperson, 1998-2000)
Gilbert S. Coloma-Agaran (former Chairperson, 2000-2002)
Daniel Quinn, State Parks Administrator
Ralston Nagata (former State Parks Administrator, *retired 2002*)
Clyde Hosokawa, State Parks (*retired 2003*)
Sherrie Samuels, State Parks (*retired 2003*)
Martha Yent, State Parks
Toni Han Palermo, State Parks
Yara Lamadrid-Rose, State Parks
Andy Monden, Engineering Division
Eric Yuasa, Engineering Division
Suzie Agraan, Engineering Division

CDS International
Pravin Desai
Amado Aguinaldo

Hawai'i Nature Center
Diana King
Roslyn Van Zyle
Jennie Peterson

Mitsunaga & Associates, Inc.
Ed Iida

Parsons Brinckerhoff Quade & Douglas, Inc.
Wayne Yoshioka

John M. Knox & Associates, Inc.
John Knox

International Archaeological Research Institute, Inc.
Myra Tuggle
Roger Blankfein
Stephen Athens

Rider Hunt Levett & Bailey
Paul Brussow

PBR HAWAII
Wm. Frank Brandt
Vincent Shigekuni

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1.0 Introduction

1.1 History of Diamond Head State Monument

Diamond Head State Monument (DHSM) was first officially established under Executive Order 2000 by Hawai'i's Governor Quinn in 1962. This early designation covered about 145 acres in a horseshoe configuration preserving the famous profile and the south and west exterior slopes from the crater rim down to Diamond Head Road. Subsequently, Executive Orders 3642, 3688, and 3743 have added additional lands to the Monument (Figure 1).

The interior of the crater had been closed to the public from 1906 until 1968, when it was opened to crater festivals and hiking under permit from the State Department of Defense (State DOD). In 1976 the Division of State Parks, Outdoor Recreation and Historic Sites (now called "Division of State Parks"), under the direction of the Department of Land and Natural Resources (DLNR), became the agency generally responsible for the planning and management of the Monument and, given the responsibility of managing portions of the crater, with the understanding that in the near future the lands would be set aside into the State Monument, so that the Parks Division rules and regulations would be applicable along with the enforcement. State Parks was also charged with designing a long-range master development plan.

1.2 Citizens Advisory Committee

As part of its planning efforts, DLNR formed a citizens advisory committee. The Diamond Head Citizens Advisory Committee (CAC), organized in October 1977, included interested citizens of the community, special-interest organizations, and representatives of government agencies (Table 1), many of whom had served on the 1969 State Department of Defense task force which considered "the future use of Diamond Head Crater." The purpose of the CAC was to assist in the development of a plan for Diamond Head State Monument.

The 1977 CAC was empowered to review all new proposals for the Monument and recommend necessary additions or deletions so that a monument master plan could be presented to the Board of Land and Natural Resources (BLNR) for approval. This same concept of a CAC will be continued to coordinate all future planning and development of the Monument and environs, as mandated by Act 313/92.

The CAC members met twice a month for more than a year, considering many current problems on the extent and use of Diamond Head as a Monument, including recreational activities. Their recommendations were oriented toward passive recreational activities, with elimination of all unnecessary roadways and structures. The CAC unanimously adopted the final conceptual plan and development plan as proposed in March 1979. The plans were finalized in the Diamond Head State Monument Planning Report dated June 1979 and accepted by the BLNR on November 9, 1979.

In 1993, the CAC was reactivated to review land issues and verify the Diamond Head State Monument boundaries in accordance with Act 313/92. Current members of the CAC (1998-2003) are shown on Table 2.

Table 1. "ORIGINAL" CITIZENS ADVISORY COMMITTEE

Citizens
Gerry Ching, Historic Hawai'i Foundation
Susanna Cheung, Variety Club School
Richard Kimball, East Diamond Head Assn.
Juli Kimura, Walters & Kimura, Inc.
Jack Larsen, House of Representatives
Aaron Levine, O'ahu Development Conference
Cynthia Marnie, The Outdoor Circle
Willis Moore, Sierra Club
Yukio Naito
Richard Paglinawan
Haydn Phillips, American Institute of Architects
Lucile Pfaltzgraff, The Outdoor Circle
Betty Ann Rocha
Adeline Schutz, Kāhala Community Assn.
Sidney Snyder, Save Diamond Head Assn.
Tamotsu Tanaka, Kapahulu Community Assn.
Gordon Tyau
Mildred Watson, League of Women Voters
Alice Woolaway, Save Diamond Head Assn.

Government Agencies
Department of Education (DOE), State of Hawai'i
State Department of Defense (State DOD), State of Hawai'i
Department of Accounting & General Services (DAGS), State of Hawai'i
University of Hawai'i (UH)
Department of Land Utilization, City and County of Honolulu
Department of Parks and Recreation, City and County of Honolulu
Federal Aviation Administration (FAA), United States Government

Table 2. CITIZENS ADVISORY COMMITTEE (1998-2003)

Citizens
Nancy Bannick, Historic Hawai'i Foundation
Russell Chung, American Society of Landscape Architects
Rick Egged, Waikiki Improvement Association
Clark Hatch, East Diamond Head Community Association
Alison Kay, Save Diamond Head Association
Wes Kinder, Individual
Fred Madlener, Hawai'i's Thousand Friends
Cynthia Marnie, Individual
Michelle Matson, Individual
Luci Pfaltzgraff, Individual
Adeline Schultz, Save Diamond Head Association (*deceased, 2000*)
Sid Snyder, American Institute of Architects
Susan Spangler, The Outdoor Circle
Richard Turbin, Neighborhood Board #3
Juli Kimura Walters, Individual
Robert Wenkamm Sierra Club Hawai'i Chapter, Hawaiian Trail and Mountain Club (*deceased, 2000*)

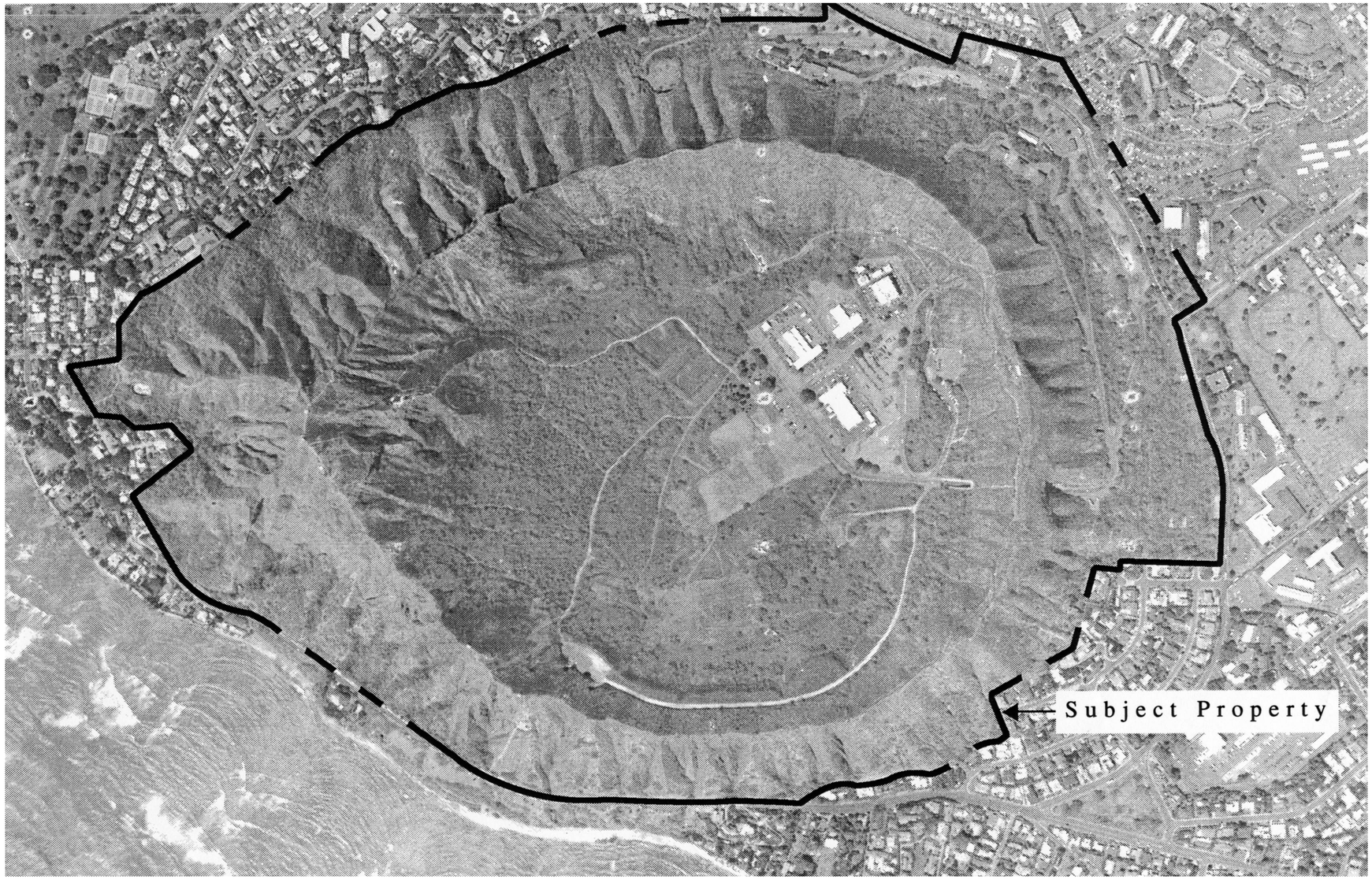

Figure 1
Aerial View of Diamond Head

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Government Agencies
Department of Defense (State DOD), State of Hawai'i
Department of Land and Natural Resources (DLNR), State of Hawai'i
Office of Hawaiian Affairs (OHA)
University of Hawai'i, Kapi'olani Community College (KCC)
Department of Design and Construction (DCC), City and County of Honolulu
Federal Aviation Administration (FAA), United States Government
Barbara Marumoto / State Representative
Sam Slom / State Senator

1.3 1979 PLANNING REPORT

In 1977, in accordance with executive and legislative directives, a study was initiated to plan, define, and develop a proposed enlarged Diamond Head State Monument. An interim plan and alternative recreational development proposals were presented for public review in August and September 1977, and the CAC was formed in October 1977 to help develop a final plan.

The final conceptual plan and the resulting development plan and phasing plan presented in the Diamond Head State Monument Planning Report, June 1979 represented the culmination and consensus of that process. They thus constitute the recommendations of the many individuals—both staff and interested citizens—and agencies that participated in the effort.

This Plan was accepted by the Board of Land and Natural Resources in 1979, and subsequently adopted by the Legislature as the official document setting forth the future direction of Diamond Head State Monument (Act 313, SLH 1992).

Objective and Policies

As part of the 1970's planning effort, planning objective and policies were formulated. The objective of the Department of Land and Natural Resources in proposing the expansion of Diamond Head State Monument, in accordance with Act 182, Session Laws of Hawai'i 1975, is to preserve and protect, and to include restoration of, Diamond Head crater while providing public recreational opportunities.

The objective of the final plan, as determined by the Diamond Head Citizen's Advisory Committee, was stated as:

"The establishment of a semi-wild interior park and development of an exterior park for family picnic outings."

Plan Policies

The policies established for the management and development of Diamond Head State Monument, as outlined below, were directed toward fulfilling the objective stated above.

1. That all recreational development be directed toward passive activities as defined in the State Comprehensive Outdoor Recreation Plan (SCORP): "Informal activities that require less intensive use and development of a site (i.e., picnicking, sunbathing, hiking)."

2. That all major actions planned by the DLNR within and adjoining the Monument require an approved Environmental Impact Statement or Assessment prior to initiation.

3. That no new permanent buildings or structures be constructed within the Monument unless required for public health, sanitation, or safety of users, or the maintenance and management support of the Monument. Further, that the visual impacts

be considered in locations, design, and landscaping.

4. That large crater festivals be phased out as park development takes place within Diamond Head crater, and any large commercial use that may detrimentally affect the environment of the crater be restricted.

5. That the DLNR acquire all available unused or unrequired Federal lands adjoining or with Diamond Head and secure the phase-out of State DOD and FAA structures within the Monument as feasible.

6. That all other agencies with land fronting Diamond Head Road between the two gatehouses be urged to coordinate their beautification efforts with the Green Landscaped Corridor Plan developed by the DLNR, and that safety features be provided for pedestrian and non-motorized transportation around the crater on Diamond Head Road and into the crater.

7. That no civilian aircraft be permitted to land anywhere within the Monument or to fly so low as to create a noise or dust nuisance or endanger people on the ground.

After considering a number of conceptual schemes, a Final Conceptual Plan was designed and approved by the CAC in June 1978. The plan restores the interior of the crater to an essentially semi-wild state, with reforested areas, an extensive wildland, and meadowlands. Public access would be through two tunnels, but the short length of the road will do little more than connect them and lead to the interpretive center, restrooms, and parking area all concentrated between the tunnels.

This development plan unanimously approved by the Diamond Head CAC, reflects a modified "wilderness" area with various uses consonant with the land uses envisioned by the Conceptual Plan. The following summarizes the key elements of the 1979 Development Plan (Figure 2):

Tunnels
The two major tunnels that access the crater would not be physically altered. Traffic circulation would be one-way with entry into the crater via the Kapahulu Tunnel and exit through the Kāhala Tunnel where a pedestrian walkway was also planned. The existing parking and scenic overlook outside the crater adjacent to the Kāhala Tunnel would be improved to handle the "anticipated influx of visitors to the area."

Interior Roadways and Parking
The paved roadway network within the Monument would be limited to corridors required for public access and to mostly existing roads through the area currently restricted only to State DOD and FAA personnel. The road from Kapahulu Tunnel would be one-way only to Kāhala Tunnel or vice-versa. While the 1979 Development Plan only shows the parking lot below Battery Birkhimer, the text describes parking being limited to a few designated parking lots with planned overflows for events on the landscaped open areas.

Interpretive Center
The proposed interpretive center would be located between the two tunnel entrances inside the crater. Its design would also reflect a rustic character to integrate into the surrounding natural wilderness concept. The structure would also be designed to reveal the panoramic outdoor scene for interpretive and fire watch security purposes. Access to the Center would be provided by the lower parking area (which is the existing parking lot below Battery Birkhimer). The present service road to Birkhimer EOC would be used for handicapped access. Although no interpretive program had been developed, the Plan did recommend that any interpretive program stress the geology, historical use, and interesting flora of the crater.

Parking
The 1979 Development Plan showed parking below the site of the proposed interpretive center, with additional parking at the Cannon Club and outside of Kāhala Tunnel. Presumably, the first choice for visitors would be to park near the interpretive center or in a second overflow lot outside of the Kāhala Tunnel (which would require walking in through

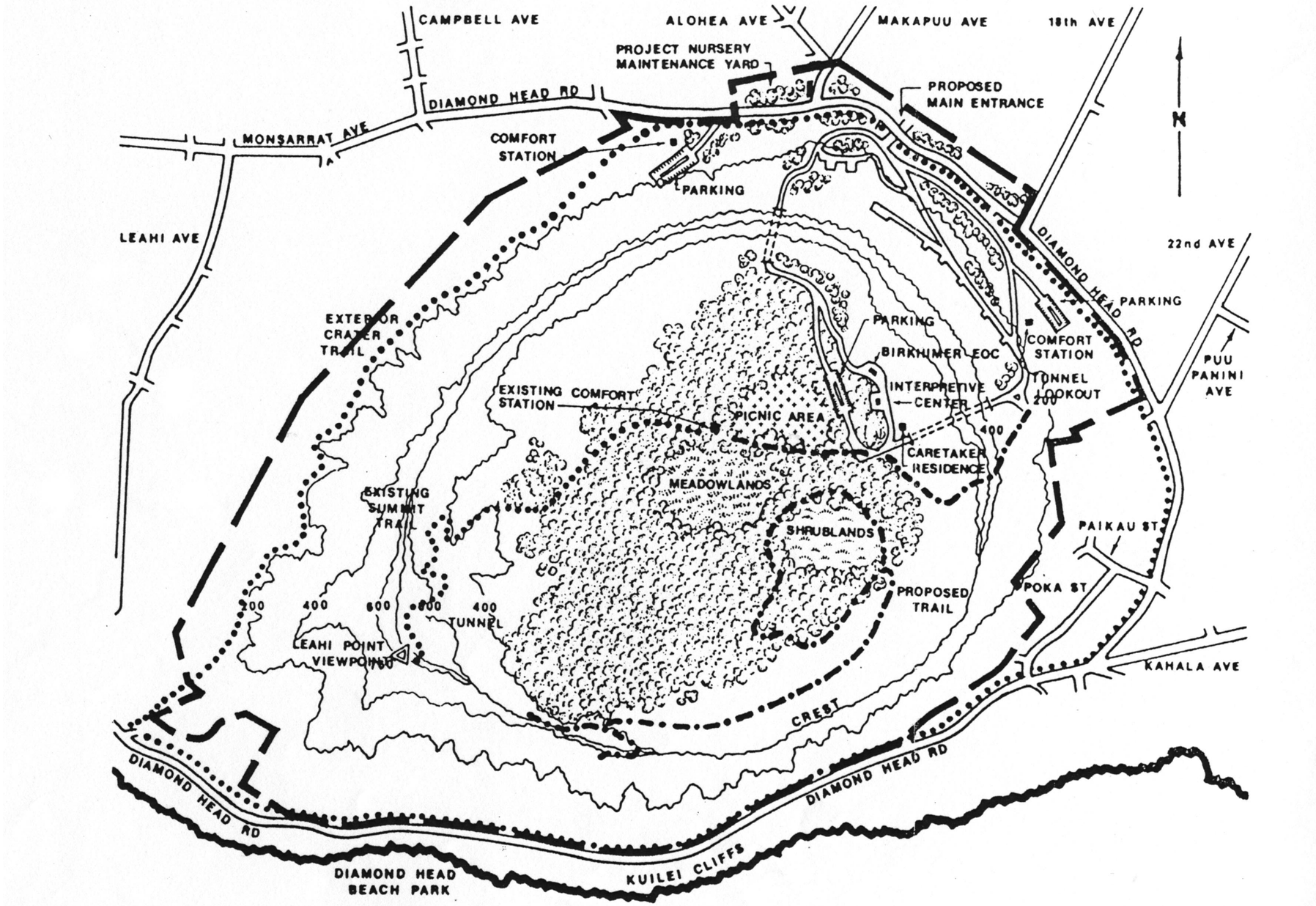

Figure 2
1979 Plan

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the tunnel). If these two parking lots were full or otherwise not available, parking at the Cannon Club would be the third alternative.

Caretaker Residence
To facilitate 24-hour security, a caretaker structure was planned to be unobtrusively located proximate to the proposed Interpretive Center.

Comfort Stations
Sanitary facilities would be provided as minimal support for the daily public use of the Monument. Shown on the 1979 Development Plan were facilities located at the Cannon Club, the existing comfort station location and another at the proposed parking lot below the Kāhala Tunnel. Portable chemical lavatories would supplement the permanent facilities for large events and usage requiring additional facilities.

Exterior Picnic Area
Exterior picnic facilities (site undetermined) were also planned to be geared for large gatherings in areas accessible by automobile. According to the 1979 Development Plan, with careful management, picnic areas outside the crater could be utilized 24 hours a day.

Interior Picnic Areas
As stated in the Plan Objective, family picnics were envisioned as a primary use for the crater. A wooded open space across the road from the Interpretive Center was recommended to serve as a low-density picnic site for visitors and hikers, and as a walk-in site for day users. This area would be designed to integrate facilities into the natural surroundings without introducing a fire hazard. No cooking facilities would be provided and a stone wall would be built as a firebreak.

Dryland Habitat
The proposed dryland habitat element of the Plan covered essentially the entire interior of the crater. Natural environmental characteristics would establish distinctive zones consisting of the (1) existing kiawe forest (to remain intact), (2) dry-lake area (wetland) labeled as "shrubland" on the 1979 Development Plan, (3) meadowlands (existing lawn area), and (4) reforested area. The reforested area would consist of small-tree vegetation reflecting the natural ecosystems for this area. Design of facilities would be just enough to satisfy the basic recreational potential of the area. Service roads, firebreaks, and other fire-control devices would be unobtrusively implemented into the design.

Upper Slopes
This element of the plan primarily addressed Lē'ahi Summit. As a major hiker destination, a closely monitored management program was recommended because of endangered plants in the surrounding area and the need to refurbish the summit while still maintaining a low profile and rustic character.

Trail System
Two separate trail systems (interior and exterior) were planned to address different needs and purposes. The exterior trail system would have a dual function as a jogging and bicycle path traversing the *mauka* end of the Monument and along the existing trail on the lower 'Ewa-*makai* slopes. Several access points would be required for neighborhood linkages and security. The trail width would be sufficient to accommodate emergency vehicles.

The interior trail system was limited to the existing trail to the summit of Lē'ahi; a new trail around the proposed shrubland (wetland) which would continue on the road to Tunnel 407 and from there to the crater rim; and a new trail starting from outside Kāhala Tunnel over the crater rim to the other side of the tunnel. Only trail access to reach panoramic view sites along the crest and Lē'ahi Summit lookout would be available. The upper slopes, with crumbly footing and sparse vegetation, and endangered plants in the area, were determined to justify limited access.

Landscaping
- Reforestation and replanting of major areas with hardy, maintenance-free plants to present a rustic natural setting.
- Non-native vegetation such as fountain grass will be monitored and contained or removed.

- Selected natural areas would be established to ensure the survival of native and endangered plants and their habitats.
- Areas with high use would be landscaped and maintained as park areas.

Linear Parkway
Diamond Head Road would be landscaped with trees, grass, and shrubbery. All overhead utility lines and poles would be eliminated.

Project Nursery and Maintenance Yard
This element would be designed to propagate and establish dryland native plants for the Monument. Once the reforestation is completed, the yard would be moved from a temporary facility outside the crater.

Planned Phasing of the 1978 Conceptual Plan

The following describes the phased implementation of the Development Plan over approximately 20 years, as envisioned by the CAC in 1979.

The first three years were to be utilized to establish the Executive Order for the Monument and develop recreational uses. The exterior parkway, roadway improvements, landscaping, burial of all utilities, and the development of trails were given priority in this period.

During the subsequent two years, the peripheral government parcels were to be included into the Monument for resource management. The visitor/interpretive center and parking area were planned for construction, as well as reforestation of the crater interior. The exterior park was to be initiated with parking and comfort stations, and new trails were planned.

The 10-year projection included the acquisition of the slopes above the Cannon Club and of properties within the crater as feasible. Most of the parcels have been acquired. The remaining FAA parcels are scheduled to be returned to the state for possible inclusion into the monument.

The final plan was to be the full recreational development of the Monument, with inclusion of Civil Defense facilities as feasible. The visitor/interpretive center and parking were to be relocated and unrequired roadways removed.

An alternative of the Final Conceptual Plan phasing was the possibility of varying the timetable of the plan to provide flexibility in response to unforeseen situations. In 1979, it was anticipated that, if, for valid reasons, the Monument development or acquisitions could not proceed in accordance with the envisioned phasing, DLNR State Parks would pursue appropriate actions and/or alternatives while continuing to move toward the objective of ultimate development of the Monument in the shortest possible time. As the end of the 20-year time period approaches, it is clear that DLNR was very successful in the acquisition of land for the Monument as was ultimately envisioned in the 1979 Development Plan. Interim facilities consisting of trail improvements, water lines, a comfort station, parking lot and small picnic area within the crater were also developed. However, funding for many of the other major improvements were never secured to implement the rest of the 1979 Development Plan.

1.4 THE NEED TO UPDATE THE 1979 MASTER PLAN

During the past 24 years since the 1979 Plan was prepared and portions implemented, visitor use of Diamond Head State Monument has increased significantly (from 41,000 visitors in 1980-1981 to 800,000 estimated visitors in 1996-1997), impacting natural resources, park improvements, and county facilities (road, water, and sewage treatment). The Federal Aviation Administration (FAA), the United States Department of the Army (USA), and the State Department of Defense (State DOD) lands identified in the 1979 Plan, have recently or are being vacated by the respective agencies. The Office of Hawaiian Affairs (OHA) is also now eligible to receive revenues derived from "ceded" lands.

1.5 THE MASTER PLAN UPDATE PROCESS AND ITS OBJECTIVES

In 1997, the State Legislature recognized the need to address this situation and funded an update of the 1979 Plan. The update is to include the preparation of plans and designs for the incremental development of the Monument, including a visitor/interpretive center. The product will be a Master Plan Update and Environmental Impact Statement and related technical appendices, as may be required for the construction of improvements to include a permanent visitor/interpretive center.

As part of State law under Chapter 6E-32, Hawai'i Revised Statutes, amendments to the 1979 document are allowed by the Board of Land and Natural Resources with the review and recommendations of the CAC, organized in October 1977.

Since January 1998, the Division of State Parks and its planning consultant PBR HAWAII have met with the CAC once or twice a month, including field trips, on the update of the 1979 Development Plan and the location and program of the proposed visitor/interpretive center. In the process of these meetings with the CAC, four sites for the visitor/interpretive center were identified within the crater, from which three were identified for further evaluation. These three sites and their accompanying master plans covering the remainder of the DHSM were then presented for public input through the State of Hawai'i Chapter 343 Environmental Impact Statement (EIS) process

The EIS Preparation Notice (EISPN) was filed with the State Office of Environmental Quality Control (OEQC) on August 25, 1998. Notice of the availability of the EISPN was published in the September 8, 1998 issue of the *Environmental Notice*. The 30-day public comment period for the EISPN occurred between September 8, 1998 and October 8, 1998. During this time there was an opportunity for public input on the desirability of the various alternatives considered. Public informational meetings were held on November 23 and November 24, 1998.

Based on the CAC's recommendations and public comments received on the EISPN, DLNR selected a preferred alternative. This preferred alternative (proposed action) was presented in the Draft EIS.

Notice of the availability of the Draft EIS was published in the *Environmental Notice* on April 8, 2000 and a second 45-day public comment period began—ending on May 23, 2000. A second set of public informational meetings was held on April 26 and May 8, 2000. Notice of the availability of the Final EIS was published in the *Environmental Notice* on November 8, 2000.

Public hearings will be held in the process of obtaining: 1) Conservation District Use Permit(s) from BLNR; 2) Special Management Area Use Permit(s) and the Diamond Head Special District Major Permit from the City and County of Honolulu; and 3) Well Permit(s) (Well Construction Permit, Pump Installation Permit and Water Use Permit), if necessary, from the State Water Commission.

1.6 CONTENT OF THE MASTER PLAN UPDATE

Each of the following chapters explains in detail the important issues that had an impact on the update of the 1979 Master Plan. The material is organized as follows:

Chapter 1: Introduction
This chapter discusses the history of the Diamond Head State Monument (DHSM), the role of the Citizens Advisory Committee (CAC) in the DHSM planning process, the original 1979 master plan, the need to update the 1979 plan, and the update process.

Chapter 2: Land and Land Use
This chapter describes the Monument's location, its existing users, its relationship with surrounding neighborhoods, and regulatory considerations, and their effect on the update process.

Chapter 3: Geology/Land Form
This chapter describes the Monument's topography, its formation, soils, climate, and hydrology.

Chapter 4: Biological Resources
This chapter describes the flora and fauna of the DHSM and what impact these resources had on the update of the master plan.

Chapter 5: Cultural/Historical Resources
This chapter discusses the Monument's numerous historical resources and its history from legends to the present, and its importance in updating the master plan.

Chapter 6: Scenic Resources
This chapter describes existing and potential scenic resources within the DHSM and their potential role in the master plan update.

Chapter 7: Public Activities
This chapter discusses existing uses within the DHSM, including existing improvements and infrastructure, potential uses of the Monument (both recreational and non-recreational), and their implications in updating the master plan.

Chapter 8: Master Plan Update
This chapter discusses the original 1979 Development Plan, amended objective and policies, master plan update alternatives, public feedback, evaluation criteria, the preferred alternative, the updated master plan, conceptual landscape plan, and project phasing and costs.

Chapter 9: Visitor/Interpretive Center
This chapter describes the conceptual architecture of the proposed visitor/interpretive center, including architectural programming, possible exhibits, and conceptual architectural design.

Chapter 10: Environmental Impacts
This chapter discusses the integration of the master plan update process with the State environmental impact statement process.

2.0 Land and Land Use

The DHSM exists within a larger context of land use and activity, which may or may not be compatible with the integrity of the Monument. Land ownership and use, particularly on parcels adjacent to or surrounded by DHSM property could affect the ultimate use of the crater. In general, land use will influence the location of park uses and park facilities. Following a description of the existing DHSM context, this section discusses the potential for future change.

2.1 Location and General Description

Diamond Head, also known as Lē‘ahi, lies on the southern coastline of O‘ahu, approximately one and a half miles south of the slopes of the Ko‘olau range. To the northwest are residences, Kapi‘olani Park, the Honolulu Zoo and Waikīkī (Figure 3). To the north are the Cannon Club, Kapi‘olani Community College and the residential areas of Kapahulu and Kaimukī. To the east is the residential area of Kāhala. To the south is Diamond Head Road and Diamond Head Beach Park.

Diamond Head is a nearly circular crater of approximately two-thirds of a mile in diameter and is bounded by Diamond Head Road and Monsarrat Road. The Diamond Head State Monument consists of the following TMKs: TMK: 3-1-42: 6, 8, 10, 14, 17, 21, 23, 24, 25, 36, 37, and 38 and TMK: 3-1-35: 22 and 23 (Figure 4). Parcels to be added to the Diamond Head State Monument include: TMK: 3-1-42: 11 (Cannon Club), TMK 3-1-42:15 (FAA), and TMK 3-1-42:16 (FAA), TMK 3-1-42:20 (por.). The entire crater is in government use.

The project is located within the Primary Urban Center of Honolulu, surrounded primarily by single-family residential land uses. Kapi‘olani Park, a major urban regional park, is located just west of Diamond Head Crater. Along the southern edge of the crater, Diamond Head Beach Park and the U.S. Coast Guard lighthouse lie on the opposite side of Diamond Head Road. Along the northeastern edge of the crater, on the opposite side of Diamond Head Road, are Kapi‘olani Community College, Kaimukī Intermediate School, and Diamond Head Memorial Park.

Geologically speaking, Diamond Head is an extinct volcanic tuff cone, with a variable-height rim surrounding the recessed interior area, which is accessible via two tunnels. The interior is an extensive open space, including a large fenced area that contains several structures presently occupied by the State Department of Defense (State DOD). The remainder of the crater is undeveloped open space except for a comfort station and parking lot for Monument visitors.

The highest point, on the southwest rim of Diamond Head, known as Lē‘ahi Summit, presents a spectacular panorama in all directions as a reward for the climb via a steep trail and stairway system.

2.2 RELATIONSHIP WITH SURROUNDINGS

Diamond Head's relationship with the surrounding environs is critical. The crater is a National Natural Landmark and a State Monument. In order to preserve its natural appearance and view aspects, the crater was placed and remains within the State Conservation (Land Use) District and also within the City and County of Honolulu Diamond Head Special District. The Conservation District limits types of land uses and activities, while the Special District protects the view of the Monument. The Monument is thus stabilized, and "mounted" into an essentially permanent setting - a large, undeveloped, natural feature ringed with urban developments of low-rise homes, parks, and government facilities such that the natural appearance of the crater can be viewed and appreciated from Koko Head to Ewa, from miles out to sea, or from the air, as an icon of Hawai'i.

The relationship of development within the Monument to that outside is also significant. The Hawai'i National Guard has many of its facilities located inside the boundaries of DHSM. The Emergency Operations Center (EOC) and Military Emergency Centers (MEC), also in the crater, are the centers of State government and communications during situations of war or disaster. Daily emergencies around Honolulu are also handled through Diamond Head from a repeater site for police, ambulance, and firefighting personnel.

2.3 REGULATORY CONSIDERATIONS

Federal

National Natural Landmark: The National Natural Landmark title is bestowed as an honor upon an outstanding natural landmark by the Federal government. The objectives of the natural landmark program are to encourage the preservation of sites importantly illustrating the geologic and ecologic character of America; to enhance the educational and scientific value of sites so preserved; to strengthen the cultural appreciation of the natural history of America among people; and to foster a greater concern and involvement in the conservation of America's natural heritage among Federal, State, and local governments, citizens organizations and individuals. There are no rules or regulations for this special award, and conservation is the responsibility of the owner (State of Hawai'i).

National Register of Historic Places: Portions of the DHSM are identified as being located within the Fort Ruger Historic District, which was listed on the National Register of Historic Places (NRHP) in 1983 (Allen and Shideler 1996:23). As such, it is one of "triggers" of the State Environmental Impact Statement law (Chapter 343, Hawaii Revised Statutes).

Americans With Disabilities Act: All facilities will be designed to meet the Americans with Disabilities Act Accessibility guidelines and the requirements of Section 103-50 Hawaii Revised Statues (HRS), except: 1) where compliance would cause substantial harm to cultural, historical, religious, or significant natural features and characteristics; 2) where compliance could substantially alter the nature of the setting or the purpose of the facility, or portion of the facility; 3) where compliance would require construction methods or materials that are prohibited by Federal, State, or local regulations or statutes; 4) where compliance would not be feasible due to terrain or prevailing construction practices.

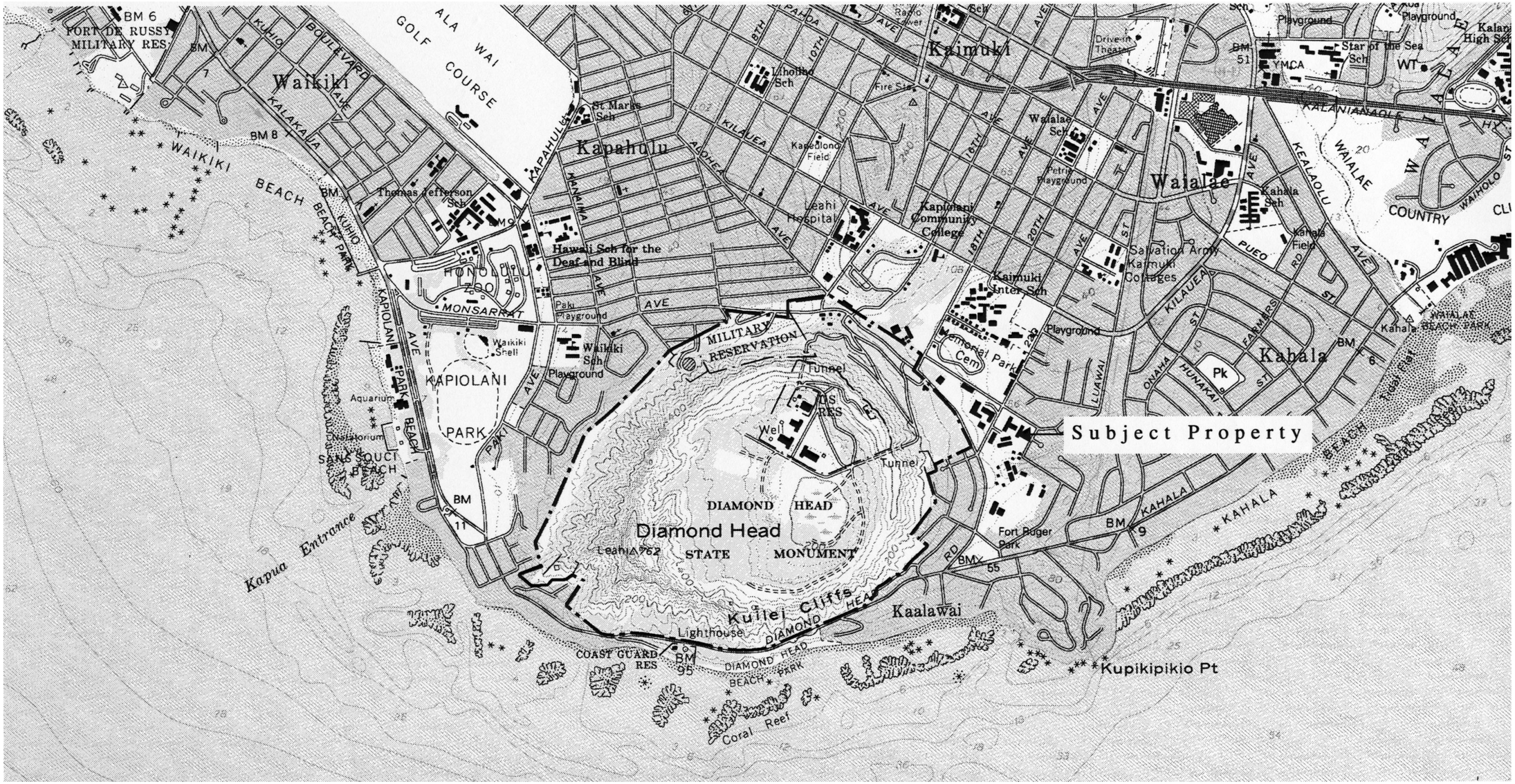

Figure 3
Location of Diamond Head
with Respect to Surrounding Residential Districts

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Diamond Head Master Plan Update

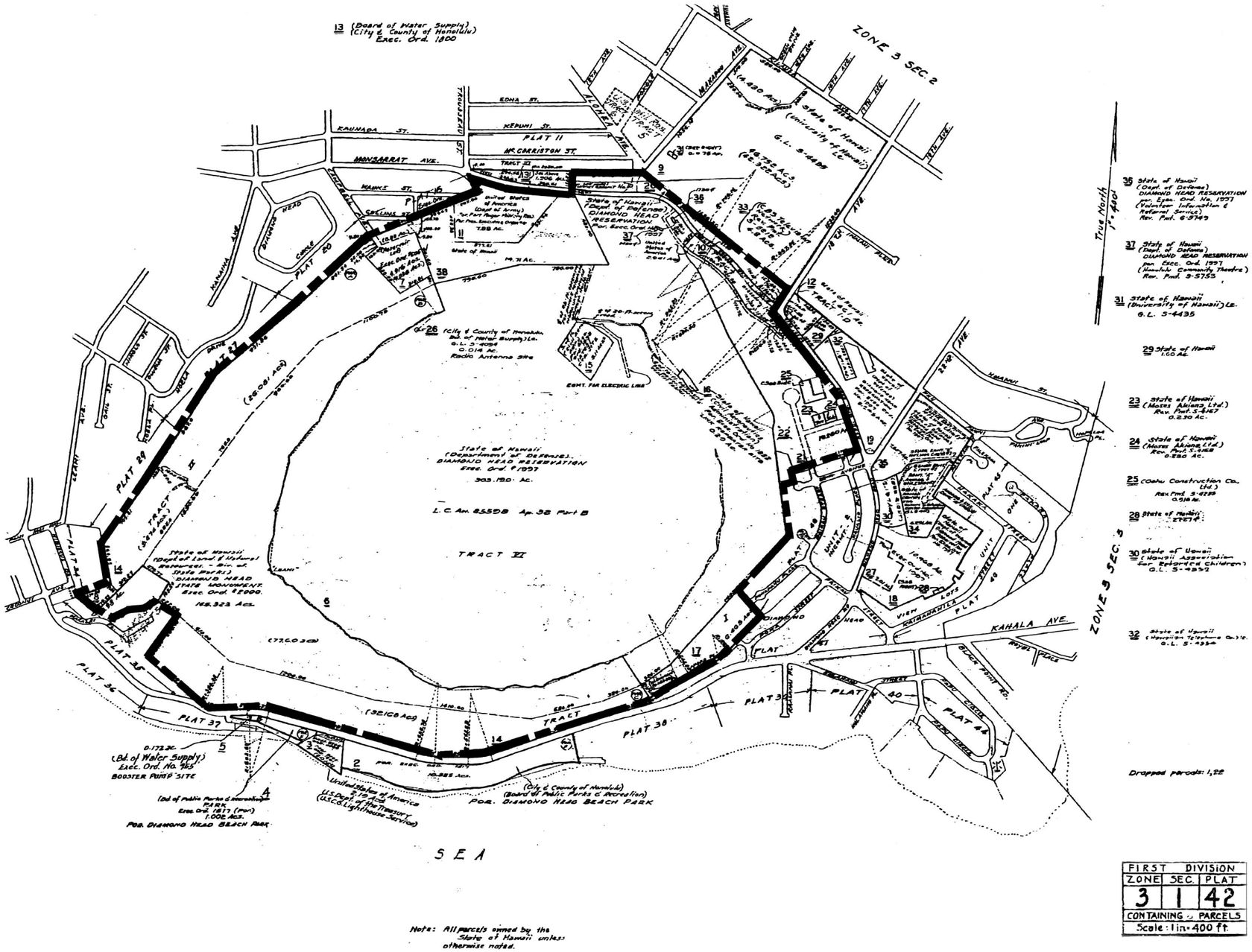

Figure 4
Tax Map Key

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0 500 1000 FEET

Master Plan Update

Diamond Head

State of Hawai'i

State Land Use District: The State Land Use Commission (LUC) places all lands in the State of Hawai'i in one of four land use districts: urban, agriculture, conservation, or rural. As illustrated in Figure 5, the DHSM consists primarily of conservation district land. Only a very small portion of the DHSM lies in the urban district and is subject to City and County of Honolulu zoning regulations.

Conservation District land is subject to the administrative rules of the Hawai'i State Department of Land and Natural Resources (DLNR), Title 13, Chapter 5. These rules define four subzones of conservation district land, two of which apply to the DHSM.

> **Resource (R) subzone:** The objective of this subzone is "to develop, with proper management, areas to ensure sustained use of the natural resources of those areas." The resource subzone encompasses lands used for parks or for outdoor recreational uses.
>
> **General (G) subzone:** The objective of this subzone is "to designate open space where specific conservation uses may not be defined, but where urban use would be premature."

Most of the DHSM is currently designated as an R (Resource) subzone (Figure 6). However, during the EISPN comment period, the State Land Use Commission noted that TMK: 3-1-42:10, 21, 23, 24, 25, 36, and 37 were classified as Conservation District but were not subsequently designated within a particular subzone. DLNR will work with the Office of State Planning to ensure that the subject parcels are placed in the proper Conservation district Subzone(s).

The portion of the crater floor where most of the State DOD facilities are concentrated and the slopes above and over the crater rim are designated as G (General) subzone. This is important because most of the proposed visitor/interpretive center will be located in a G (General) subzone.

All structures must be consistent with the purpose of the Conservation District. The park's primary structure, the proposed visitor/interpretive center, will probably be located mostly within the General (G) subzone and thus will be subject to those restrictions. The General (G) designation is the least restrictive of the conservation district subzones. Since the proposed master plan update involves use of lands within the Conservation District, approval will be sought from the State Board of Land and Natural Resources (BLNR).

State Comprehensive Outdoor Recreation Plan: The SCORP, which deals with all existing and proposed recreational areas lists among its purposes:

- Identify recreational demand and need by State, County, and Planning Area.
- Provide statewide and regional recommendations for development and preservation of recreation and open-space resources.

Diamond Head is included in the 1996 SCORP report.

State Plan: The statement of Program Objectives (DLNR) pertaining to Diamond Head is as follows:

> To enrich the leisure time of people of all ages by making available for appreciation and study other unique features of the State. In the future, emphasis will be placed on interpreting these features.

State Monument: State Parks criteria define State Monuments as: "Areas, usually limited in size, established primarily to preserve objects of historic and/or scientific interest, and places commemorating important persons or historic events. The only facilities usually provided are those required for the safety and comfort of the visitors, such as access, parking, water, sanitation, interpretive devices, and sometimes facilities for picnicking and other recreational facilities."

Amendments to the Diamond Head Master Plan: Updates (or amendments) to this plan must be approved by BLNR (with the review and recommendations of the CAC).

Well Construction Permit: Pursuant to Hawai'i Revised Statutes, Chapter 174C, State Water Code, if any wells are proposed within the DHSM, a Well Construction Permit and/or a Pump Installation Permit must be sought from the State Commission of Water Resource Management.

In addition, since the proposed water supply source for the project is located in a designated water management area, a Water Use Permit from the State Commission on Water Resource Management would be required prior to use of this source.

Environmental Impact Documentation: Chapter 343, Hawai'i Revised Statutes, requires that an EA or an EIS be prepared for the proposed development at DHSM. Several factors trigger this: 1) the use of State land and State funds; 2) the existence of historic resources listed on the National Register of Historic Places; 3) development on conservation district land; 4) development within the Special Management Area; and 5) the possible need for Well Permits (Well Construction Permit, Well Installation Permit, Water Use Permit) from the State Water Commission. An Environmental Impact Statement Preparation Notice (EISPN) was filed with OEQC on August 25, 1998 and was published in the September 8, 1998 issue of the *Environmental Notice*. The Draft EIS was published in the *Environmental Notice* and distributed on April 8, 2000. Notice of availability of the Final EIS was published in the *Environmental Notice* on November 8, 2000. The Final EIS was accepted by the Governor on January 25, 2001.

State Historic Preservation Division (DLNR): All plans for the DHSM will be subject to review by the State Historic Preservation Division, under the State's historic preservation law (Chapter 6E-8).

State Department of Health: While all of the proposed uses on the crater floor will be served by the municipal wastewater collection, treatment and disposal system, Department of Health permits may be required for any comfort stations not connected with the municipal wastewater system (for instance for a comfort station on Lē'ahi Summit trail).

City and County of Honolulu

General Plan: As required by the City Charter, the General Plan for the City and County of Honolulu serves two purposes. The first is a statement of the long-range social, economic, environmental, and design objectives for the welfare and prosperity of the people of O'ahu. Second, the General Plan is a statement of broad policies that facilitate the attainment of the objectives of the plan. Objectives and policies of the General Plan appropriate to Diamond Head are as follows:

Objective

To preserve and enhance the natural monuments and scenic views of O'ahu for the benefit of both residents and visitors.

Policies

1. Protect the Island's well–known resources: its mountains and craters; forests and watershed areas; marshes, rivers, and streams; shoreline, fishponds, and bays; and reefs and offshore islands.

2. Protect O'ahu's scenic views, especially those seen from highly developed and heavily traveled areas.

3. Provide opportunities for recreational and educational use and physical contact with O'ahu's natural environment.

Primary Urban Center Development Plan: Diamond Head, mostly located within the Preservation District within the Primary Urban Center (PUC) Development Plan (DP), falls under policy statements dealing with preservation. Small portions of the DHSM are located within the Park, Military, Public Facility, and Residential Districts. Eventually, these latter designations on portions of the

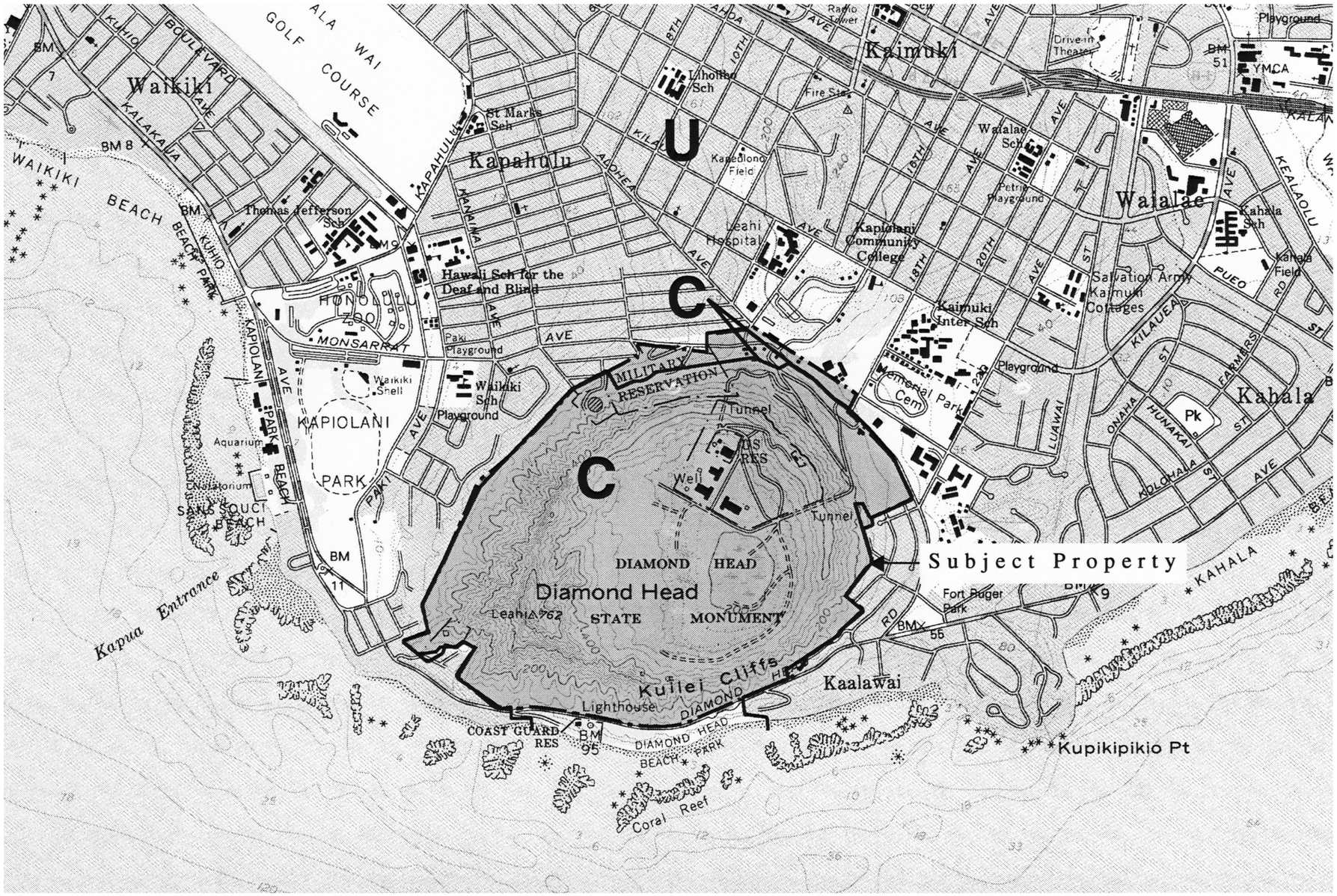

Figure 5
State Land Use Boundary Map

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Master Plan Update

Diamond Head

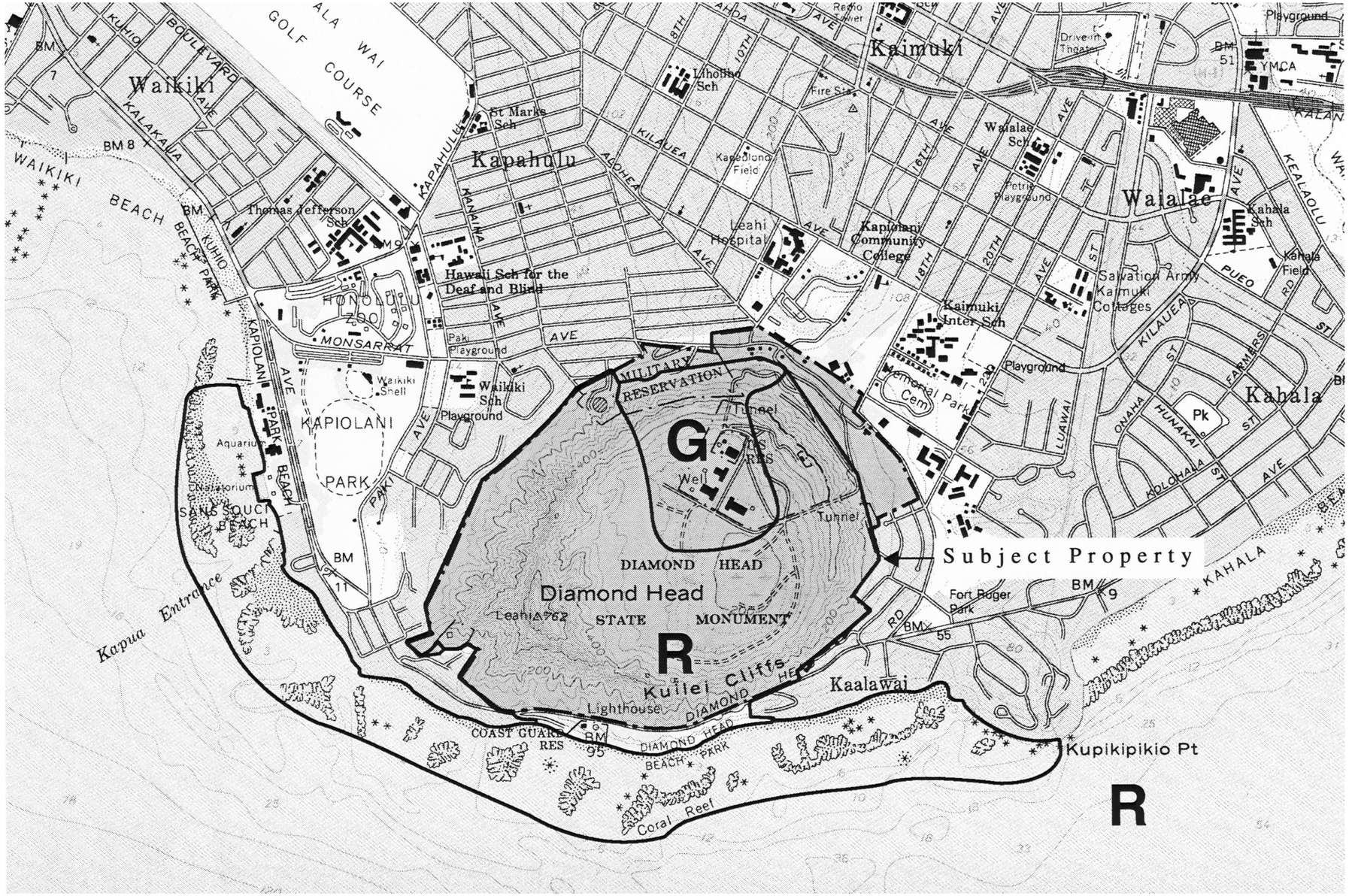


Figure 6
Conservation District Subzones

Master Plan Update

Diamond Head

DHSM should be amended on the PUC DP Land Use Map.

Land Use Ordinance: The P-1, Restricted Preservation District establishes most of DHSM's underlying zoning (Figure 7), it is "intended that all lands within a state-designated conservation district be zoned P-1 restricted preservation district." As such, "within the P-1 restricted preservation district, all uses, structures and development standards shall be governed by the appropriate state agencies." Portions of the Monument are zoned P-2, General Preservation, F-1, Military and Federal Preservation, and R-5, Residential District.

In their review of the Draft EIS, the City and County of Honolulu Department of Planning and Permitting (DPP), wrote that, "the proposed use is considered a public use and is a permitted use within any zoning district regulated by the city."

One exception where the plan does not conform with existing land use regulatory controls is that the height limit of the City and County of Honolulu's Diamond Head Special District will be exceeded. The Diamond Head Special District calls for 0 feet height limit in the area around the DHSM. The proposed visitor/interpretive center, comfort stations, wetland viewing platform, entry guardhouse (at Makapu'u Avenue) and a people mover booth will all exceed this height limit. It should be noted that current (or recently built) projects (not covered by the Master Plan Update), including an interim interpretive kiosk and toll booth at the entry to Kāhala Tunnel will also exceed this height limit.

Diamond Head Special District (Ord. #77-123): The Special District designation (Figure 8) is for "Areas wherein natural and man-made objects of beauty and historic, cultural, architectural and scenic significance may be preserved, enhanced and perpetuated."

Every development in a special district is classified into one of three categories: major, minor, or exempt. Major and minor projects require a special district permit. Major permits are required for projects that may significantly change the intended character of special district. Major permits require review by the neighborhood board before submission of the application, a public hearing by the Director of the Department of Planning and Permitting (DPP) (formally Department of Land Utilization), and review by the Design Advisory Committee. Minor permits are required for projects that will have limited impact. The Director of DPP has the right to review and modify such projects. Exempt projects have negligible or no impact. They include projects that require emergency repairs, interior work and, in some cases, do not change the exterior appearance of a structure. It is anticipated that implementation of the Master Plan Update will require a Major Permit.

Special Management Area (SMA) Permit: The entire DHSM lies within the Special Management Area (SMA), a County designation designed to protect shoreline areas and natural resources of the coastal zone. Because implementation of the DHSM Master Plan Update within the SMA will probably exceed $125,000, an SMA Use permit is required from the County.

In their review of the DEIS, DPP wrote that, "…the project is within the Special Management Area and a major Special Management Area Use Permit will be required. It would be appropriate for the project's Master Plan to be comprehensively reviewed during the processing of this permit."

Draft Honolulu Bicycle Master Plan: In July 1998, the City and County of Honolulu Department of Transportation Services (DTS) published the *Draft Honolulu Bicycle Master Plan*. The plan provides a strategy for the bicycle component of Honolulu's future transportation system. It identifies an integrated network of on-road bike lanes and off-road multi-use paths. The plan also provides recommendations for the development of a regional network of almost 100 miles of new bicycle routes, stretching from Kāhala to Pearl City. While the portion of the DHSM that encompasses area roads is limited to Diamond Head Road and Makapu'u Avenue between the Cannon Club and 18th Avenue, DLNR is coordinating with DTS to try to accommodate

improved bicycle facilities as part of the DHSM Master Plan Update. Current proposals include the construction of a multi-user, grade-separated pedestrian bike path along Diamond Head Road between 22nd Avenue and the Cannon Club and the provision of secure bicycle parking at the Cannon Club and at the entries to the crater.

2.4 IMPLICATIONS FOR MASTER PLAN UPDATE

The major concern of the public and the CAC is the disposition of government lands into the monument and the development of facilities within the boundaries, in accordance with Section 6E-32, HRS.

2.4.1 Relocation Plan

The largest of the existing facilities in the crater, the FAA CERAP was recently demolished and the site has been restored. The FAA has recently relocated to a new CERAP facility at Honolulu International Airport.

In addition, the State DOD is planning to relocate its National Guard Facilities to Barbers Point, which may involve vacating Building 301, 303, and 304. When funding is available, these buildings will be demolished and the building sites will be landscaped (Figure 9).

2.4.2 Land Acquisition

Currently, there are nearly 500 acres of land within the Diamond Head State Monument covered under Executive Order No. 2000, dated April 9, 1962, No. 3642, dated February 2, 1995 and No. 3688, dated May 3, 1996 (TMK: 3-1-42: 6, 8, 10, 14, 17, 21, 23, 24, 25, 37, and 38). Executive Order No. 3688 overlaps Executive Order No. 1997, which is under the State Department of Defense. Executive Order No. 3743, dated August 13, 1998, added TMK: 3-1-35:22 and 23. In accordance with Act 182, SLH 1975, "all State lands within and adjacent to the monument shall be returned to the Department for inclusion within the monument, except for land upon which is situated a structure in active use for the proposes originally disposed of." Of lands identified for inclusion into the Monument, the following remain to be incorporated (Figure 10):

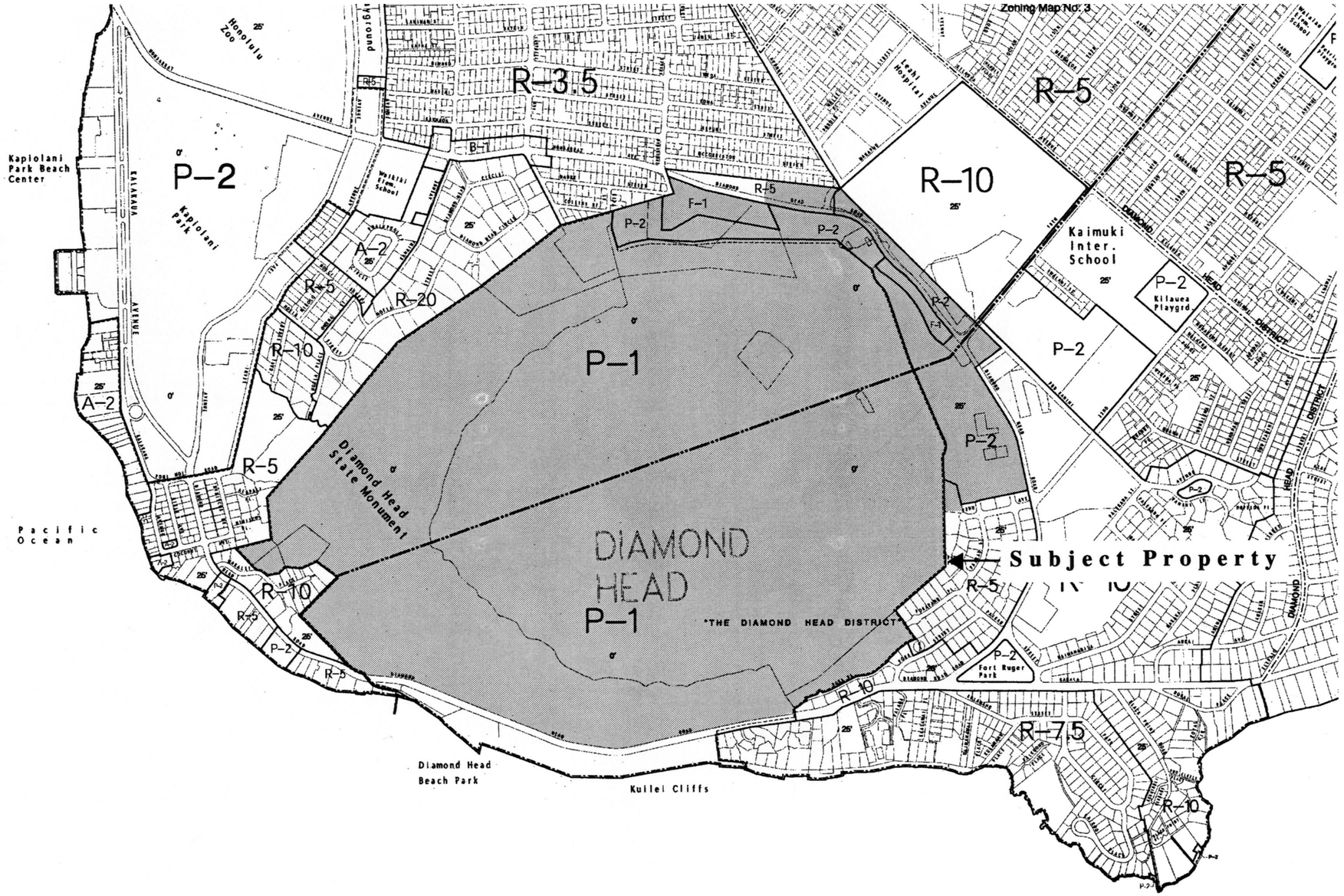
Approximately two acres of land currently used as a State Parks Baseyard along Diamond Head Road as identified as TMK: 3-1-42, portion of parcel 20.

Approximately 3.4 acres of land that up until recently had been used by the Federal Aviation Administration within the Crater identified as TMK: 3-1-42, parcels 15 and 16.

Approximately 7.0 acres of land comprising the Cannon Club as used by the U.S. Army and identified as TMK: 3-1-42, parcel 11.

2.4.3 Government Rules and Regulations

Each level of government has established legal requirements with regard to zoning, management, facilities, and use of Diamond Head under the respective designations – City and County of Honolulu Special District, State Monument, and National Natural Landmark. Each of them can be considered as a development and use constraint. Implementation of this master plan update will require a number of governmental approvals, providing the public and governmental agencies with numerous opportunities for input and refinement of the project proposals.



Legend

PRESERVATION ZONES

P-1 ..... RESTRICTIVE
P-2 ..... GENERAL
F-1 ..... MILITARY AND FEDERAL

RESIDENTIAL ZONES

R-3.5 ..... RESIDENTIAL
R-7.5 ..... RESIDENTIAL
R-5 ..... RESIDENTIAL
R-10 ..... RESIDENTIAL
R-20 ..... RESIDENTIAL

APARTMENT ZONES

A-1 ..... APARTMENT
A-2 ..... APARTMENT
A-3 ..... APARTMENT

Figure 7
Zoning Map

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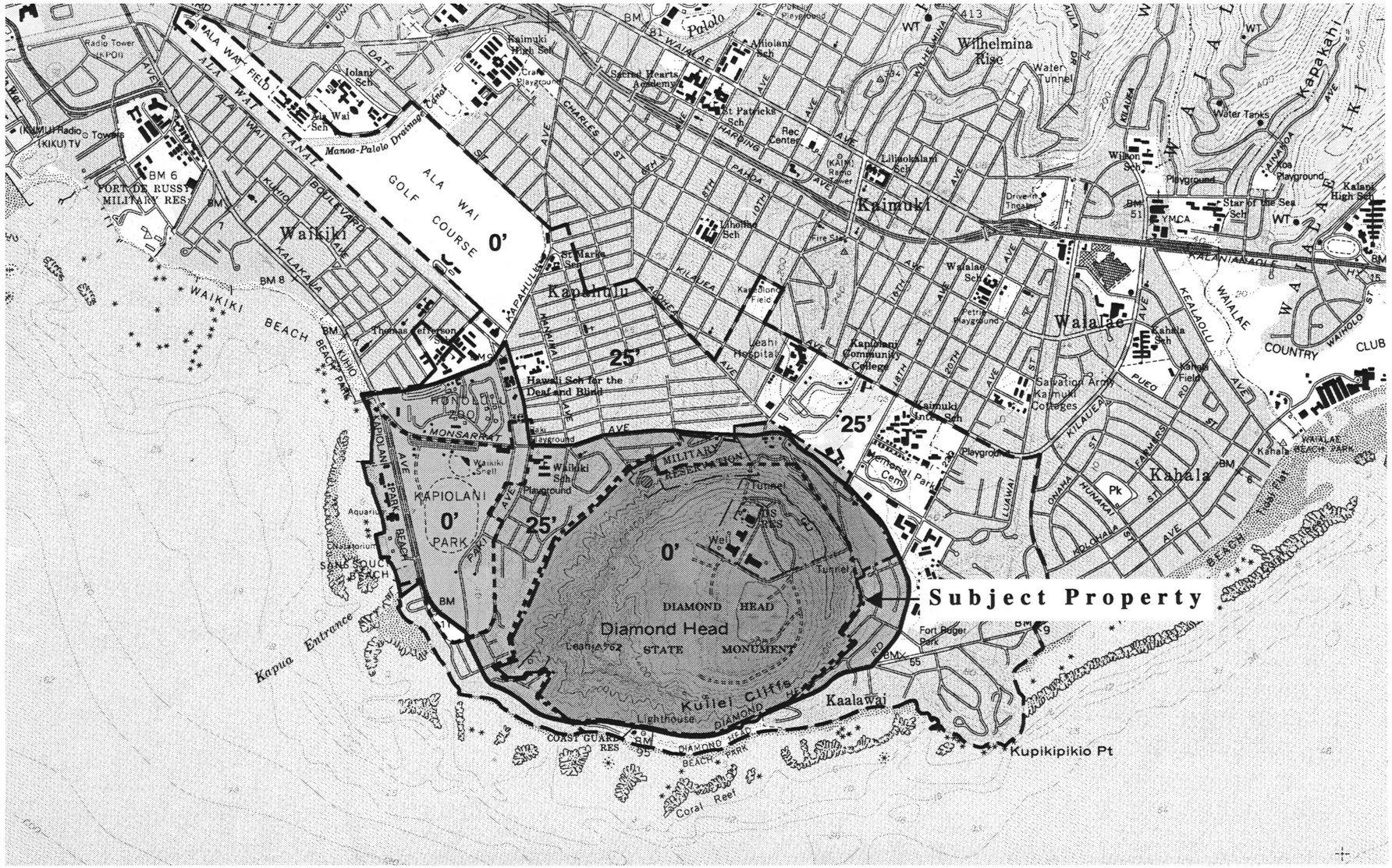


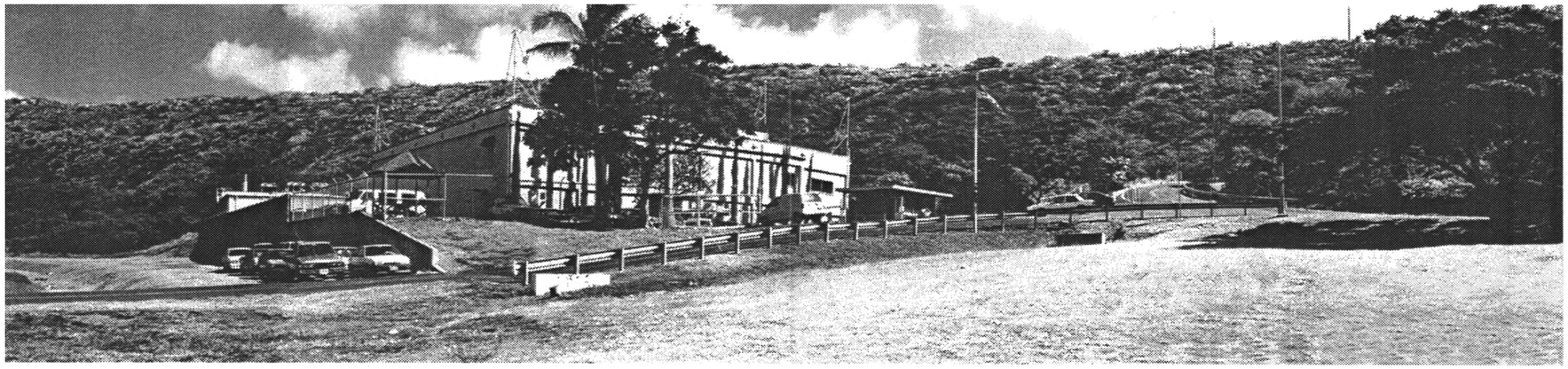
Legend

District Boundary .....

Height Limitation ..... 25'

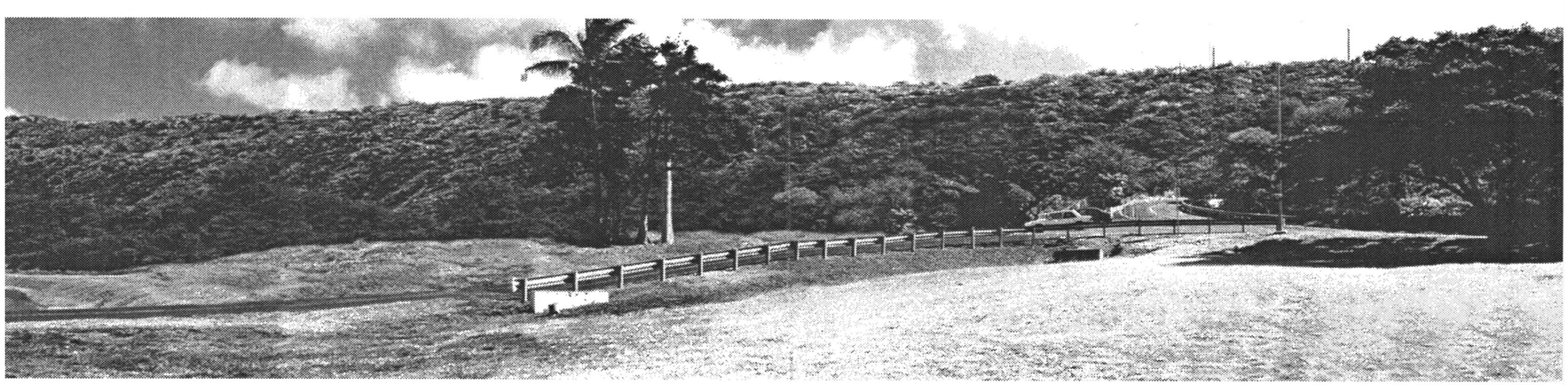
Core Area .....

Figure 8
Diamond Head Special District



A Panoramic View of the Existing CERAP Facility Inside the Diamond Head Crater.

Existing



A Digital Enhancement Showing CERAP Site After Demolition and Regrading.

Future

Figure 9
FAACERAP Site

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Diamond Head

Master Plan Update

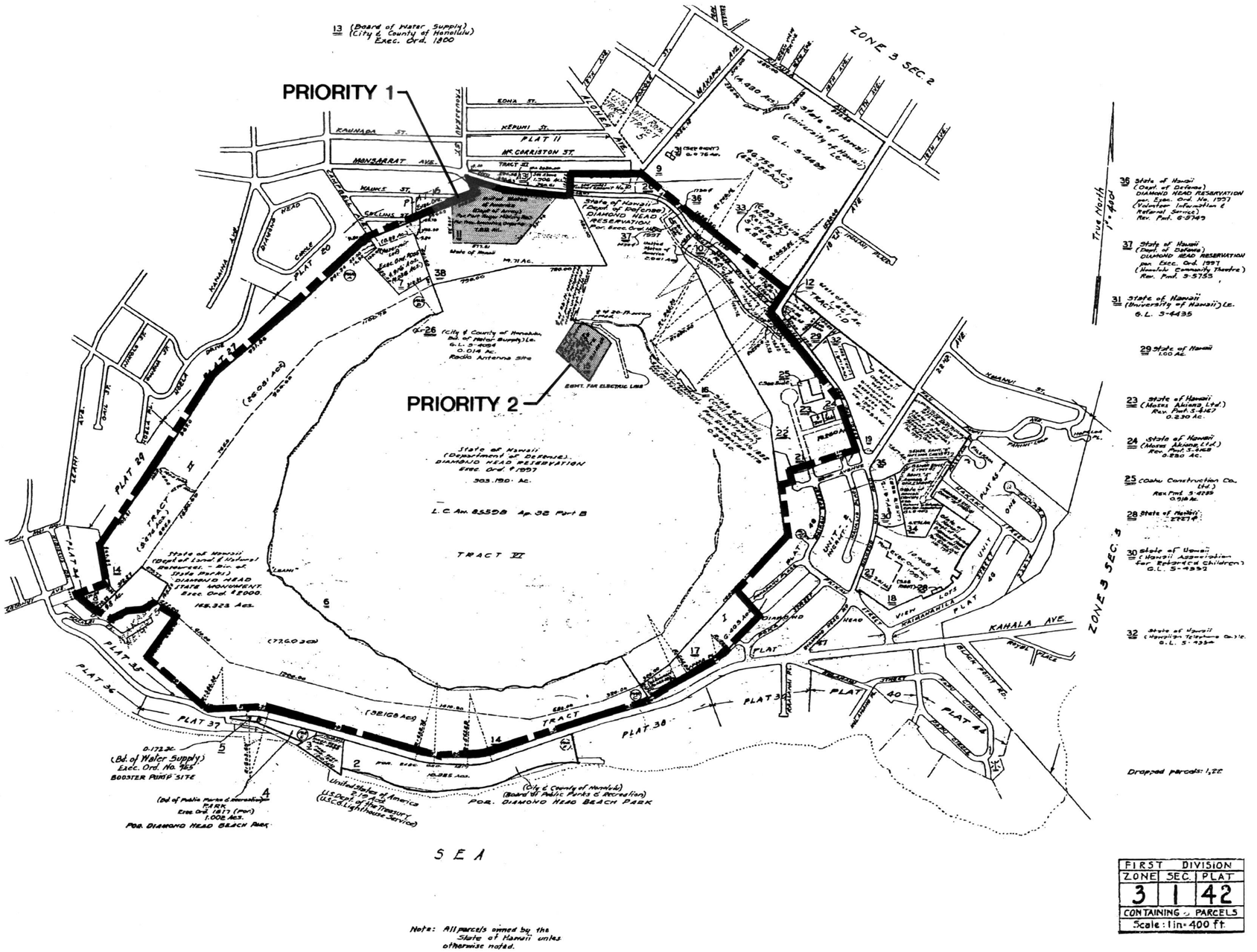


Figure 10
Land Acquisition Map

Master Plan Update

Diamond Head

3.0 Geology/Land Form

This chapter describes the physical features of the crater and the forces that are shaping it (climate, drainage). The understanding of the physical character of the Diamond Head crater is important in developing plans for its improvement, its use and its management.

3.1 TOPOGRAPHY

Diamond Head Crater, is a broad, saucer-shaped crater situated on the Honolulu plain, bounded on the south by the ocean, as shown in Figure 11. The nearly level floor of this roughly circular crater is much broader than the rim is high – its diameter is about two-thirds of a mile (3,520 feet), while its highest point, on the southwest rim, is 761 feet.

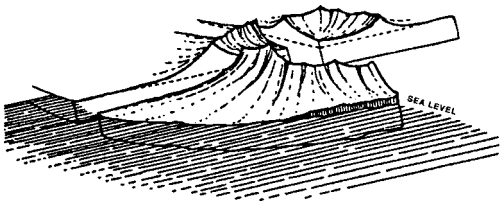


Figure 11
Topography and cutaway Sketch of Diamond Head Crater

Diamond Head

The principal departure from the circular form occurs as an elongation of the southwest rim to the highest point, in a direction about S 60 degrees W, and the longer axis of the crater is approximately 15 percent greater that the shorter axis.

The elevation of about one-fourth of the total perimeter of the rim is below 400 feet, slightly more than half is between 400 and 500 feet, and the remainder is more than 500 feet in elevation. The lowest point, on the southeast side, is about 320 feet above sea level.

The crater floor has slopes running from 2 to 12 percent; about half are 6 percent or less. The lowest point of the crater, due east of the center – covering an area of less than 5 percent of the floor – is less than 200 feet above sea level. Slightly more than half the floor area is below 300 feet.

Two thirds of the crater rim is a sharply crested, circular ridge of 500- to 800-feet width at its base. The slopes, in general, are steep; the outside slope being dissected into alternating ravines and spurs. The remaining one-third of the rim, including all those parts of the crest rising above 500 feet, is somewhat less regular, much more massive, and much more deeply dissected. It is the only part of the crater that shows any considerable amount of dissection of the inside rim.

The massive rim of Diamond Head is eroded by numerous deep, narrow ravines that follow radial courses down the steep surface. Most of the ravine bottoms are only 2 to 3 feet wide – in some places just a few inches. The steeper portions on some ravine channels contain series of potholes. The side walls of the channels are generally fairly smooth, except near their tops.

Most of the cliffs at the heads of the majority of the ravines rise 50 to 200 feet, nearly or quite to the crest of the crater rim and range from slopes of 70 degrees to vertical or slightly overhanging declivities. The smaller ravines head in rounded, funnel-like coves, above which are graded slopes of spurs.

Between the ravines are long, narrow, radial spurs having longitudinal slopes averaging 30 to 35 degrees, but in places these are cut back at the base so that the slope becomes 40 to 45 degrees. The slopes of these spurs are covered by beds of calcareous talus breccia that mantle them, in some places, up to within 100 to 150 feet of the adjacent rim crest.

3.2 GEOLOGY

Diamond Head is the best known of the pyroclastic craters of the world, and is an ideal example of the class. Its significance is such that Diamond Head has been designated as a "Registered Natural Landmark" by the Federal Government.

3.2.1 Summary

Following the erosion of the Koʻolau Range and the formation of a long line of sea cliffs extending from Makapuʻu Head to Pearl Harbor, the eruption of Diamond Head took place well over 150,000 years ago. At that time the sea stood about 40 feet higher than present levels and probably extended to the base of the Koʻolau Range; thus the site of Diamond Head was covered, in part, with offshore coral reefs. It is probable that during the eruption, tuff (rock composed of finer parts of volcanic detritus) was deposited over the reefs in the area north of Diamond Head in amounts sufficient to connect the crater with the main mass of the Koʻolau Range by a neck of land. From what is known of the configuration of the Kaimukī lava, formed at a later date, it seems unlikely that this connection was broken before the formation of the Kaimukī crater. With that renewal of volcanic activity, many thousands of years later, the main vent of Diamond Head remained dormant, but three other vents, not known to have been active previously, opened – Kaimukī, Mauumae, and Kupikipikio. The lavas of Kaimukī and Mauumae established two separate crater masses; the Mauumae lavas made more permanent the neck of the land that joined Diamond Head to the Koʻolau Range. Lava from the Kupikipikio dike added considerably to the height of the Kupikipikio Point and gave greater stability to the original reef-rock mass over which it erupted.

The sea remained about 40 feet higher than present levels for a rather brief period, during which wave action cut cliffs in the tuff, and then receded to a position not more than 12 feet above the present level. Further recession of the sea to its present position, and the continuation of weathering and erosion to the present day, are the closing geologic events of the Diamond Head region.

3.2.2 The Pyroclastic Volcano

The Greek word "pyroclastic" means "fragmented by fire." Hot volcanic materials, such as pockets of magma (molten rock), persist deep within the rocks of volcanic regions. The magma can move above from one pocket to another and even rise to the surface on occasion. Gases generated by magma usually work their way to the surface through cracks or, more slowly, through porous rocks, and escape. When water runs down through the cracks in any quantity, however, thereby coming into direct contact with the hot magma, great amounts of steam are generated with explosive force. The force of this steam breaks through the overlying rocks, fragmenting both the rocks and the hot volcanic materials. All of this pulverized material, and even much larger rocks, can be blown high into the air with the steam. Dust and smaller particles may also be converted into a mud-like material, or simply moist ash, by the steam. Falling back to the surface of the ground, the finer ejected material forms stratified layers that harden and, with time, are consolidated into rock-like material called tuff.

Geologists have recorded 30 eruptions of the pyroclastic type in the southeastern region of Oʻahu. All of these have occurred within a radius of 12 miles of Honolulu and are, therefore, referred to as the "Honolulu volcanic series." Several of these eruptions formed craters similar to Diamond Head; these are well known-Ulupau, Aliamanu, Punchbowl, Tantalus, Round Top (Ualakaʻa), and the series from Manana to Koko Head. The fact that several of these craters can be connected by a straight line indicates that they may have been formed along fissures or fault lines.

3.2.3 The Formation of Diamond Head

In the case of Diamond Head, ground water, both fresh and salt, filtered through the sub-ocean or sub-reef materials, came in contact with hot rocks and molten magma, and generated explosive steam. There was probably a violent earthquake and a deafening roar, and

then the explosion blew a hole up through the layers of limestone, shattering it into small fragments. Moistened by steam and ground water, these materials were blown miles into the air with great clouds of steam.

This activity continued for a few hours, perhaps a day or so, and then quieted down. As the material settled back to earth, it fell most abundantly around the throat through which it had been ejected, forming a cone (Figure 12). Some of the material formed layers down the inside walls, plugging the throat; others formed layers down the outside of the cone. Since the northeast tradewinds were blowing, more of the detritus settled in a southwesterly direction, making that the highest part of the cone. Where the material was soft, much of it was eroded away. Later on, dust, ash, and volcanic mud became compacted and cemented into beds of tuff, which are hard, but not as hard as basalt or lava rock.

In later years, the sea level again rose and eroded away a mile or more of the southern slope of the crater into a sea cliff.

While there is a surprising amount of agreement between the accounts of Diamond Head given by various geologists, there are some differences of opinion on the formation of this volcano, centering on: 1) the time at which the explosive eruptions took place; 2) the nature of the landscape at that time – whether the site was under water or on a raised limestone reef and whether or not it was covered with vegetation; and 3) the duration of the period of explosions, or how long it took to form Diamond Head.

3.2.4 Structural Geology of Diamond Head

Seven principal rock formations are found in the Diamond Head region. The oldest of these is the Koʻolau basalt, which makes up the main mass of northeast Oʻahu. Next is a complex series of calcareous sandstones, conglomerates, and eolian calcareous sandstones. The Diamond Head tuff is third in the age sequence, followed by the Kaimukī basalt, the Kupikipikio basalt, and the Kupikipikio black ash. The exact age relationships of these last three are not known, although they are believed to be essentially contemporaneous. The youngest rock in the region, excluding modern alluvium and talus, is the calcareous talus breccia, found on the lower, exterior *makai* slopes of the crater.

Blocks of marine limestone are found in the tuff of Diamond Head. Fragments ranging from less than half an inch to more than three inches in diameter occur indiscriminately in all parts of the mass, indicating that the ejection broke through coral limestone. All available evidence leads to the belief that limestone is generally present beneath the surface in the entire area of the Diamond Head-Kaimukī projection.

The areal extent of the Diamond Head tuff is roughly Kapiʻolani Park to the west, Kilauea Street to the north, Luawai Street to the east, and along Kaimanahila to the ocean on the south. The tuff varies in depth, with the deepest sections located along the leeward (southwest) slopes of the crater.

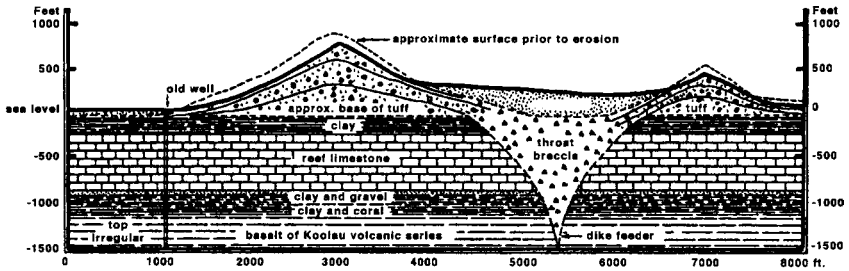


Figure 12

Profile of Geologic Strata
Through Diamond Head Cone and Crater

Talus breccia, with thickness of 5 to 25 feet, and exceptionally to 50 feet, mantles extensive areas of the exterior slopes of Diamond Head. It extends to within a vertical 100 feet of the rim crest on some of the spurs, although considerable areas above the 200-foot contour line are above it. The bedding, crude and irregular, is shown chiefly by the calcareous laminae that separate the materials accumulated during different stages of deposition.

3.3 SOILS

The soils of O'ahu – which have developed from volcanic materials that include lava, ash tuff, and cinders – are inherently rich in iron, magnesium and aluminum, but deficient in phosphorus.

Diamond Head soils consist largely of one-time volcanic ash and lapilli altered to palagonite, but contain, in addition to the magmatic debris, a considerable quantity of talus breccia that formed and was cemented by calcium carbonate when the sea level was 40 feet higher that its present level. Occasional blocks of Ko'olau basalt and numerous fragments of coral limestone from the reef that covered the original volcano site can also be found.

The Makalapa clay series predominates in the alluvium within the crater (Figure 13). These soils are mildly alkaline in their dark grayish-brown, 8-inches-thick surface layer and mildly to moderately alkaline in their 18-to-36-inches lower layer. They are underlain by light-gray to dark grayish-brown, weathered, volcanic tuff. The Makalapa clay series is divided into three types, described below.

The MdB soils come from the shallower slopes (2 to 6 percent) of the crater. Their clay components are very sticky and plastic and therefore very difficult to work. Their shrink-swell potential is high and they crack widely on drying. The permeability and runoff of MdB are slow and the erosion hazard is slight. The available water capacity is about 1.4 inches per foot of soil. Roots can penetrate to the volcanic tuff beneath.

The MdC soil is similar to the MdB except that it occurs on fans (6 to 12 percent slope). Runoff is slow to medium and the erosion hazard is slight to moderate.

On the MdD soil (12 to 20 percent slope), runoff is medium and the erosion hazard is moderate.

Particularly beneath the developed area in the crater's interior, fill of miscellaneous composition and various depths has been added.

3.4 CLIMATE

Diamond Head Crater is situated within the leeward-lowlands climatic subregion of O'ahu. In general, the climate is characterized by a two-season year, by mild and fairly uniform temperatures, by generally humid conditions, and by a dominance of tradewind flow (although the slopes of the crater may negate this flow). Dry weather prevails except for occasional light tradewind showers, which drift over from the mountains to windward, and for periods of major storms. In some leeward areas, an afternoon sea breeze is common, especially in summer.

3.4.1 Seasons

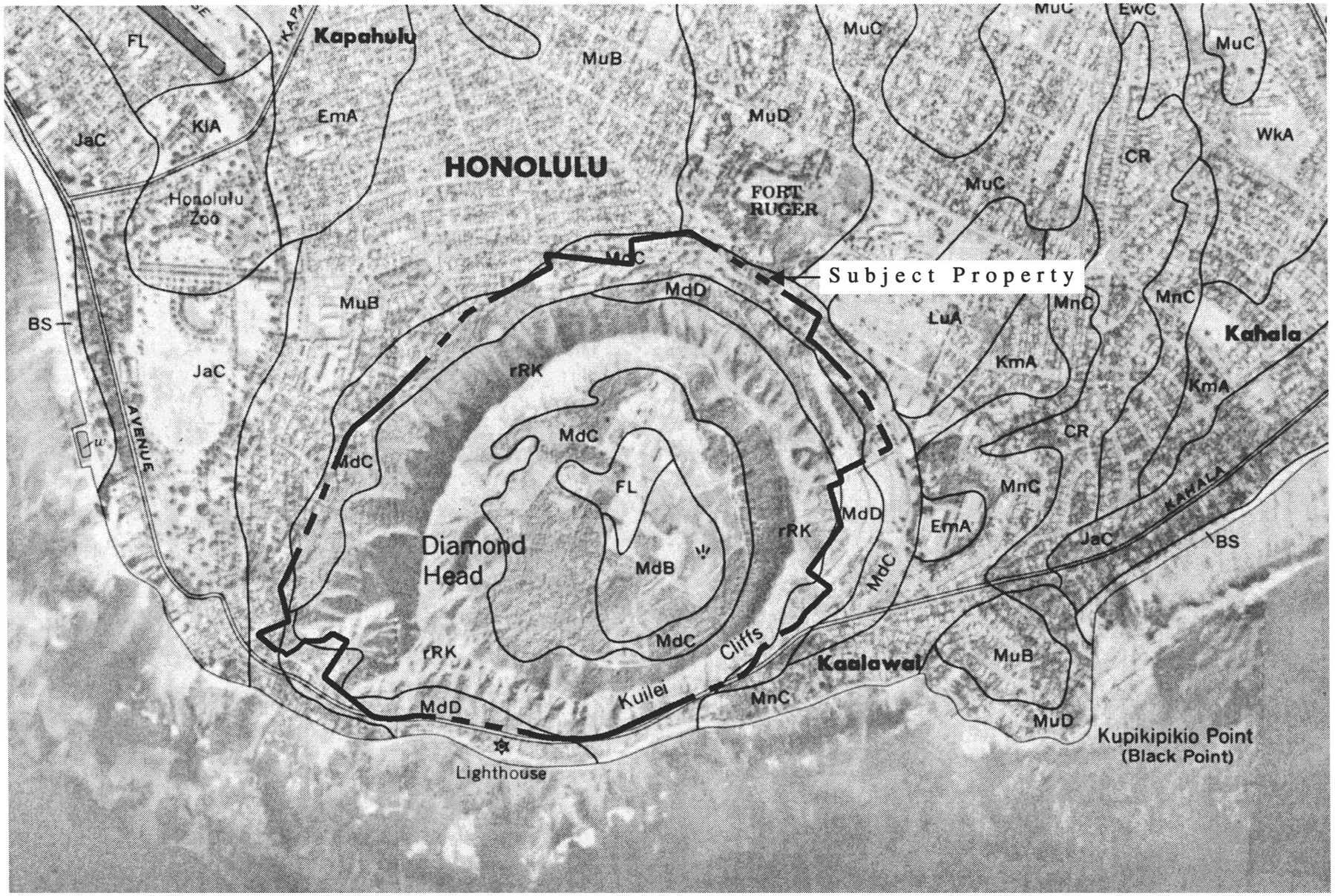
The two seasons recognized are the seven-month winter season (October through April) and a five-month summer season (May through September). Summer is definitely the warmer season, with an overwhelming dominance of tradewinds, rarity of rainstorms, and thus, lower average monthly rainfall.

3.4.2 Temperature

The average-temperature range in leeward O'ahu is small. The warmest month is August, with an average temperature of 78.4ºF; the coldest is February, at 71.9ºF. Temperatures above 95ºF are infrequent.

3.4.3 Wind

As in all mountainous areas, the wind conditions at Diamond Head crater are complex. The high



Legend

MuB ..... Molokai Silty Clay Loam, 3 to 7 % slopes
MdC ..... Makalapa Clay, 6 to 12 % slopes
MdD ..... Makalapa Clay, 12 to 20 % slopes
rRK ..... Rock Land
FL..... Fill Land, Mixed
MnC ..... Mamala stony silty clay loam
MuC ..... Molokai silty clay loam, 7 to 15 % slopes
EmA ..... Ewa silty clay loam, moderately shallow
LuA ..... Lualualei Clay
KmA ..... Keaau Clay
Jac ..... Jaucas Sand
CR ..... Coral Outcrop

Master Plan Update

Figure 13
Soils Map

PBR HAWAII

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Diamond Head

rim of the crater certainly distorts and disrupts the general wind flow, but how it affects the wind situation within the crater is not well known.

The most prominent feature of the air circulation is the northeast tradewind flow toward the southwest. Tradewinds averaging more that 14 miles per hour dominate the flow of air across wide reaches of the lowlands. Light trades permit a diurnal cycle of land and sea breezes. Extremely high winds are unusual inside the crater. The trades prevail 80 to 90 percent of the time from May through September; from October through April, they blow across the islands only 50 to 80 percent of the time on the average.

Local wind regimes may either reinforce or oppose the general flow of air, depending on the local circumstances. Extremely high winds occur only occasionally, and then only as a result of a major storm, the passage of a cold front, or an unusual local situation. The major storms are chiefly events of the winter season and may yield very high winds from any direction.

3.4.4 Humidity and Cloud Cover

Under tradewind conditions, the moisture content of the air is relatively high. The relative humidity commonly averages 60 to 70 percent, with nighttime values frequently between 70 and 80 percent, afternoon values commonly between 50 and 55 percent and seldom below 40 percent. Winter humidity is somewhat higher than in summer and, in terms of daily variations, the maximum values occur with the minimum temperatures during the late night and early morning.

The Diamond Head area is basically sunny. The heavy masses of clouds that frequently cling to the Koʻolau Range crest are usually fragmented by the tradewinds, which sweep the shreds rapidly over Diamond Head and out to sea. Only during extended Kona storms, which occur two or three times a year and most frequently in the winter, may overcast conditions persist over Diamond Head for more than a day.

3.4.5 Rainfall

The mean annual rainfall for Diamond Head is about 25 inches, with a pronounced contrast between the rainy winter season and the drier summer season. Most of the winter rainfall occurs in general storm situations, while most summer rainfalls consists of brief tradewind showers.

The heaviest storm rains frequently occur in localities that do not have the greatest average rainfall, and it is not uncommon during such storms for relatively dry areas such as Diamond Head crater to receive within a single day, or even a few hours, totals approaching their mean annual rainfall.

At all times of the year in leeward Oʻahu, rainfall is most likely to occur during the night or early morning (59 percent) and least likely to occur during mid-afternoon; in general, this diurnal variation is far more pronounced in summer than in winter.

The amount of rainfall is highly variable from one year to another, however. The precipitation of a particular month may vary by 200 to 300 percent over a period of years; in Honolulu, in a 62-year period, for example, the extreme values were 46 and 10 inches. Rainfall variability is far greater during the winter, when occasional storms may contribute appreciably to rainfall totals, than during summer, when tradewind showers provide most of the rain. With such wide swings in precipitation, it is inevitable that there will be occasional drought years in which the winter rains fail and there are only two, one, or even no rainstorms of real magnitude. Such a deficiency of winter storms hits hardest the

normally dry areas, such as Diamond Head, which depend chiefly on winter rains and receive little precipitation from the summer tradewind showers. In these localities the small amount of rainfall that occurs during the usual dry summer season is insufficient to prevent severe drought.

3.4.6 Storms

Most of the time, O'ahu's weather is dominated by the tradewinds; non-tradewind conditions are quite different. Four classes of non-tradewind disturbances produce major storms affecting the state – cold-front storms, Kona storms, hurricanes and tropical storms, and storms associated with upper-level low-pressure systems.

Cold-front storms occur during the winter when cold fronts sweep across the islands, bringing locally heavy showers and gusty winds. As few as one or two, or as many as six or more cold-front storms may occur in a year. Perhaps once every three or four years, on the average, a cold front storm will produce winds strong enough to do scattered damage to trees, crops, and houses.

Kona storms, like cold-front storms, are features of the winter season, occurring when a storm eddy, or low, moves past the islands, bringing wide-spread heavy rains, often accompanied by strong southerly winds. The rainfall in a well-developed Kona storm is more widespread and more prolonged that in the usual cold-front storm. If the Kona storm is accompanied by high winds, the winds are usually steadier and more prolonged, but not as strong as the extreme winds of the cold-front storm. An occasional entire winter may pass without a single well-developed Kona storm; more often, however, one or two such storms occur per year, and rarely four or five. Kona rains, lasting from several hours to several days, may fall steadily, but the longer-lasting ones are characteristically interrupted by intervals of lighter rain or even partial clearing, as well as by intense showers superimposed upon the more moderate regime of continuous, steady rain.

True tropical storms, of which the hurricane is the most intense, rarely strike the Hawaiian Islands, but they may pass close enough to yield heavy rains, high winds, and great waves crashing against the coasts. Six true hurricanes have struck since 1950, although at least as many others have passed within 300 miles or so during the past decade. Tropical storms, similar to hurricanes but with less intense winds (below 74 mph), are more frequent. Hurricanes and tropical storms are not limited to the winter season – they are most likely to occur from July through December.

Storms associated with upper-level low-pressure systems often resemble a Kona storm and may be mistaken for one, except for the absence of the persistent and sometimes strong southerly winds that frequently accompany Kona storms. The surface winds during these events may be from any direction, and are often light.

Intense local rainstorms, other than tradewind storms, are small events that occur most typically in the late afternoon or early evening at any time of year. Waterspouts and other funnel clouds are not uncommon in the Hawaiian area. About 20 of them are reported in the average year, although probably at least as many more are sighted but not reported. Occasionally a waterspout will drift onshore and do some damage. Some tornadoes have been known to form over the islands with the same effect, but these phenomena appear to be far less violent than the worst of their counterparts in the mainland United States. Lightning and thunder of the violence common in some areas of the mainland are quite uncommon in Hawai'i.

3.5 HYDROLOGY

Hydrology is the science devoted to the investigation of the properties, distribution, and circulation of water in the atmosphere, on the surface of land, and in the soil and underlying rocks. It incorporates wide fields of study — geology, topography, soils, and climate — the essential elements affecting the hydrographic nature of an area. As these elements are addressed separately in this report, we shall limit the hydrology of the study area to surface and ground water.

3.5.1 Surface Water

The source of surface water in this area is precipitation. Though relatively dry, this area may receive heavy rains during a winter storm. When this occurs, runoff is at a maximum because of the shallow soil depths and soil type (Makalapa clay series) on the crater slopes. This water runoff creates problems of erosion and mudslides onto the roadways in the interior.

Drainage both inside and out is along radial lines in the narrow, steep-sided ravines. No streams flow, except for brief periods following heavy rains. The interior drainage runs to the lowest point, where it ponds and either is pumped out of the crater, evaporates, or percolates through the ground. During the rainy winter seasons a pond sometimes occupies the lowest part of the crater floor for two or three weeks at a time; however, flooding appears to have been less frequent in recent years. This change may be related to a periodic fluctuation of rainfall or a progressive change toward drier conditions.

There is a slim possibility that the change may be in some way connected with the general lowering of the ground-water level in the Honolulu region in recent years.

3.5.2 Ground Water

In Hawai'i, ground-water sources fall into one of four categories: 1) lens-shaped bodies of fresh water floating on salt water, either freely or confined by the coastal caprock under artesian pressure; 2) brackish water where there is no fresh-water lens, or in the transition zone between salt water and the fresh lens; 3) water impounded at higher elevations by volcanic-dike systems; and 4) water perched on impervious strata. The crater ground water is in the fourth category; the lens is shallow and the tuff, which is much less permeable than the basalt, limestone, and recent alluvium, serves as a caprock or retaining member.

3.6 Implications for Master Plan Update

Physiography

Although Diamond Head is considered a dormant volcano, eruptions could still occur for thousands of years. Of immediate concern is the physiographic condition in which two-thirds of the crater rim is sharply crested, creating potential falling-rock conditions to residential areas below on the exterior, and people hiking trails in the interior. The outside upper slopes, which are sharply dissected into deep gullies, and the crumbly texture of the volcanic materials both inside and outside of the crater, are serious hazards.

Soil

The inherent qualities of Makalapa clay (low permeability, high shrink-swell potential, high plasticity) in themselves become a limiting factor for development. Areas with slight-to-moderate slopes have been disturbed somewhat, especially in the bottom lands, where fill material and exposed rocks cover the crater floor.

Hydrology

Intermittent heavy rains during winter storms cause sheet drainage that forms a pond on the crater floor. On occasion, this ponding has flooded a portion of a road and a sewage pump station and therefore a water pump was installed to alleviate flooding. Rotting vegetation creating a stench and problems with night mosquitoes also contributed to the need for pumping out the stagnant water. Designs will have to consider ways to create and maintain ponding for a wetland habitat in the area.

Future non-potable groundwater improvements that could be developed to supply irrigation water for the proposed project may include development of water supply wells and construction or improvement of storage and pumping facilities within the crater. Development of groundwater sources is subject to review and approval by the State Commission on Water Resource Management (CWRM).

Climate

Passing tradewind showers and winter storms are annual weather hazards to the user, for whom slippery conditions are more treacherous on the upper, steeper slopes. The pronounced wet and dry seasons in general, however, cause the greatest overall effects on the physical environment. Subtle relationships of soil to vegetative growth directly influence development constraints and recreational pursuits.

Along the crater rim turbulent winds are created by the merging updrafts from the crater floor and crater exterior. Lengthy trails along this rim are not recommended because of these unpredictable turbulences. Occasional strong winds also sweep the valley floor, kicking up small dust storms during the dry months.

4.0 Biological Resources

This chapter describes the biological resources of the DHSM. Although most of the crater is covered by alien, dryland species, there are some unique resources that should affect its development, use, and management.

4.1 FLORA

According to the Department of Land and Natural Resources, today the flora of the crater consists of an alien, coastal dryland plant community. The crater slopes and floor are dominated by *kiawe* trees (*Prosopis pallida*) and *koa haole* shrubs (*Leucaena glauca*) with an understory of lantana (*Lantana camara*), *'ilima* (*Sida fallax*), and alien grasses (California grass, buffel grass, sour grass, and fountain grass).

Alien Floral Species

The *kiawe (Prosopis pallida*) is native to South America and is related to the mesquite (Algaroba). It was introduced to Hawai'i in 1853 when a single tree was planted on the grounds of the Catholic Mission on Fort Street in Honolulu (Wagner et al, 1990: 693). *Kiawe* is a common tree found on the leeward side of all the major Hawaiian Islands. It has adapted well to Hawai'i's semi-arid environments and shallow soils resulting in forests of these trees. As the growth of these trees expanded in the late 1800s, the seed pods were collected as feed for cattle, horses, mules, and pigs. The livestock promoted the extensive spread of these trees throughout the islands. Today the wood is favored for charcoal. *Kiawe* trees grow up to 60 feet in height and have hard, dense wood with thorns, small bipinnate leaves, spirul seed pods, and elongate yellow mimosaceous flowers (small, ball-like clusters).

Koa haole or *ēkoa* (*Leucaena leucocephala*) was also introduced in the 19th Century and spread rapidly throughout the Hawaiian Islands. This species is native to the Neotropics. Like *kiawe*, the *koa haole* has adapted well to Hawai'i's dry, lowland climates and is found in areas with a wide range of soil conditions. *Koa haole* is considered both a shrub and small tree that spreads into shrublands, often with a grassy understory. It was probably introduced for fodder, firewood, and erosion control. Like *kiaw*e, *koa haole* has small bipinnate leaves. It has ball-like mimosaceous flowers that are green to white. The seed pods, however, tend to be elongated and flat.

The highly invasive fountain grass community is potentially the most devastating to native dry and mesic ecosystems. The species is one of the worst invaders in the Hawaiian Islands (potentially second behind *Miconia calvescens*) and is targeted for eradication from Diamond Head by the Oahu Fountain Grass Working Group.

Recently, the U.S. Fish and Wildlife and the State Department of Land and Natural Resources approved additional personnel to assist the Oahu Fountain Grass Working Group in eradicating fountain grass from Diamond Head Crater. The control methods consist of: manual clearing (pulling weeds, clipping of flowering seed heads), chemical application (herbicide Velpar), and incineration of collected material to prevent inadvertent dispersal by field personnel. Focus areas for fountain grass control include Diamond Head trail, where seed can "hitchhike" onto visitor's clothing, and "fringe" areas where fountain grass has been observed moving into new areas.

An effective alien plant control program must consist of replacing the removed alien plants with native plants. This will decrease the potential for the alien plants re-invading the control areas, thereby facilitating a more permanent solution. Simply removing the alien plants will only result in a continuous cycle of control and invasion.

Native Floral Species

One native shrub, *Schiedea adamantis* (Figure 14), is listed as an endangered species and is only known to exist on the northern rim of the crater (U.S. Fish and Wildlife, 1994). The numbers of this plant appear to vary greatly from year to year but have survived fires, competition from alien species, and construction activities.

Bidens Cungata may also be present, as it was last seen years ago below the summit.

It is likely that a native coastal and dryland forest existed in the crater prior to Western Contact. According to DLNR, this dryland forest may have consisted of the following trees, shrubs, and ground covers.

Trees:	*ʻAlaheʻe*, *ʻiliahi*, *lama*, *ʻōhai*, *ʻuhiʻuhi*, and *wiliwili*.
Shrubs:	*ʻAʻaliʻi*, *ʻakia*, *ʻakoko*, *maʻo*, *naio*, *pua kala*, and *ʻulei*.
Ground cover:	*ʻIhiʻihilauakea*, *ʻilima*, *iwaʻiwa*, *hinahina*, *kakonakona*, *nehe*, *paʻu o hiʻiaka*, and *pili* grass.

Ilima (*Sida fallax*) is a perennial shrub that is commonly associated with coastal and lowland dry communities. Small hairs cover the stem and broad ovate leaves giving the plant a velvet look and feel. The solitary, five-petal, orange-yellow flowers occur year-round. The seeds are held in an ovoid pod. *ʻIlima* is found scattered throughout the crater, on the floor and the slopes.

Pili grass (*Heteropogon contortus*) is a perennial and is found in open, dry, sometimes rocky, land. *Pili* was preferred to other thatch material because of its pleasant odor, brown color, and neat appearance. In a dry locality, a house made of *Pili* grass lasted 10 years or longer. The plant forms tufts as high as 3 feet, has leaf blades 4 to 12 inches by about .25 inch, and has narrow, crowded flower spikes up to 4 inches long. The spikelets overlap and each fertile one bears a conspicuous red-brown awn or bristle about 4 inches long, made crooked with two bends.

Hawaiian cotton (*maʻo*; *Gossypium tomentosum*) is a perennial shrub that grows 0.5 to 1.5 meters in height. The plant has solitary, yellow flowers and 3 to 5 lobe leaves. The seeds are found within the lint balls. Common in arid coastal plains, some plants have recently been planted in the wetland area.

One of the unique habitats within this mostly alien, coastal, dryland plant community is the wetland on the crater floor. An early description of the lake or pond within Lēʻahi crater is from 1831 when botanist Dr. F. J. F. Meyen was making observations of Oʻahu. He describes the lake as follows:

> *Its crater is about 100 feet deep and had, when we were there, a small pool of water at the bottom, which was completely covered with plants. (Pultz and Jackson, 1981: 55)*

This pond is centered in the southeastern quadrant of the crater floor. The wetland occurs after heavy rains because of low permeability through the tuff soils. Descriptions of the crater floor from the late 1800s describe this wetland as a lake that encompassed as much as half of the crater floor, which attracted various species of waterbirds. The size and duration of the pond appear to have varied greatly over time. David Hopper, a biologist with the U.S. Fish and Wildlife Service, notes that the existing pond may measure up to 6 feet deep near the drainageway sump, while shallower depths of less than 2 feet may encompass three to five acres during peak rains (Hawaiʻi Army National Guard et al, 1997). The pond is most evident during the winter months after heavy rainfall while it may be completely dry during the summer. When water is present in the depression around the pump, native waterbirds and endangered native sedges have been documented.

Two rare and endangered sedges were discovered in the wetland in 1997, *Torulinium odoratum* subsp. *auriculatum* and *Cyperus trachysanthos*. The last sighting of *T. odoratum* subsp. *auriculatum* in this wetland was 1939. In 1997, 27 individuals of *T. odoratum* subsp.

auriculatum and 56 individuals of *C. trachysanthos* were noted in Diamond Head.

The distribution of *Cyperus trachysanthos* is inherently linked to the formation of the wetland during heavy winter rains. As such, the sedge species may not be present all year round, but rather a significant seed bank may persist from year to year, permitting re-sprouting during the rainy season.

Endangered Plant Species

At least three endangered species are found inside and on the slopes of Diamond Head: 1) *Spemolepis hawaiiensis*, 2) *Cyperus trachysanthos* in the wetland area, and 3) *Schidea adamantis* on the crater rim.

Figure 14
Schiedea Adamantis

Diamond Head

4.2 FAUNA

The fauna seen today in Lē‘ahi is dominated by introduced, alien species. According to DLNR, an 1899 photograph of the crater interior indicates grazing animals, possibly cattle, horses, and/or goats were in the crater and the floor appears to have been a grassy pasture. Mules were used by the Army in the construction of the batteries and Fire Control Station Diamond Head in the crater. The presence of these grazing animals may account in part for the shift to a *kiawe-koa haole* forest.

Alien Birds

Today, the fauna of the crater is dominated by alien bird species common in an urban setting. The common birds seen in the crater today are:

Brazilian Cardinal. Native to South America, this bird is identified by its brilliant red head, crest and throat. The back, wings, and tail are an ashy gray. Both sexes are alike. This species was introduced on O‘ahu in 1928. These are the first birds to sing in the morning. They nest in trees often 25 feet or more above ground.

Kentucky Cardinal. Native to North America, the male bird is all red while the females are yellowish brown with varying amounts of red in plumage. These birds were released on O‘ahu between 1929 and 1931. These birds are common in dry, *kiawe* thickets.

Myna or Mynah. Introduced from India, these birds are marked by a black head and neck, a brown back, and yellow around the eye. It is reported that the mynah was introduced in 1865 to combat the plague of army worms ravaging the pasture lands throughout Hawai‘i. It was reported as abundant in Honolulu in 1879 and is now abundant in lowland areas. These birds are often described as comical, charming, and intelligent. They can also be quite noisy, aggressive, and quarrelsome, especially when in groups. Adults are about nine inches.

Doves. The barred dove is distinguished by bars on the neck, back, and wings. It is generally small (8 inches) with pale brown above and gray below. It is thought to have been introduced

from Malaysia in 1922. The spotted dove is larger (12 inches) and grayish brown in color with white spots on the neck. It was introduced from eastern Asia, although date is unknown. These doves are common in dry areas where *koa haole* and *kiawe* flourish.

Sparrows. The House Sparrow was released on O‘ahu in 1871 and is native to Europe and Northern Asia. It is a small bird (6 inches) that is generally brown with streaks of buff and black and gray underside. The Java Sparrow is native to Java and Bali and was introduced to Hawai‘i in 1865. This small bird (5 inches) has distinctive markings – black head, two large white ear or cheek spots, brownish gray underside, pearl gray back and pinkish beak. Sparrows are usually seen in flocks of several birds.

Bulbul. The red-vented bulbul is brown with a black head and tail, a white abdomen, and crimson under the tail. Native to Asia, the bird was released in 1965 or earlier. These birds are described as noisy and aggressive and they tend to perch in trees and on wires.

Japanese White-Eye (*Mejiro*). Introduced from Japan in 1929, this small (4.5 inches) bird is marked by its olive-green color and conspicuous white eye ring. These birds are described as very active and constantly moving in search for food. They are usually seen in flocks and often noisy.

Francolins. Found in dry open grass and shrubby country, these birds were introduced for hunting in the 1860s. These tend to be larger birds (13-16 inches) with distinctive cackles and calls.

Yellow-Fronted Canary. Widely distributed in Africa, this small (4.5 inches) bird was first reported on O‘ahu in 1964. The underparts, auxiliary feathers, rump, cheek, and a line over the eye are yellow in the male; the female is more gray or green on the upperparts, has a necklace of spots, and has paler yellow underparts than the male. The species is now a common resident in the Diamond Head-Kapi‘olani Park region of Waikīkī.

Native Birds

The presence of native Hawaiian birds in the crater has not been well documented. According to DLNR, the following birds are assumed to be present during various times of the year and under certain environmental conditions:

Hawaiian Owl (*Pueo*). This is a short-eared owl native to all the Hawaiian Islands. This large bird (13-17 inches) is brown and buffy white, streaked with darker brown. The *pueo* hunts both day and night and ranges from open grassy areas to rainforests. The *pueo* was worshiped by the Hawaiians. According to traditional Hawaiian beliefs, the god Kāne might appear as an owl and turn aside the weapons of enemies. Owls were also family protectors.

Hawaiian Coot (*‘Alae Ke‘oke‘o*). This subspecies of the American Coot is found on all the main islands except Lāna‘i. It averages 14 inches in size and is grayish black with a white bill and frontal shield. The coot is found in marshes and ponds and rarely flies. It builds floating nests of aquatic vegetation and prefers open water areas.

Hawaiian Gallinule (*‘Alae ‘Ula*). This subspecies of the Common Gallinule is less common than other endemic waterbirds. It averages 13 inches in size and is gray with a red frontal shield and yellow-tipped bill. It favors ponds, marshes, and taro patches, and prefers to stay near the vegetation. In Hawaiian mythology, this bird was said to have brought fire from the gods to the Hawaiian people.

According to DLNR, when the wetland is present, several native birds and one migratory bird return to the crater, including the *koloa* (duck), the *kōlea* (plover), *‘alae ke‘oke‘o* (Hawaiian coot), and *‘alae ‘ula* (Hawaiian gallinule). It is also reported that prior to the bulldozing and filling, the wetland contained *Euglena* (microscopic plant-animal) and *Bufo marinis* (toad). The presence of the indigenous dragonflies (*Anax junius* and *Pantala flavenscens*), freshwater crustaceans (*Saphnia* spp.), and introduced tilapia has also been noted for the wetland area.

Other species commonly sighted in and around the crater include: *Felis catus* (house cat), chickens (*Gallus*), and rats (*Rattus*).

4.3 IMPLICATIONS FOR MASTER PLAN UPDATE

Both the soil characteristics and the semi-arid conditions limit the kinds of plants that grow in Diamond Head. These factors limit the flora to hardy plants, most of which are exotics, although some have developed a dormancy period in order to survive. The dry conditions also create a potential fire hazard.

The interior of Diamond Head Crater receives much human use by government agencies (State DOD), as well as by the civilian populace. The relatively high occurrence of rare and endangered species within the area means that appropriate management activities are needed to minimize the adverse impacts to these species and help promote their recovery.

According to the *Endangered and Rare Species Survey and Management Recommendations for Hawai'i Army National Guard Lands* prepared by the U.S. Fish and Wildlife Service, June, 1998, management plans are necessary to ensure that endangered species within the crater areas are appropriately protected from harmful activities. While such management plans have been, at least in part, implemented for the endangered *Schiedea adamantis*, the other endangered and rare species inhabiting the crater have only recently been found and/or, only recently received listed status (e.g., *Spemolepis hawaiiensis* and *Cyperus trachysanthos*). As a consequence, management for these species are only in the early planning phase. Management efforts should promote the preservation and recovery of rare and endangered species and include the removal/control of alien species and fire control, among other measures.

As part of a Natural Resources Management Plan, a fire protection plan should be implemented. In accordance with recommendations from the Division of Forestry and Wildlife, this plan should include the installation of firebreaks within and around known colonies of endangered species and the removal of flashy fuels.

Ecological Services at the United States Department of the Interior recommends, "draining the wetland periodically in order to eradicate non-native fish that compete with native waterbirds for food sources such as algae and native invertebrates, and in order to make the wetland accessible for weed control. Weed control methods that retain the resting eggs of native crustaceans should be used (i.e, do not bulldoze)." Ecological Services suggests that some fluctuations in water level be maintained because the native sedges may require periodic flooding. Natural hydrology should be modified in order to maintain water in the wetland during dry years. "Such a managed, fish free wetland may support native waterbirds year-round and may also be used as a reintroduction site for the proposed endangered orange black damselfly (*Megalagrion xanthomelas*) or the endangered water fern *Marsillea villosa*." Regardless of the chosen method for managing the wetland Ecological Services strongly recommends active trapping for predators, such as mongooses, rats, and feral cats, as they feed on eggs and birds.

The property may be harboring rodents that could be dispersed to the surrounding areas when buildings are demolished or sites are cleared. Before any demolition or site clearing, rodents will be eradicated and the Department of Health, Vector Control Branch will be notified, as required under Hawai'i Administrative Rules, Chapter 11-26, "Vector Control." To eradicate rodents before any demolition or site clearing, rodent traps and rodenticides will be set out on the site for at least a week, or until the rodent activity ceases.

5.0 Cultural/Historical Resources

This chapter describes the history of Diamond Head, from its known traditional use, its use in the 19th century, its use for military purposes, and its present-day use. This history is important for planning and managing DHSM, not only for its interpretive value, but for its recreational and scientific value as well.

5.1 Place Names

Diamond Head was given its name by British sailors who found natural calcite crystals on the slopes of the mountain and mistook them for diamonds (MacDonald and Abbott 1970:373). Hawaiians called the volcanic cone Lē‘ahi, Lae‘ahi, or Lae-ahi; for this report, the name Lē‘ahi is used interchangeably with Diamond Head. Clark (1977:41) summarizes the etymology of the Hawaiian name:

> ...to the old Hawaiians the mountain was either Lē‘ahi or Lae‘ahi. Because the original meaning of the name is obscure, the correct spelling and translation have never been agreed upon by students of Hawaiian. One interpretation says that Lē‘ahi is a contraction of the two words *lei* (a wreath) and *‘ahi* (fire)[1], the two words combining to mean “wreath of fire” ... The other popular interpretation is that Lē‘ahi is a contraction of *lae* (a cape or promontory) and *‘ahi* (the yellow-fin tuna), the combination meaning “point of the *‘ahi* fish.”

In the legend of Pele and Hi‘iaka, Hi‘iaka is said to have compared Diamond Head to the brow of the *‘ahi* (Palikapu n.d.):

> Me he i‘a la ka Lae o Ahi
> E kalali au ae nei i ke kai
>
> Like a fish is the Brow-of-the-ahi
> Resting high above the sea.

[1]Clark misspells the Hawaiian word for fire, which is *ahi*; there is no glottal at the beginning of the word. The word for the yellow-fin tuna begins with the glottal (*‘ahi*).

Clark (1977:41) also suggests the possibility that the cone was used as a reference point in locating the fishing grounds of the *‘ahi*.

An alternative translation of the name combines *lae* and *ahi* as “cape of fire” (D. Tuggle, pers. comm.). From certain points of the southern coast of O‘ahu, the rising sun on the summer solstice appears to emerge as a glowing fire from the center of the crater. This translation may also tie into the presence of a *heiau* called Ahi that was reputed to be located on the crater rim; this *heiau* was “dedicated to the god of the winds as a protection against sudden, violent updrafts which could put out” the navigation fire that was tended at the *heiau* (Division of State Parks 1979:21).

Other names for Diamond Head include Point Rose (given to the geologic feature in 1786 by Captain Nathaniel Portlock in honor of the secretary of the British treasury), Diamond Hill, and Conical Mountain.

5.2 Legends and Traditional Use

Diamond Head is a prominent feature of Honolulu's landscape, and Hawaiian traditions and historical accounts paint Lē‘ahi as a backdrop to a continuum of social, political, and religious events. From at least the 15th century, chiefly residences lined the shore of Waikīkī,

and cultivated fields spread across the Waikīkī plain to the foot of the crater and inland to the Koʻolau valleys. There were numerous temples in Waikīkī, of which several were located around Diamond Head.

One of Kamehameha's main *luakini heiau*, Papaʻenaʻena, was situated at the base of the southern slopes. Other *heiau* in the vicinity include Kupalaha Heiau, which may have been connected with Papaʻenaʻena, Pahu-a-Maui Heiau on the crater's eastern cliffs overlooking the ocean (the site of the present Diamond Head lighthouse), Kapua Heiau near the present Kapiʻolani Park, and Ahi Heiau on the peak of Diamond Head (Division of State Parks 1979:21). Kanahele (1995:71) also writes of a *heiau* – Hale Kumukaʻaha – that was built by the ruling chief of Oʻahu, Kaʻihikapumanuia.

Traditional use of the interior crater of Lēʻahi is somewhat a mystery. The only legendary reference to the crater is the story of Pele and her sister Hiʻiaka. Pele is the fire goddess who is popularly associated with the active volcano Kīlauea on the island of Hawaiʻi. Beckwith (1970:168) writes:

> The Pele myth is believed to have developed in Hawaiʻi, where it is closely associated with aumakua worship of the deities of the volcano, with the development of the hula dances, and with innumerable stories in which odd rock or cone formations are ascribed to contests between Pele and her rivals, human or divine. The myth narrates the migration or expulsion of Pele from her distant homeland and her effort to dig for herself a pit deep enough to house her whole family in cool comfort or to exhibit them in their spirit forms of flame and cloud and other volcanic phenomena.

Diamond Head is one of a number of dormant, shallow craters at which Pele and her sister Hiʻiaka stopped in their search for a new home. Fornander (1916:104) describes the journey of Pele and Hiʻiaka, who begin their travels on Kauaʻi. Their first attempt at a new home on the island of Oʻahu is at Āliamanu and Āliapaʻakai (the present day Salt Lake). Finding these places too shallow, they then try to live at Lēʻahi but also find it unsatisfactory. Their journey takes them to Molokaʻi, then to Maui, and then finally to what becomes their home at Mokuʻāweoweo on the island of Hawaiʻi, where Pele is "successful in digging deep without striking water, an element inimical to her fiery nature" (Beckwith 1970:170).

The crater also figures in stories related to its use as a burial ground. In 1823, the Scottish botanist James Macrae (1972:39) climbed the summit of Diamond Head:

> … we had gained the summit, which is high and steep, without anything growing on it but tufts of dry grass in loose sand, which came up very easily and rendered the ascent more difficult. ... In the centre is a level flat, two acres in size, covered with longer grass than the external declivity. On the inside part next to the sea, the depth is upwards of 500 feet, counting from the narrow ridge round the top, which is almost circular.

In the dark of the afternoon twilight, Macrae's assistant found many human skulls on the inside slopes of the crater. Macrae (1972:40) was later told by his American cook (who had been in the islands for six years) that "the chiefs used to take their criminals upon the top of Diamond Hill to put them to death by throwing them over the precipice, where they were left unburied in the hollow." There are no other references to this practice so its veracity cannot be checked (compare with Mark Twain's story, below).

Addleman ([1940]:4) writes that "on the *ewa* side of the mountain, accessible only from the top, are some of the oldest burial caves on the island, though they were rifled of their contents." He does not cite a source for this information.

The American writer Mark Twain describes a harrowing horseback ride up the side of the crater, and the presence of a large mass grave at the foot of the hill (Day 1975:58-59, brackets added):

> … we got to a point [along the base of Diamond Head] which we were expecting to go around in order to strike an easy road home; but we were too late; it was full tide and the sea had closed in on the shore. Young Henry McFarlane said he knew a nice, comfortable route over the hill… We

> climbed a hill a hundred and fifty feet high, and about as straight up and down as the side of a house, and as full of rough lava blocks as it could stick.
> … It was a great relief to me to know that we were all safe and sound on the summit at last, because the sun just disappearing in the waves, night was abroad in the land, candles and lamps were already twinkling in the distant town ... But a new trouble arose while the party were admiring the rising moon and the cool balmy night breeze, with its odor of countless flowers, for it was discovered that we had got into a place we could not get out of - we were apparently surrounded by precipices...
> ... A Kanaka came along presently and found a first-rate road for us down an almost imperceptible decline, and the party set out on a cheerful gallop again, and O'ahu [Twain's horse] struck up his miraculous canter once more.
> Gaily laughing and talking, the party galloped on, and with set teeth and bouncing body I clung to the pommel and cantered after. Presently we came to a place where no grass grew - a wide expanse of deep sand. They said it was an old battleground. All around everywhere, not three feet apart, the bleached bones of men gleamed white in the moonlight.

Just a few years previous to Twain's visit, Dr. H. Willis Baxley visited Hawai'i as a special commissioner of the United States. In a tour of the Diamond Head area, he noted burials off the "eastern face of the headland" (Baxley 1865:522):

> … in the sands of the sea-shore, beyond the reach of ordinary high water, an immense trench is found, in which lie innumerable human bones piled in indiscriminate confusion, and in every degree of disorganization; some few of them being perfect in structure, and bleached by the sun, where disinterred by the northeast wind, forming interesting ethnological specimens.

Baxley's tour began on Waikīkī beach and continued on to Wai'alae, suggesting that the location of the burials (in the context of Baxley's transit around the crater) is near the Black Point peninsula.

It should be noted that burials in the Waikīkī area are not uncommon. Davis (1989:22-23) lists several archaeological sites with human remains, extending over an area from the present Fort DeRussy to Diamond Head.

5.3 HEIAU AND BURIAL CAVES

Based on the historical research and substantiated by previous archaeological investigations, there is little likelihood for archaeological sites of pre-contact Hawaiian or early post-contact origin in the crater. The archival research suggests that the only Hawaiian activity that might have taken place in the crater was dryland farming (dating to 1822), although there are unsubstantiated stories describing the remains of human sacrifices on the interior slopes and human burials in caves and crevices within the crater walls (Addleman [1940]:4, Division of State Parks 1979:21), no physical evidence of human sacrifices or human remains have been found.

There are several *heiau* that have been mentioned to be in the vicinity of Diamond Head, although none remain intact. Only one (Ahi Heiau) falls within the boundaries of the State Monument. However, the association of the temples with the politically important region of Waikīkī merits comment in this report.

Ahi Heiau is said to have been located on the rim of the crater (within the monument boundaries), where navigational signal fires were kept lit. There is only one uncited reference to this *heiau* (Division of State Parks 1979:21) and no physical evidence of a structure has been identified. If such a *heiau* or signal fires were an actuality, this would be a compelling argument for the name of the crater to be Lae-ahi or "cape of fire" (as opposed to the translated reference to the *'ahi* fish).

The most significant *heiau* in proximity to the crater is Papa'ena'ena Heiau, also called Lē'ahi Heiau. It was located on the western slopes of the crater, on a prominence overlooking Waikīkī. McAllister (1933:71-74), who labels it Site 58, describes it as a large, quadrangular, paved terrace, with walls on three sides and open

on the west side; a series of stepped terraces descended to the west from the top of the platform. It has been described as ranging in size from as small as 18 x 12 m (60 x 40 feet) to as large as 60 x 30 m (200 x 100 feet); McAllister (1933:74) averages the various measurements to 38 x 21 m (128 x 68 feet) with walls over 1.8 m (6 feet) high and 0.9 m (3 feet) wide.

Thrum (1926:109; see quote below under ʻĀpuakēhau Heiau) suggests that this *heiau* may have been constructed by the Maui chief Kahekili after his conquest of Oʻahu in 1783, but most historical accounts and descriptions of the *heiau* place its most noted use in the time of Kamehameha in the early 1800s. The ruling chief is said to have offered sacrifices in conciliation to the gods after two-thirds of his army was wiped out by the *mai okuʻu*, possibly yellow fever, in 1804 (McAllister 1933:71, referencing Tyerman and Bennett 1831:423); during this ceremony, Kamehameha chose his young son Liholiho to say the *ʻamama* prayer, thus indicating that Liholiho, rather than his other sons Kinaʻu or Lunalilo, would be his heir (Iʻi 1959:37).

Kanahele (1995:56) writes that Papaʻenaʻena was also a surfing *heiau*, "where surfers came to offer their sacrifices in order to obtain *mana* and knowledge of the surf."

Several visitors to Waikīkī made observations of the *heiau* (see McAllister 1933:71-74), one of the first being Tyerman and Bennett's graphic description of the 1804 ceremony. In 1824, the visitor Stewart (1970:299) described the *heiau*:

> It seems well situated for the cruel and sanguinary immolations of the heathen, standing far from every habitation, and being surrounded by a wide extent of dark lava, partially decomposed and slightly covered with an impoverished and sunburnt vegetation. It is the largest most perfect ruin of the idolatry of the Island I have yet seen.
>
> … Pieces of cocoa-nut shells, and fragments of human bones … were discoverable in different parts of the area.

Probably the last description of the structure before it was destroyed was by G.W. Bates in 1854 (McAllister 1933:74, quoting Bates 1854:94). Although he found no human remains, Bates found the structure itself to be remarkably intact:

> The walls I found to be from six to eight feet high, eight feet thick at the base, and four at the top. On climbing the broken wall near the ocean, and by carefully looking over the interior, I discovered the remains of three altars located at the western extremity, and closely resembling parallelograms.

Thrum (1926) states that the stones of the *heiau* were removed by Kanaʻina in 1856 for building walls and roads in Waikīkī. A copy of an 1875-1877 map by surveyor C.J. Lyons shows the *heiau* on the boundary between the Diamond Head lands of Lunalilo/Kanaʻina and LCA 5931 to Pehu. An 1883 map of government lands in Kapahulu (HGS 1883) shows only the label "heiau of Papaenaena" in Parcels 28 and 29 of Lunalilo's lands.

A temple drum from the *heiau*, shown in a photograph accompanying a 1968 newspaper article (Cooke 1968), is curated at the B.P. Bishop Museum:

> It is made of a hollowed coconut trunk, and the border of its base is inlaid with human teeth. Shark skin, stretched over the 24-inch top, is held with lacings of ancient sennit cord.

Kupalaha Heiau may have been a sister *heiau* to Papaʻenaʻena (Kanahele 1995:61). McAllister (1933:78) notes that Thrum recorded this *heiau* as "entirely obliterated" and its location is uncertain.

Pahu-a-Maui Heiau (McAllister's Site 59) is located at the site of the present lighthouse on Diamond Head Road. It is said to be a *heiau* for "fishermen and seamen, and priests made offerings while watching for schools of fish in the channel" (Division of State Parks 1979:21).

Makahuna Heiau was also a fishing *heiau* located near Diamond Head. Kanahele (1995:61) writes that it was "dedicated to

Kanaloa, the god of the Seas, and hence attended to by fishermen and seamen." This is likely the same temple referred to in a 1911 newspaper feature article (Advertiser 1911):

> In front of Diamond Head, by Judge Dole's place[2], can still be seen the remains of a Kuula heiau, a temple to the fish god of all the Islands, and place of the Kuula cult which played so great a part in ancient Hawai'i. Here is where the priests offered sacrifice to Kuula, and where they watched for the shoals of fish in the channel beyond. There are still traces of the floors and walls to be seen in this spot.

McAllister (1933:196), however, quotes Tucker (1916) as saying that Makahuna Heiau was of the *po'okanaka* class. Tucker places his *heiau* near Dole's residence:

> … located at this place in order to propitiate, by human sacrifice, the departure of the Aliis to foreign shores, and Black Point, between that and Kāhala, was called Keala o Kahiki (the way to Tahiti). These ruins are mostly all overthrown [sic] and have been used probably to make fences or for road purposes.

Other *heiau* in Waikīkī include Kulanihakoi Heiau (Kanahele 1995:61) and 'Āpuakēhau Heiau (also called Helumoa). The latter temple is where the Maui chief Kauhiakama was sacrificed in the 16th or early 17th century. The desecration of his bones incited his descendent Kahekili to wreck vengeance on the O'ahu people when he succeeded in conquering the island in the late 1700s (Thrum 1926:109):

> The time of Papa'ena'ena's construction, or to which of O'ahu's rulers it is to be accredited is nowhere shown in the native accounts; nor when it succeeded the activities of the 'Āpuakēhau (Waikīkī) temple, Helumoa, on whose altar Kauhi-a-Kama, a high chief of Maui, was offered in sacrifice with great indignities by the O'ahu chiefs, about the middle of the 16th century. Many years later, Kahekili, a noted descendant and king of Maui, with an invading army avenged this outrage in the sanguinary battle of Niuhelewai, Kapalama, defeating King Kahahana and conquering the island. This was in 1783, and it is not unlikely that the heiau of Papaenaena was erected by Kahekili in recognition of his victory, and ignoring the hitherto important and prominent temple of Helumoa, at 'Āpuakēhau, whose altar was so defiled by the ignominious treatment of his illustrious ancestor.

Kapua Heiau was a *luakini heiau* (Kanahele 1995:61); McAllister (1933:78) references Thrum in describing Kapua Heiau as a *heiau po'okanaka* and says that its walls were torn down in 1860. The name of the *heiau* suggests that it was located within the land area called Kapua at the western foot of the crater.

Hale Kumuka'aha Heiau was built by the ruling chief of O'ahu, Ka'ihikapumanuia (Kanahele 1995:71). It is not known where the *heiau* was located.

5.4 DIAMOND HEAD IN THE 19TH CENTURY

In the early years of the 19th century, people tended gardens in the crater (Pacific Planners [1968b]: History, 2) and one visitor described finding "an abundance of melons and watermelons growing wild, upon which we feasted" (Mathison 1825:376). In 1831, the botanist, Dr. F.J.F. Meyen, noted the crater contained a small pool of water "which was completely covered with plants" (Meyen 1981:55).[3]

Mahele and Land Distribution

In the mid-century division of lands between the king and his high chiefs, Diamond Head, which lies within the *'ili* of Kapahulu in the *ahupua'a* of Waikīkī, was awarded to William C. Lunalilo, the future king of Hawai'i (1873-1874). It was

[2]An 1883 map of Kapahulu government lands shows Grant 4081 to S.B. Dole located at Kaluahole, just west of and below the peak of Diamond Head.

[3]The crater pond was filled in by military bulldozing (Pacific Planners Corp. [1968b]: Ecology, 2), and a pump was installed in 1972; standing water can occasionally be seen there today.

designated Apana 32 of Land Commission Award (LCA) 8559-B (dated may 25, 1854.

The *'ili* of Kapahulu was one of 239 lands held by Lunalilo before the Mahele (Kame'eleihiwa 1992:229). Lunalilo inherited most of these lands from his mother Kekāulohi, the daughter of Ka'ahumanu's younger sister Kaheiheimālie, and Kamehameha's younger half-brother Kalaimamahū (Kame'eleihiwa 1992:125). His father Kana'ina, who was a lower ranking chief, was instructed by Kekāuluohi's will to act as the *kahu* (administrator) of Lunalilo's inheritance. During the Mahele, Lunalilo relinquished 174 of his lands and retained 65 of them, including Kapahulu. In 1850, he gave up another 22 lands as commutation to the government (Kame'eleihiwa 1992:243).

In 1858, Kana'ina, acting as Lunalilo's kahu, succeeded in having legal guardians appointed to manage his son's estate. He believed that Lunalilo, who was 24 at the time, was incapable of handling his personal affairs and that the estate would be lost if not placed under guardianship. From that point until Lunalilo's death in 1874, the estate was managed by others. In his will, Lunalilo bequeathed his lands to his father, with the stipulation that upon the latter's death, the estate would be placed in a trust for the benefit of "poor, aged and infirm people of Hawaiian ancestry" (Kame'eleihiwa 1992:309). Kana'ina died three years after his son, in 1877.

In 1884, the Kapahulu portion of Lunalilo's Mahele award, LCA 8559-B, was subdivided by the Lunalilo Estate. Diamond Head was encompassed in Parcel 36, an area of 729 acres, and was transferred from the estate to the Hawaiian Government for the sum of $3,310 (Bureau of Conveyances Liber 88:223-224). Over the next 10 years, at least two requests to lease all or portions of Parcel 36 were made (Dole 1889; Isenberg 1894), although records do not indicate the intended uses. One of the applicants for a lease, Sanford B. Dole, had a grant at the base of the southwestern slope of the crater.

A list of Kapahulu lands indicates that the areas to the north and east of the crater were used for pasture (Dole Collection 1884). The "Kapahulu sea fishery" is listed as Lot 40 (Probate Record 2414); an 1852 letter from Kana'ina (1852) to the Minister of Interior specifies that *he'e* (octopus) is the *kapu* fish of the Kapahulu lands.

The Late 1800s

From the 1870s, Charlie Peterson, also known as "Diamond Head Charlie" (Scott 1968:669), sat atop Lē'ahi with his telescope to watch for ships approaching on the horizon. To alert Honolulu of an approaching vessel, he would descend the crater on horseback and gallop to town. Later, he used signal flares and a telephone. It was he who, on January 20, 1891, announced the arrival of the U.S.S. Charleston, which was sailing draped in black with flags at half-mast. The Charleston was returning with the body of King Kalākaua who died in San Francisco (Pacific Planners [1968b]: History, 9). In 1892, lighthouse beacons installed on the lower slopes of the promontory added lighthouse keeper to Peterson's roles (Thompson n.d.:12). The advent of the Pacific Cable in 1902 made Diamond Head Charlie's job obsolete (Scott 1968:669).

Diamond Head was the site of a brief military skirmish in 1895. Following the overthrow of Queen Lili'uokalani in 1893, loyalists made plans for an armed attempt to restore the monarchy. Weapons were smuggled into the islands from San Francisco, landed at Rabbit Island near Makapu'u Point, and then "secretly transported and buried in the sands of Ka'alāwai, near Henry Bertlemann's home[4]" (Clark 1977:39). Kuykendall and Day (1961:185) continue the story:

> The time set for the uprising was early on the morning of January 7, 1895, but rumors had put the government on guard, and an advance unit of the insurrectionists was intercepted at Waikīkī on the night of January 6. In a brief exchange of shots, a prominent supporter of the government, Charles L. Carter, was mortally wounded.

[4]A 1920 map by M.D. Monsarrat shows that a "Bertlemann" was resident at the southwest point of Diamond Head, in the area called Kaluahole (see Fig. 4 for location).

Fighting continued across the slopes of Diamond Head and the rebels retreated into the Koʻolau valleys where they were eventually captured (Kanahele 1995:154).

Diamond Head at the turn-of-the-century was a backdrop to changes in the face of Hawaiʻi, Oʻahu, and Waikīkī. An 1899 photograph shows livestock, probably horses, grazing in the crater (Photo 2). In 1905, a lone Hawaiian tended a cow and a garden of lima beans, radishes, tomatoes, tobacco, and beets (Advertiser 1945:editorial page). A year later, the farmer was gone, at least as it appears in a description of the crater as a "rarely visited local attraction" (Advertiser 1906:5):

> From the rim of Diamond Head crater the wonderfully symmetrical basin strikes one as a beautifully laid out park. There had formerly been a large pond in the center from which the water has either all evaporated or percolated into the soil leaving a remarkably circular basin which is covered with verdure of a different shade from that surrounding it. The balance of the floor of the crater is covered with lantana and mimosa with innumerable algaroba trees interspersed. If the climber were to see nothing more than the floor of the crater and the green sides sloping into it he would feel repaid for this exertions in climbing. Once on the rim he finds that he can walk around two-thirds of the crest on a comparatively good path from every point of which an ever changing panorama presents itself of the beautiful city of Honolulu and its suburbs and the irregular surf-bordered shore of the island.

Outside the crater, the U.S. government had annexed the Hawaiian Islands less than a decade earlier and a military camp had been set up in the fields of Kapiʻolani Park under the shadow of Diamond Head.[5] This small garrison at Camp McKinley consisted of the 1st New York Volunteer Infantry Regiment and a battalion of the 2nd U.S. Volunteer Engineers (Linn 1997:9), the first formal presence of the U.S. military troops in Hawaiʻi.

5.5 MILITARY AND MODERN USE

The summit of Lēʻahi, at 230 m (761 feet) above sea level, affords an excellent and unobstructed view of the ocean from Koko Head in the east, to beyond the ʻEwa Plain to Waiʻanae in the west. The quality of this vantage point and its location in proximity to Honolulu Harbor and Pearl Harbor made Diamond Head the obvious ground from which to observe naval activities and protect Oʻahu's southern shoreline.

The utility of Diamond Head did not go unnoticed by the U.S. Army. In 1905, Secretary of War William Howard Taft visited Honolulu, and then recommended to the National Coast Defense Board that harbor defenses be strongly improved. This recommendation was in line with an overall national strategy in which Pearl Harbor and Honolulu, the only significant deep-water ports in Hawaiʻi, served as the first line of defense against an enemy invasion of the West Coast. These harbors were to be protected by a number of coastal defense forts.

In 1906, the U.S. government acquired the 729 acres of Lunalilo's Parcel 36 from the Hawaiian Government, as well as other adjacent lands (including Black Point), to create Fort Ruger Military Reservation, the easternmost of the coastal defense forts. It was named after Major General Thomas H. Ruger, who served in the Civil War (Addleman 1940:4).

In April 1907, Captain Curtis W. Otwell, District Engineer of the Army Corps of Engineers, was charged with construction of an eight-mortar battery (Dorrance n.d.:1). Eventually named Battery Harlow, it was located on the northern flat outside the crater and was the first structure to be built at the newly designated fort. Construction was completed in 1910 under the direction of Otwell's successor, Major E. Eveleth Winslow (Fig. 5), and Battery Harlow became part of Hawaiʻi's first coastal defense system, the

[5]Camp McKinley was intended as a temporary encampment, pending construction of a permanent installation (Meeken 1974:54). The last units to occupy the camp departed in 1907.

Artillery District of Honolulu.[6] Dorrance (n.d.:3) describes the strategy of the coastal defenses (Fig. 6):

> The [Battery Harlow] mortars covered the approaches to Honolulu Harbor and could reach as far as the approaches to the entrance to Pearl Harbor. They complemented the 6-inch and 14-inch guns emplaced at the closer approaches to Honolulu Harbor at Fort DeRussy and the harbor entrance submarine mining facilities at Fort Armstrong located at the Honolulu Harbor entrance. Any enemy vessel attempting to enter Honolulu Harbor would encounter, first, the deck piercing projectiles of the mortars, next, the side armor piercing projectiles of the Fort DeRussy guns, and, if *they survived those weapons, last, the hull-threatening submarine mines planted in the harbor entrance by the soldiers at Fort Armstrong.*

Built in 1910-1911, the fire control station at Lē‘ahi was the core of O‘ahu’s coastal defense (Hibbard 1980:9). The view of the ocean from Battery Harlow was blocked by the protective slopes of Diamond Head and thus, the battery commander could not spot enemy vessels at sea. To solve this problem, Winslow designed a lookout and fire control station to be constructed at the remote location on the peak of Lē‘ahi. Dorrance (n.d.:3) writes of the construction challenge posed by the difficult access of the crater floor:

> The engineers drove a tunnel through the crater wall a little above and to the right of the mortar battery. Narrow gauge tracks were put down through the tunnel and across the crater floor to the base of the inner crater wall below Lē‘ahi. A switch back path was constructed from the end of the tracks and up to a ledge at the 560 foot level. Here a stairway rose some 40 feet up to a tunnel leading to another small ledge. A winch and cable lift was installed here to hoist construction material. From this position another 99 step concrete staircase led to a tunnel at the upper end that constituted the lowest level of the four-level fire control station.

Materials for the control station were transported on a mule-powered rail line through the tunnel next to Battery Harlow (now called Kapahulu Tunnel), and then hauled by trail from the tunnel to the base of the escarpment below the peak. The winch and cable system (the foundations of which remain) lifted materials and supplies to the peak.

Two companies of the Coast Artillery arrived in 1909, before the battery or support facilities were completed. They lived in a tent camp while they cleared the parade grounds (see Allen and Schideler 1996, which is a photograph of Fort Ruger in 1910), graded the future fort area, built roads and sewer lines, and constructed temporary officers’ quarters (Dorrance n.d.:6). Addleman (1940:5) writes that “there was no appropriation for roads so the troops exchanged labor on roads for the city in return for the use of road equipment.” The Quartermaster Corps completed construction of permanent facilities, including officer’s quarters, barracks, offices, a storehouse, machine shop, and stables, in 1912 (Dorrance n.d.:9).

In 1914, construction on inland defenses began, in response to growing American suspicion of its residents of Japanese descent (Linn 1997:104) and fears of Japanese aggression like that seen at German-held possessions in the western Pacific; the Alien Land Law passed in

[6]The Artillery District was headquartered at Fort Ruger and consisted of additional batteries and gun emplacements at Forts Kamehameha at Pearl Harbor, DeRussy on Waikīkī Beach, and Armstrong at Honolulu Harbor (Meeken 1974:26). The Artillery District was renamed Headquarters Coast Defenses of O‘ahu sometime between 1911 and 1913, and redesignated Hawaiian Coast Artillery District in 1921. At that time, the headquarters was moved to the Alexander Young Hotel in Honolulu and then shortly after to Fort Shafter. Fort Ruger was named a subordinate command, Coast Defenses of Honolulu (Meeken 1974:40).

California, forbidding immigrants to own land, was also thought to be a possible provocation of war (Thompson n.d.:40, Hibbard 1980:1). On the rim of the crater, Batteries Hulings and Dodge each contained two 4.7-inch guns to protect the Wai‘alae and Kāhala regions to the east. An additional six rapid-fire 6-pounder guns pointed in the same direction were emplaced on the crater rim (Dorrance 1995:154) and a road connected all components of the complex (Thompson n.d.:41). Battery Birkhimer, with a 360 degree field of fire with four 12-inch mortars, was situated on the crater floor; the cannons were too large to be taken through the existing tunnel and were carried over the crater wall. Some researchers mention a ramp or possibly a graded road that was constructed to transport these guns (J. Bowman, pers. comm.); C. Hosokawa (pers. comm.) of the Division of State Parks suggests some of the groves in the hillside behind Battery Birkhimer might be evidence of sliding the cannons into place; Thompson (n.d.:41) simply states that “the mortars had to be hauled over the rim of the crater, the tunnel being too narrow to admit them.” Also completed in 1916 were two 5-inch guns on pedestal mounts at Battery S.C. Mills on Black Point. Virtually all fortifications at Fort Ruger were completed by 1916 (Linn 1997:92).

The 1920s saw new construction at Fort Ruger, as well as changes to defense facilities. Additional support buildings in the form of officers’ quarters, barracks, service club, and chapel were built at Fort Ruger in the 1920s. The 3rd Balloon Company arrived at the fort (Anonymous n.d.a.:3), requiring construction of an appropriate hangar; Allen and Shideler (1996:20, referencing a photograph at the U.S. Army Museum at Fort DeRussy) note that it was located outside the northeast crater rim and that the balloon field was south of the hangar. By the mid-1920s, the land defense batteries of only a decade earlier were determined to be obsolete and were disarmed or assigned other functions (Dorrance 1995:158, brackets added):

> The 4.7 inch guns were removed from Batteries Barri [at Pearl Harbor], Hulings, and Dodge. Battery Birkhimer (four 12-inch mortars) was found to be too cramped and poorly designed. The battery was extensively rebuilt and subsequently listed as a harbor-defense battery.

A 1932 photograph shows development in the crater interior that includes a rifle range in the center of the crater, as well as roads and various structures. Also visible is the marshy area in the eastern portion of the crater.

The last major development at Fort Ruger before World War II was the construction of Battery Granger Adams at Black Point in 1935. This battery was named in honor of Brigadier General Granger Adams, an artilleryman and 1876 West Point graduate (Thompson n.d.:73). Around the same time, the original tunnel next to Battery Harlow was widened and a six-room complex for a Coast Artillery fire command post was built in the tunnel (Thompson n.d.:76).

On December 7, 1941, the Japanese attacked Pearl Harbor. Considerable damage to sites in Honolulu, including Diamond Head (most likely Battery Birkhimer), was initially thought to be from the attack, but was eventually attributed to defective navy ammunition (Allen 1950:8, quoting the commander of the coast artillery; brackets original):

> A great deal of it [the ammunition] was defective, and “duds.” Unfortunately, the “duds” detonated on contact with the ground. . . . they did not burst in the air. They burst all over town. They burst all over DeRussy, where I was. I saw them burst, two of them, up in the crater on Diamond Head, knocking out one of my mortars.

At the time of the attack, only Battery Granger Adams was manned. On the night before the attack, a submarine was sighted off the O‘ahu coast. Holmes (1979:33) writes:

> When the word came down the line that night to “open fire on a surfaced submarine in gird position Helen seven five,” the batter was ready. The two big guns were swung around to proper bearing and the gunpointers found they were looking right into the windows of the house we knew as “George Hunter’s old house,” not fifty yards away. Moreover, ranged down the slope to the water’s edge, under the muzzles of the

> guns, were twenty other houses where families were sleeping in blissful ignorance of what was happening on the other side of the chain-link fence that divided the Army from the civilian area.

In the aftermath of the attack, Hawai'i shifted to a state of continuous emergency and plans for building up the coastal defenses were made. Construction of Battery 407 on the southern face of Diamond Head, one of four permanent batteries for 8-inch guns that were installed during the war, was begun in 1943 (Thompson n.d.:117). Troops poured into the islands en route to the western Pacific, and hundreds of soldiers were housed in barracks built on the crater floor (Division of State Parks 1979:21). The Hawaiian Seacoast Artillery Command was established at Fort Ruger, and controlled operations at Forts DeRussy, Kamehameha, Mōkapu peninsula, and battery positions on the North shore of the island (Meeken 1974:40). A second tunnel, now called Kāhala Tunnel, was bored through the wall of the crater.

In 1947, Fort Ruger became the headquarters of the new South Sector Command. An undated map attributed to the South Sector Command (Office of the Engineer n.d.), which must post-date 1947, shows the layout of the installation in the early post-war period.

After World War II, however, seacoast artillery was declared obsolete and all guns in the United States, including those at Fort Ruger, were scrapped (Meeken 1974:41). In 1950, Fort Ruger, including parts of Diamond Head crater, became the headquarters of the Hawai'i National Guard. And for the first time since 1906, the crater was accessible to the non-military public.

5.6 HISTORICAL SITES

Portions of the DHSM are identified as being located within the Fort Ruger Historic District, which was listed on the National Register of Historic Places (NRHP) in 1983 (Allen and Shideler 1996:23). It is a noncontiguous district that includes the remnants of O'ahu's earliest U.S. Army coastal defense fortification (Hibbard and Napoka 1980): five batteries, 12 gun emplacements on the rim of the crater, the Lē'ahi Fire Control Station, remnants of a winch and cable system, the Kapahulu Tunnel, and remnants of the original guardhouse (which has since been demolished).

5.7 ARCHAEOLOGICAL SURVEY

A total of 35 sites or site types was identified during the assessment survey of Diamond Head State Monument (Figure 15). All are the remains of 20th century use of the crater, primarily the development of Fort Ruger as the first coastal defense fortification on the island. Nine sites are located along the crater rim, 10 sites are within the crater exterior. Table 2 of the 1998 Tononari-Tuggle and Blankfein report summarizes the sites that were recorded.

5.8 SIGNIFICANT EVENTS OF THE PAST CENTURY

The following is a sequence of the major events associated with Diamond Head since 1898.

1898 - Joint Resolutions of Annexation gave fee title of Hawaiian government lands to the U. S. Government.

1900 - Hawai'i became a Territory and, in accordance with the Organic Act, the Federal Government was given power to take Territorial lands.

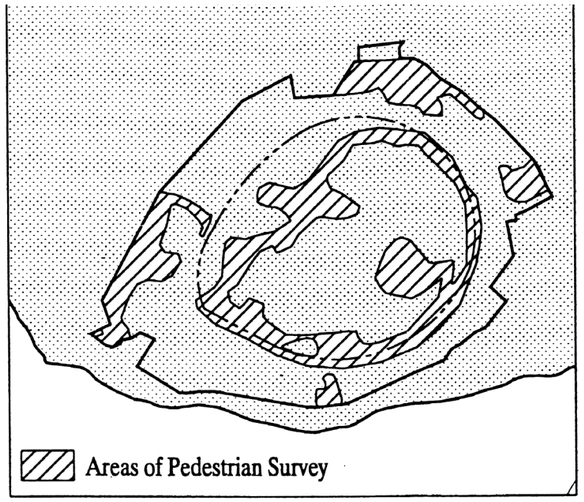
1906 - The Federal Government acquired Diamond Head for the exclusive use of the military.

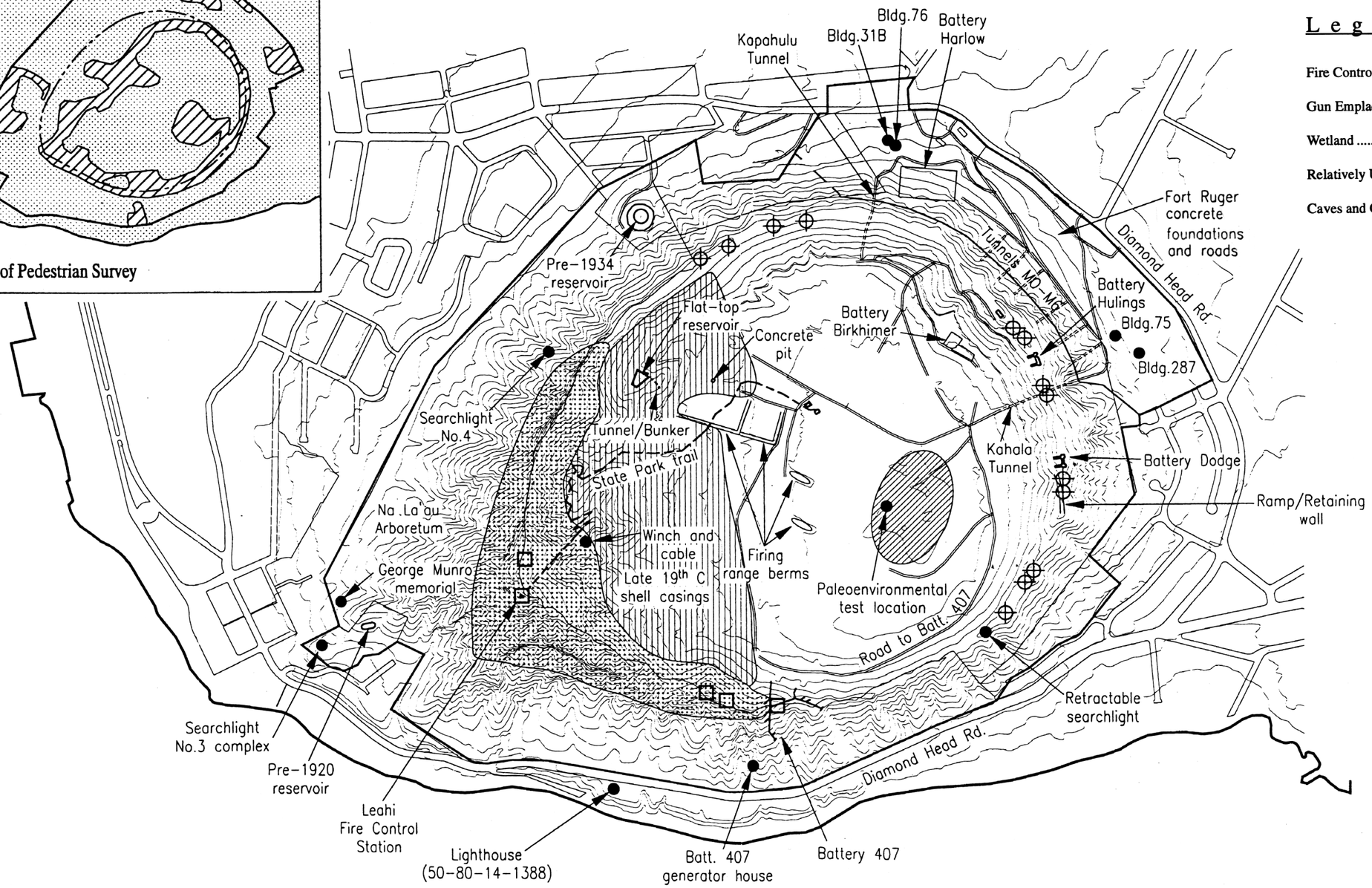
1950 - The U. S. Army turned Diamond Head land over to the Hawai'i National Guard under permit.
The Na La'au Arboretum was started by George Munro.

1955 - President Eisenhower turned Diamond Head land over to the Territory of Hawai'i for Defense and Civil Defense.

1958 - Governor William Quinn of Hawai'i turned over some crater land to the Civil Aeronautics Administration (FAA).

1959 - The Statehood Admissions Act gave Federal agencies five years to review





Legend

- Fire Control Station / Bunker
- Gun Emplacements
- Wetland
- Relatively Undisturbed Crater Floor
- Caves and Crevices

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Figure 15
Identified Sites

and justify their continuing need for crater lands.

Hawai'i became a State in accordance with the Admissions Act.

1962 - Governor Quinn established Diamond Head Monument by Executive Order No. 2000, to acknowledge the exceptional natural value of the crater and the need for its preservation. The area covered by that order included only 145.323 acres, all on the outer slopes. The State Department of Defense gained the crater interior and *mauka* exterior lands of Diamond Head.

1963 - Diamond Head was included in the Conservation Land Use District by the State Land Use Commission.

A Quit Claim Deed by the U. S. Army released restrictions on Diamond Head.

1964 - The County General Plan designated Diamond Head as "preservation" lands.

1965 - Diamond Head Monument was designated by Legislative Act 249 (SLH 1965) as an historic site to be administered by the Department of Land and Natural Resources (DLNR).

1967 - Pacific Planners Corporation was hired by DLNR for planning (visual and historical).

1968 - Diamond Head was designated as a National Natural Landmark.

The Board of Land and Natural Resources established extended boundaries for Diamond Head Monument and initiated action for legislation, designation, and management of the Monument.

Senate Resolution No. 16 requested the State and County to acquire land to preserve the visual and historical aspects of Diamond Head.

1969 - The first Annual Sunshine Music Festival was held in the crater.

The County of O'ahu amended its General Plan to include park and recreation use on the exterior slopes of Diamond Head.

Diamond Head was included in a Preservation District under the Comprehensive Zoning Code.

The first Diamond Head Task Force report was completed on the future use of Diamond Head.

1970 - The State Legislature barred the State Department of Defense (State DOD) from constructing new facilities within the crater.

A Senate Resolution requested the State Parks Division to develop historic preservation plans for Diamond Head.

Another Senate Resolution requested the City and County to create a Historic, Cultural and Scenic District which would include Diamond Head.

1971 - The report "Preservation of Diamond Head to State Monument" was presented to the Legislation by DLNR (in accordance with the 1970 Senate Resolution).

1974 - The Legislature funded $250,000 to the State DOD for planning and construction of public access and facilities for Diamond Head.

1975 - Enlargement of Diamond Head State Monument was proposed, to include all adjacent State lands and to open the same for public access, recreation, and enjoyment (Act 182).

House Concurrent Resolution No. 47 established the policy to develop a park for Diamond Head.

Funds were appropriated for planning a State Park for Diamond Head.

The Diamond Head Historic, Cultural and Scenic District No. 2 was established by the City and Council of Honolulu.

1976 - Diamond Head State Monument was included under the State's Historic Preservation Law.

Funds were appropriated for master planning. A consultant contract was negotiated, and then was dropped, as it was too expensive.

1977 - Funds were appropriated for planning for adjacent State lands.

Public access and recreation planning were started for the Monument.

1978 - Governor George Ariyoshi dedicated Diamond Head State Monument interim facilities and opened the crater for public recreational use.

1979 - Planning of Diamond Head State Monument was completed.
An Executive Order formally transfers much of Diamond Head State Lands to the DLNR for expansion of the existing Monument.
Construction of roadway, trails, and parking improvements, a new water line for irrigation needs, grading, and landscaping to include the exterior of the crater were initiated.

1979 - On November 9, 1979 the DLNR accepted the Diamond Head State Monument Planning Report, and "authorized the Department's staff to proceed with land acquisition, design and development of the Monument in accordance with the report."

1982 - Fort Ruger Historical District placed on the Hawaii Register of Historic Places.

1983 - Fort Ruger Historical District placed on the National Register of Historic Places.

1987 - HCR No. 100 HDI - clarifying the intent of the legislature with respect to the Diamond Head State Monument - was adopted by both Houses of the 1987 Legislature. The concurrent resolution set forth a clear position that the exterior slopes of Diamond Head shall remain free of development to assure that no tennis facility is built on Diamond Head's outer slopes.

1988 - House Bill No. 3041 SD 2 was approved by the legislature, signed by Governor John Waihe'e June 7, 1988 and became Act 195/88. This was a most significant piece of legislation in that for the first time those state lands adjacent to the monument and those lands to be included in the monument boundaries were identified by Tax Map Key Number. $100,000 was also appropriated for fiscal year 1988-1989 to further implement plans for Diamond Head State Monument.

1992 - House Bill No. 3982 Relating to Diamond Head was enacted and became Act 313/92. This legislation pulled together the loose ends with respect to defining the Diamond Head State Monument boundaries, implementing the long-range plan for Diamond Head State Park as a semi-wilderness park and reactivating the Diamond Head Citizens Advisory Committee. The 1979 Planning Report adopted by the Land Board became the "official document" for the preservation of Diamond Head.

1992 - HCR 230 HD 1 - was adopted by the 1992 Legislature. The Concurrent Resolution adopted by both Houses of the Legislature requested a report identifying suitable land for the relocation of the Federal Aviation Administration facilities now located in Diamond Head Crater.

1993 - HCR No.451 HD1 SD1 - Requested the Chairperson of the Board of Land and Natural Resources to reconvene the Diamond Head Citizens Advisory Committee.

1993 - In response to HCR 451 HD 1 SD 1 of the 1993 legislation, the Diamond Head Citizens Advisory Committee met September 30, 1993. Its first priority was to review land issues, and verify the Diamond Head State Monument boundaries in accordance with Act 313/92.

1993 - In October 1993, the U.S. State Appropriations Committee approved funds to relocate the FAA facility in Diamond Head Crater.

1995 - The objectives and policies were reviewed and portions of the policies were amended and approved by the Diamond Head CAC on November 16, 1995, but were not formally adopted by the Board of Land and Natural Resources.

1997 - In 1997, the State Legislature recognized the need to address increasing use of the crater and funded an update of the 1979 Plan. The update is to include the preparation of plans, and designs for the incremental development of the Monument, including a visitor/interpretive center.

5.9 SUMMARY

Diamond Head is a noted representation of the natural forces of island creation. Looming over

the Waikīkī plain, it was the backdrop, if not an active setting, for the activities of the Hawaiian chiefs from at least the 15th century until the late 1800s. As the site of Fort Ruger, it was the vanguard installation for the defense of Hawai'i and the mainland in the first half of the 20th century. Since the 1950s, it has suffered bulldozing and demolitions, brush fires and brush fire fighting, and even 1960s rock concerts.

Diamond Head is now preserved as a State monument to the natural and cultural history of the region. Plans are currently in process by the Division of State Parks for an improved interpretive program that transmits an understanding and appreciation of the history of the crater to monument visitors (Yent 1998).

Historical research indicates a long history of human activity around the crater, but within the crater itself, it was not until the 20th century and the development of coastal defenses that significant, landform-altering events took place. This is reflected in the cultural resources that were identified during the present survey, almost all of which are related to the military occupation of Fort Ruger. The exceptions are the remains of Na La'au Arboretum that was a recent use of the exterior crater slopes, small arms bullet casings on the interior slopes that might date to the turn-of-the-century, and the wetland area that might hold clues to the paleoenvironment of the crater.

Traditional Sites

The archival research, previous archaeological studies, and the present field survey suggest that there is little likelihood for archaeological sites of pre-contact Hawaiian or early post-contact origin. Historical documents note only that possible dryland farming might have taken place in the crater; there are also stories of human burials in the crater walls and human sacrifices on the interior crater slopes. These historically referenced possibilities for cultural remains were checked during field survey, with no evidence for any such remains found. No other cultural remains that pre-date the military period were discovered.

One *heiau* is said to have been located on the summit of the crater, although the information source for this is ambiguous. Of the numerous other religious sites identified in the Waikīkī region, the closest to the State monument were on the lower exterior flanks of the crater, outside of the monument boundaries. The reconstructed distribution of Waikīkī *heiau* indicates a clear focus toward the Waikīkī plain of *heiau* associated with the high chiefs (e.g., Papa'ena'ena Heiau on the prominent overlook below Diamond Head and 'Āpuakēhau Heiau in the middle of the chiefly residential area along the beach); fishing *heiau*, on the other hand, are located on the low cliffs overlooking the ocean on the south side of the crater, once noted as a famous fishing grounds (Clark 1977:39). As in pre-military historic times, Diamond Head seems to have been the background to, rather than the stage upon which, events took place.

No subsurface testing was carried out during the present project. There is a slight possibility for buried cultural deposits, particularly in areas that have not been extensively graded or excavated (e.g., southwestern slopes and the upper gullies in the northwestern portions of the interior crater).

Military Sites

Virtually all sites located during the present survey are related to the development of Fort Ruger as part of the coastal defenses of O'ahu, which clearly stands as the most significant historical event in the history of Diamond Head. The sites range from massive reinforced concrete batteries to reservoirs to soil-bermed firing ranges, and they date from 1909 to the 1950s. The essential components of the coastal defense complex of Fort Ruger are located within the State monument boundaries. The four batteries are Harlow, Hulings, Dodge, and Birkhimer and they represent three main periods of defense development: Battery Harlow was the original coastal defense facility and the other three batteries were built as part of a subsequent land defense network; Battery Birkhimer was remodeled in 1920-21 and reflects the changing orientation in defensive strategy given post-World War I changes in armament technology. The Lē'ahi Fire Control Station was built in

support of Battery Harlow (as well as batteries at Fort DeRussy) and is particularly significant as an unusually complex example of fire control buildings. The other sites include other fire control stations, searchlight housings, observation points, magazine tunnels, and gun emplacements.

The National Register of Historic Places (NRHP) nomination form for Fort Ruger states that the fort is "significant in the history of the military in Hawai'i as the first coastal defense fortification established by the United States Army in the Islands" (Hibbard and Napoka 1980). It further specifies that the Lē'ahi Fire Control Station is particularly important as a unique example of such facilities, being the most elaborate construction of this type of facility in the United States.

Since the 1950s when the U.S. Army relinquished control over much of the installation, many facilities have been altered and demolished. However, even if most of the support and administrative facilities of the fort are in alternative uses or are only concrete foundations, the defensive structures remain as testament to this important part of U.S. military presence in Hawai'i. Many are in excellent condition and clearly demonstrate the important function they served in protecting O'ahu's southern coastline.

Wetland

In the southeastern quadrant of the crater interior, there is a seasonally moist wetland that is significant as a potential source of information on past environmental conditions in the crater. Coring and pollen analysis of two samples from the wetland during the present project show that there is intact sediment underlying fill layers and that pollen preservation is good. The assumption of this work is that, since its inception, the basin should have received a continuous influx of sediments and microfossil plant remains from within the wetland, as well as from erosional transport of sediments and plants remains on the interior crater slopes. The basin, therefore, should contain a stratigraphically intact record of past environmental conditions inside the crater.

5.10 IMPLICATIONS FOR MASTER PLAN UPDATE

5.10.1 Areas of Potential Cultural Resource Sensitivity

Based on the defined evaluation criteria, the following areas (numbered 1 through 4 on Table 6, Tononari-Tuggle and Blankfein 1998) are designated areas of potential cultural resource sensitivity. Areas 5 and 6 are evaluated to be areas of low cultural resource sensitivity.

All sites identified during the present survey. Until such time that an inventory level survey can be carried out, sites identified during the present survey should be considered sensitive areas. This includes the Fort Ruger grounds, which includes standing structures, concrete foundations, roads, and retaining walls. Inventory level survey will allow the recording of sufficient site information so as to make evaluations of significance as defined by the NRHP. Although many of the major coastal defense features fall within the Fort Ruger Historic District, inventory level documentation of these features has not been completed. The only site for which there is detailed documentation is Battery Harlow (see Allen and Shideler 1996).

Wetland. Although this is technically not a cultural site, the seasonal wetland has the potential to produce paleoenvironmental data that could contribute to a better understanding of the crater environment in pre-contact times. The full extent of the wetland, however, is difficult to determine because of modern alterations to the central crater and the boundary is an estimation.

Relatively undisturbed portions of the crater floor. The absence of historical or traditional references to use of the crater interior does not discount the possibility that it may have been used in pre-contact or early historical periods. There have been no subsurface archaeological investigations (other than the present wetland coring) to refute or substantiate the presence of buried cultural deposits reflecting human use of the crater before the military occupation. The

western portion of the crater (the slopes below and south of the Lē'ahi Fire Control Station and the upper gullies north of the State Parks trail) may have some potential for buried deposits, based on the fact that late 19th/early 20th century ammunition was found in this area (which suggests that there may be little disturbance in the area). A rough guide to the boundary of this undisturbed area is the graded road that encircles the central portion of the crater (C. Hosokawa, pers. comm.).

Caves and crevices in the steep portions of the crater wall. Although there are apocryphal stories of burials in the crater, as well as historical but second-hand references to cave burials being rifled, only a full survey of the cliff areas would eliminate the possibility of human remains in caves and crevices of the crater wall. There are portions of the crater rim that would most likely contain burials (if any exist).

5.10.2 Recommendations

The evaluation of cultural resource sensitivity is a preliminary step in cultural resource documentation. For the purposes of the master plan process, it provides a broad view of archaeological and historical site potential that allows for an informed assessment of future data collection and management requirements for defined areas of the monument. The next step in the documentation process, which can be phased as development plans become more detailed and concrete, is an inventory survey, as called for in the State of Hawai'i rules governing procedures for historic preservation review (under HRS Chapter 6E).

Table 3 of the 1998 Tononari-Tuggle and Blankfein report summarizes the recommendations by site and sensitive area. These recommendations should be incorporated into the updated master plan for implementation as part of future development projects (as they come on-line).

In addition, the O'ahu burials council and the State Historic Preservation Division will be contacted if any human burials, artifacts, or other cultural remains or deposits are encountered during the excavation and grading phases of the project. Moreover, if warranted, a consultation process will be initiated for the proposed project and the Office of Hawaiian Affairs will be named a required consultant, pursuant to Section 106 of the National Historic Preservation Act.

Inventory Survey. An inventory level survey would identify, locate, and record sites in sufficient detail to allow evaluations of site significance based on NRHP and State criteria. An additional purpose of the survey (specifically for management purposes) would be to establish baseline data on site conditions against which future conditions can be monitored. Areas designated as having potential cultural sensitivity should be surveyed at the inventory level prior to any State Parks development.

A detailed architectural study of Lē'ahi Fire Control Station is recommended as a mitigation action as part of the current plans for interpretive development of the monument (Yent 1998). The structure, which is highly significant as a unique and complex example of fire control stations, is presently the destination of many of the visitors to the State Monument. The intensity of public use has a deteriorating effect on the integrity of the structure, which should be documented in detail before it is further adversely impacted. It can only be anticipated that public use will increase with additional development of the State Monument.

If any future development in sensitive areas of the crater entails subsurface excavation (e.g., trenching, grubbing, or grading), it is recommended that an archaeological monitor be present to examine exposed soil profiles or deposits. This will allow an evaluation of the above sensitivity assessment for relatively undisturbed areas of the crater, which can be revised, if necessary, after the first monitoring has been conducted.

Management Recommendations. Based on the recommended inventory survey, and particularly the significance evaluations, further recommendations can be made as to (1) future data collection requirements such as detailed architectural recording or archaeological data recovery, and (2) long-term preservation

requirements for significant sites, particularly those in areas of high public use.

It should be noted that, at present, the primary sources of potential damage to historic structures are from vandalism and general deterioration. Vandalism is represented primarily by graffiti and trash and is most evident in the Fort Ruger area, at the retractable searchlight bunker on the southern crater rim, and in the exposed concrete reservoir on the western exterior slopes. All structures are suffering from some degree of deterioration; the Lē'ahi Fire Control Station is particularly vulnerable due to high public traffic. The present restrictions to public access to most parts of the crater, however, have generally helped to preserve and protect the structures.

Interpretation. From the very inception of the monument in the early 1960s, there has been a strong interest in the history of Fort Ruger and the military structures as historic sites. Future interpretive development of the monument should acknowledge this original (and continuing) interest.

An example of integrating interpretation and recreation, as well as disparate interpretive themes, is an eastern crater (below) rim trail that utilizes the existing road cut, with Battery Hulings and Dodge and the 6-pound gun emplacements as observation points. A trail could follow segments of the early 20th century road that connected the various components of the defensive system; interpretation can deal with the emplacements themselves (how they were used), as well as how they fit into the overall defensive system. The emplacements and trail offer excellent (and already constructed) vantage points from which to view the interior of the crater (including almost all of the identified sites), east Honolulu, and inland toward the Ko'olau mountain range. Interpretation can be directed into the crater with a focus on the defensive complex and out of the crater addressing any number of interpretive themes (including traditional Hawaiian settlement and activities) that tie the crater to a larger regional and historical context.

As early as 1906, the visual assets of a rim trail were recognized (Advertiser 1906:5):

> From the rim of Diamond Head crater the wonderfully symmetrical basin strikes one as a beautifully laid out park. ... If the climber were to see nothing more than the floor of the crater and the green sides sloping into it he would feel repaid for his exertions in climbing. Once on the rim he finds that he can walk around two-thirds of the crest on a comparatively good path from every point of which an ever changing panorama presents itself of the beautiful city of Honolulu and its suburbs and the irregular surf-bordered shore of the island.

Cultural Resource Management Plan. Ideally, a cultural resource management plan (CRMP) for Diamond Head State Monument should be completed at the earliest opportunity. Such a plan would incorporate the above three recommendations: (1) inventory survey of the monument, including full site documentation and evaluations of significance, (2) management recommendations for identified sites in the context of short-range development plans and long-range maintenance and preservation, and (3) incorporation of historical sites into the monument interpretive program. Although these recommendations could be carried out independently, an integrated CRMP approach is more effective for planning purposes.

6.0 Scenic Resources

This chapter describes Diamond Head's scenic resources, not only as it is viewed as a landmark in Honolulu, but also the views provided from the crater. An understanding of these resources is important in updating the master plan for the DHSM.

6.1 LANDMARK

Diamond Head is a prominent natural landmark that can be viewed from the sea, from the air, and from much of urban Honolulu. The most familiar profile of Diamond Head is from the west and northwest, as shown on the cover; views from the east and north provide different, but no less distinctive profiles.

6.2 SCENIC RESOURCES FROM THE CRATER

The views from the trail, summit, and rim of the crater attract many visitors to the park. The panoramic views of southeastern O'ahu provide many photographic opportunities for visitors. The following locations are lookout locations that can be developed through the interpretive program.

1. Concrete Landing with Winch. Panoramic views of the crater interior and the coastline to the east, including Kāhala, Koko Head, and Hawai'i Kai.

2. Southern Rim. Visitors currently use several locations at the summit for scenic viewing and photographs.

a. Top of Fire Control Station Diamond Head. Railings and an interpretive sign have been installed at this location to encourage use as a scenic lookout and discourage further access along the rim. This location offers a panoramic view west and north that encompasses Waikīkī, Honolulu, Pearl Harbor, the Wai'anae and Ko'olau Ranges, Pūowaina (Punchbowl), and Mount Tantalus.

b. Bunker #1. This concrete slab to the southeast of the Fire Control Station offers a sweeping view of the coastline to the east that encompasses Koko Head and Hawai'i Kai. It also provides a good view south of Diamond Head Light House and the reef fronting Kāhala. It is the best view of the Fire Control Station where the construction form and four levels can be readily observed.

c. Bunker #2. Visitors are not currently encouraged to visit this structure to the north of the summit, but there are plans to use this concrete structure as an alternate lookout during renovation

work on the Fire Control Station. This site offers a view similar to the summit but also includes more of the Kapahulu and Kaimukī areas.

d. View corridor of exterior – view west to north to east:
   - La Pietra (site of Papa‘ena‘ena Heiau)
   - Natatorium
   - Kapi‘olani Park with Waikīkī Shell and the Zoo
   - Waikīkī Beach
   - Royal Hawaiian Hotel
   - Magic Island and Ala Moana Beach
   - Tripler Hospital
   - Punchbowl Crater
   - Tantalus
   - Mānoa Valley and Pālolo Valley
   - Koko Head
   - Black Point

e. View corridor of interior:
   - Batteries
   - 2 Tunnels
   - Pistol Ranges
   - Bunkers
   - Roads

3. Northern Rim. This offers a panoramic view of the northern exterior of the crater, including the remaining buildings of Fort Ruger, Kapi‘olani Community College, and the community of Kaimukī.

4. Eastern Rim. From the interior crater side of Kapahulu Tunnel, there is a paved road that is used to access various antenna, facilities including the FAA Link Site. A portion of this road extends below and along the eastern crater rim to a facility known as the Retractable Searchlight. This road is mostly unpaved and, in some areas, is heavily overgrown. However, it is clearly wide enough for a pedestrian trail with some improvements. This road provided access to Batteries Hulings and Dodge, various unnamed gun emplacements, and the Retractable Searchlight. These facilities are located on the crater rim and offer hard paved surfaces from which to view eastern Honolulu, including the ocean, Black Point, Kāhala, Kaimukī, the Ko‘olau Mountains, Koko Head, and Koko Crater. On clear days, Moloka‘i and Lāna‘i are also visible.

5. Tunnel 407. This facility consists of tunnels that extend through the southern wall of the crater. Although the longest tunnel is only 10 feet wide, the southern opening offers views of the ocean, the Diamond Head Lighthouse, Black Point, and Koko Head.

The entire facility, including the entry and parking lot, is relatively flat and provides unhindered accessibility.

6. Kapahulu Tunnel. While Kāhala Tunnel is wider and higher and is aligned directly at Lē'ahi Summit, Kapahulu Tunnel enters the crater at a higher elevation and offers greater visibility of the crater interior.

7. Ridge Next to the Flat-Top Reservoir. The sides of the reservoir follow the sloping contours of the adjacent ridge and crater wall. The ridge and reservoir are within a short walking distance from the existing trail to the summit of Lē'ahi. The top of the ridge offers an elevated view of the interior of the crater, with minimal effort.

8. Pistol Ranges. Two large U-shaped berms enclosing roughly square-shaped level areas were constructed for use as firing ranges. The western berm is transected by the trail to the summit. These berms offer similar (but lower) views to those from the ridge next to the Flat-Top Reservoir.

9. Kāhala Tunnel Lookout. On the crater exterior, immediately outside of the Kāhala Tunnel is a lookout with a small paved parking lot. The lookout overlooks eastern Honolulu, including the ocean, Black Point, Kāhala, Kaimukī, the Ko'olau Mountains, Koko Head, and Koko Crater. On clear days, Moloka'i and Lāna'i are also visible.

6.3 Implications for Master Plan Update

The visual impact of the Monument as a Natural Landmark has remained important to many as urban Honolulu has developed around the Crater. The public and the CAC have fought many battles to keep the gaze of developers and government in check.

The landform, Diamond Head Crater, is a pyroclastic cinder cone generally comprised of a friable tuff-type soil structure, which is easily scarified and subject to accelerated erosion. Uncontrolled access, however, along the slopes have brought about visible scarring as the soil breaks away. The exterior visual impact of Diamond Head as a "Registered Natural Landmark" (Department of the Interior, 1968) has been kept intact through City and County Ordinances and the Department's (DLNR) efforts to preserve the natural beauty of this world renown cinder cone. Past proposals on the development of the Crater would have altered this natural landscape.

There are numerous natural and man-made areas in and around the crater that offer unobstructed vistas, whether the views are of the inside and/or the outside of the crater. Some of these lookout locations are presently in use, but there are many more that are currently restricted to visitors. While clearly the best views are along the crater rim, concerns about the destruction of the *Schidea adamantis* habitat, erosion from foot traffic, and hiker safety, disallow unimpeded access along the rim of Diamond Head. Many of the lookout locations identified above could mitigate the adverse impacts from rim access, while providing many more viewing opportunities than are currently provided.

7.0 Public Activities In Crater

This chapter describes existing uses and facilities, including infrastructure, and what implications these public activities may have on the planning and management of the DHSM.

7.1 EXISTING USES

Today, many structures and facilities house the operations of the State Department of Defense (State DOD). Scattered around the rim of the crater are bunkers, gun emplacements, tunnels, antennas, and other structures that reflect the current and historical governmental uses of the crater.

The many present users of land within Diamond Head State Monument include: State DOD, State Parks, as well as the utilities with their easements for water, electricity, telephone and communications. All of these users will be affected by changes to the planning and management of the DHSM.

The State DOD is affected the most because of policies to stop further construction within the crater and the limited availability of land on the exterior as a result of residential development. All facilities and structures along Diamond Head Road between the Cannon Club and 18th Avenue (excluding Birkhimer EOC and the storage bunkers) are to be vacated for inclusion into the Monument. Facilities and structures that remain must be utilized for what they were originally intended or risk being included also. However, it should be noted that the State DOD is currently planning for an eventual move to Barbers Point.

The State DOD is also the agency in charge of land being utilized by the Civil Defense, the military, and other tenants, who are also affected by the policies of the Monument. For example, the Civil Defense Agency moved into Birkhimer EOC from buildings on the exterior.

The FAA has recently relocated to its new facilities at Honolulu International Airport. The FAA demolished the CERAP building and restored the site of the former building.

The current State Park uses within the crater include sightseeing, picnicking, and hiking. Despite relatively minor improvements (trail improvements, comfort station, parking lot, grassed field) since the 1970s, the estimated daily count of visitors has risen from 112 in 1981 to 2,740 in 1997.

7.2 FACILITIES AND RELATED DEVELOPMENTS

7.2.1 Existing Improvements

Many structures and facilities presently exist around and within Diamond Head Crater (Figure 16). A series of large buildings within the crater houses the facilities of the State DOD. A State Parks comfort station adjoins remnants of abandoned rifle and pistol ranges. Scattered around the rim are bunkers, gun emplacements, tunnels, antennas, and other structures. Some of the existing structures and facilities that are not now available to the public have potential interpretive value. These include:

Flat-Top Reservoir. A flat-topped, earth-covered reservoir is located in a gully at the base of the northwestern crater wall. The sides of the reservoir follow the sloping contours of the adjacent ridge and crater wall. The floor is irregular and concrete-lined. The vertical facing wall of the reservoir is supported by large triangular buttresses approximately 0.6 m (2 feet) wide and spaced about 3 m (10 feet apart); this wall is inscribed with the date "1911", which is presumably the construction date.

Tunnel 407. This facility consists of tunnels that extend through the crater wall. Access from the crater interior is through large iron doors. The exterior openings are the gun emplacements, which were designed with casements that would protect the guns from falling boulders, presumably those dislodged due to enemy fire or from concussions from the battery itself. Although the longest tunnel is only 10 feet wide, the southern opening offers views of the ocean, the Diamond Head Lighthouse, Black Point, and Koko Head. The entire facility, including the entry and parking lot is relatively flat, and provides unhindered accessibility.

Battery Harlow. Battery Harlow is located at the base of the exterior northeastern crater wall and is presently accessible only by controlled access roads from either Diamond Head Road or Kapahulu Tunnel. Battery Harlow is listed as Feature 2 on the National Register nomination form for the Fort Ruger Historic District. Battery Harlow became operational in 1910 as the first permanent structure at Fort Ruger and the earliest of a system of coastal defense fortifications on O‘ahu. It has three bunkers separated by two courtyards that are set below a huge parapet built against the north-facing slope of Diamond Head. The east bunker is two stories (one below grade) and the west and central bunkers each have one story. The central bunker houses the plotting room and mechanical data transmission system; there is a smaller concrete structure for the command post on top of the central bunker that appears to be accessed by exterior stairs. Each courtyard had four pits for 12-inch mortars. This massive, concealed, concrete structure remains in relatively excellent condition, although the traverse ring rails were removed from the mortar pits and filled with concrete when the armaments were removed after World War II.

Cannon Club. The Cannon Club is located on the northwest exterior slope of the crater off of Monsarrat Avenue. It consists of two structures. The main structure contains approximately 15,000 square feet of interior space and the second is a two-sided pavilion with approximately 5,000 square feet. The Cannon Club offers spectacular views over Kapi‘olani Park towards Waikīkī and the ocean beyond. The site allows for parking of vehicles.

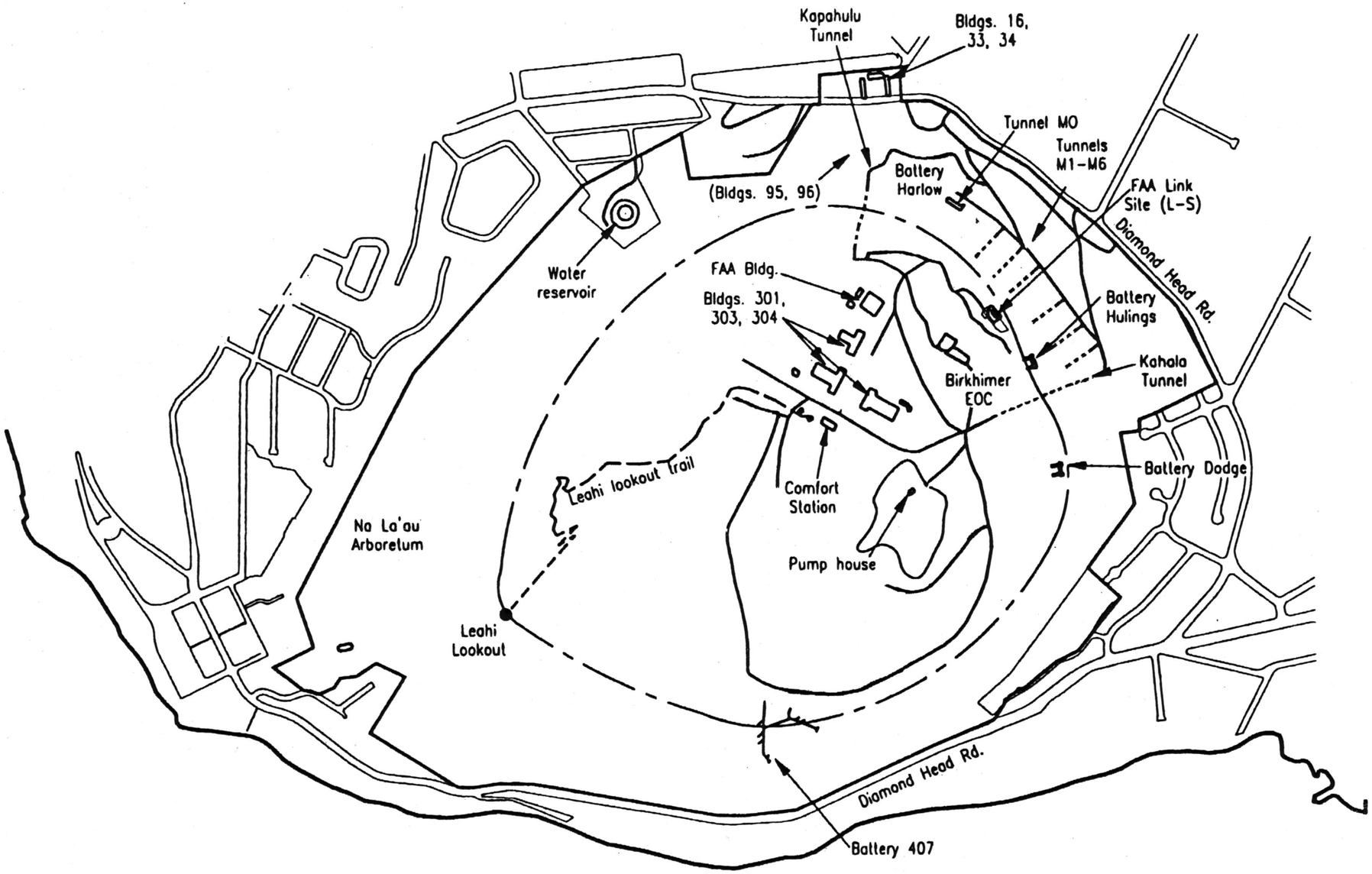

Figure 16
Existing Facilities

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In September 2001, an interim lease agreement to the University of Hawai‘i for use of the Cannon Club was approved by BLNR.

Existing Road Below the East Crater Rim. From the interior crater side of Kapahulu Tunnel, there is a paved road that is used to access various antenna facilities including the FAA Link Site. A portion of this road extends below and along the eastern crater rim, southward, to a facility known as the Retractable Searchlight. This road is mostly unpaved and, in some sections, is heavily overgrown. However, it is clearly wide enough for a pedestrian trail with some improvements. This road provided access to Batteries Hulings and Dodge, various unnamed gun emplacements, and the Retractable Searchlight. These facilities offer hard, paved surfaces from which to view eastern Honolulu, including the ocean, Black Point, Kāhala, Kaimukī, the Ko‘olau Mountains, Koko Head, and Koko Crater. On clear days, Moloka‘i and Lāna‘i are also visible.

Batteries Hulings and Dodge. Batteries Hulings and Dodge are located just below and inside the crater rim on the eastern portion of the crater and are listed as Features 3 and 4 (respectively) on the National Register nomination form for the Fort Ruger Historic District. The batteries were built in 1915 as part of an Army land defense system for the island. By the mid-1920s, however, the land defense batteries were determined to be obsolete and were disarmed. The gun platforms for each battery are on the exterior of the crater. The entrances to the two batteries face onto a dirt road that is cut into the interior hillslope just below the top of the rim.

Various Gun Emplacements Along the East Rim of the Crater. Intermittently spaced along the eastern portion of the crater rim road are pairs of semi-circular-shaped retaining walls around circular concrete floors; tie-down fasteners are set in the center of each concrete floor. These structures are listed collectively as

Feature 5 on the National Register nomination form for the Fort Ruger Historic District. These structures, which are the foundations for rapid-firing 6-pound guns that were installed as part of

the land defense system for southern O'ahu (1915 to 1925) contemporaneous with Batteries Hulings and Dodge.

Retractable Searchlight. At the terminus of the eastern rim road is a retractable searchlight housing. This structure was probably built in 1932 during the coastal defense and anti-aircraft searchlight project to build 161 lights on O'ahu. This facility was a "concealed reinforced concrete shelter having a sliding top." The top of the structure slid open when the searchlight was to be operated; gears connected to a winch raised the searchlight (mounted on a platform) to operating position above the sliding top.

Kapahulu Tunnel. Immediately west of Battery Harlow is the exterior portal of the Kapahulu Tunnel, which is listed as Feature 10 on the National Register nomination form for the Fort Ruger Historic District. The tunnel was originally 175 m (580 feet) long, 2.4 m (8 feet) wide, and 2.1 m (7 feet) high; it was excavated to expedite construction of the Lē'ahi Fire Control Station and allowed a mule-powered, 1961 and now accommodates motorized vehicle traffic. While Kāhala Tunnel is wider and higher and is aligned directly at Lē'ahi Summit, Kapahulu Tunnel enters the crater at a higher elevation and offers a greater view of the crater interior.

There are several park-related facilities in the area around the trailhead in the central crater floor:

Parking Lot. The existing parking lot for the park has 40 designated car stalls and 2 handicap vehicle stalls. Overflow parking occurs along the entry road to the lot. Buses drop off visitors and park along the entry road.

Restroom. Located off the northern side of the parking lot.

Open Field. A large, grassed field with trees along the western edge (formerly the Rifle Range).

Trail. The historic trail to the summit has been modified over the years for park purposes and safety, including the addition of railings (1981-1982), concreting the lower portion of the summit trail (1988), and exiting on the 3rd level of the Fire Control Station with the addition of the metal stairs near the summit (1982).

Other facilities are located on the exterior of the crater:

Exterior Lookout. On the outside of the crater at the entry to the Kāhala Tunnel is a pull-off that serves as a lookout for the shoreline from Black Point (Kāhala) to Koko Head. On clear days, Moloka'i is visible.

Na La'au Arboretum. Located on the western exterior slope of the crater. Originally developed in 1950, the site has not been maintained in recent years.

7.2.2 Access and Traffic

Existing Conditions

Regional and sub-regional access to Diamond Head State Monument is provided primarily by a network of arterial and collector roadways. Access to the H-1 Freeway is provided by a combination of Campbell Avenue and Kapahulu Avenue and a combination of 18th Avenue, Kilauea Avenue, Hunakai Street, and Wai'alae Avenue. Access to Waikīkī is provided primarily by Diamond Head Road/Monsarrat Avenue. Residential collector roadways within the Kaimukī area also provide secondary access.

Diamond Head Road. Diamond Head Road provides the primary access to the DHSM. Diamond Head Road also provides access to KCC and other non-residential uses in the area.

It is a two-lane, two-way major collector that traverses the north, east, and south slopes of Diamond Head crater. It has a posted speed limit of 25 miles per hour (mph). Intersections in the vicinity of the DHSM are located at Makapu‘u Avenue, Kapi‘olani Community College (KCC) Driveway, DHSM Access, and 18th Avenue. All intersections are unsignalized, T-intersections with stop sign control on the intersecting street approaches.

Makapu‘u Avenue. Makapu‘u Avenue is a two-lane, undivided major collector that connects Kilaue‘a Avenue to Diamond Head Road. The posted speed limit is 25 mph. Makapu‘u Avenue provides access to Lē‘ahi Hospital and to KCC parking lots.

Kapi‘olani Community College Access. The entrance to KCC provides access to campus parking. The entrance is approximately 825 feet west of the DHSM access. Additional entrances to KCC are provided along Makapu‘u Avenue and Kilaue‘a Avenue.

Diamond Head State Monument Access. The DHSM access is a two-lane, undivided roadway. The roadway passes through the wall of the crater via Kāhala Tunnel. The posted speed limit of the access road is 10 mph and 5 mph through Kāhala Tunnel.

18th Avenue. Eighteenth Avenue is a two-lane major collector between Diamond Head Road and Kilaue‘a Avenue. North of Kilaue‘a Avenue, 18th Avenue is a two-lane residential roadway. The posted speed limit is 25 mph.

Operations of the intersections in the project vicinity were analyzed to identify existing intersection operational characteristics. The intersections were analyzed using the methodologies for unsignalized intersections outlined in the *1994 Highway Capacity Manual (HCM).* Operating conditions at an intersection are expressed as a qualitative measure known as Level of Service (LOS) ranging from A to F. LOS A represents free-flow operating conditions, while LOS F represents congested conditions. The overall intersection LOS is a weighted average of the LOS of individual traffic movement groups. In addition to traffic volumes, intersection analyses included data such as peak hour factors, truck percentages, and roadway grades.

According to the Traffic Impact Analysis prepared for the Diamond Head State Monument Master Plan Environmental Impact Statement, the existing conditions intersection level of service analysis shows that the intersections in the project vicinity operate acceptably overall. During the peak hours, left turns out of Makapu‘u Avenue and 18th Avenue experience delay. Because the magnitude of traffic demand for these movements is relatively low, and because the delay occurs only during the peak hours, this situation may be acceptable. Should there be a community desire to provide traffic signal control, both the Makapu‘u Avenue and 18th Avenue approach volumes satisfy the peak hour traffic volume warrant as defined by the *Manual on Uniform Traffic Control Devices*.

Future Traffic Without the Project

The preferred DHSM master plan and various alternatives were evaluated for two future scenarios: Year 2003 representing a five-year horizon and Year 2008 representing a 10-year horizon.

The Years 2003 and 2008 roadways in the study area are assumed to retain the same configuration as existing conditions. Minor changes are assumed regarding access to the DHSM. In addition to the four intersections analyzed for the existing conditions, the operations of proposed accesses along Diamond Head Road were studied.

Existing DHSM visitor traffic was established through traffic counts by PBQD and vehicle classification and interview surveys conducted by SMS Research, Inc. Site-generated traffic was defined as DHSM visitor traffic. The level of future visitor activity was provided to this analysis effort after discussions between DLNR and the CAC. For the preferred master plan and for a number of alternatives, the number of visitors was assumed to decrease ten percent from existing conditions. The master plan proposes to shuttle non-walking visitors into the crater with people movers as opposed to

allowing them to drive into the crater. It was determined that restricting the ability of visitors to drive into the crater would reduce the number of visitors at DHSM. This effect is desirable, according to reports of DLNR and CAC discussions. The people mover transportation into the crater coupled with the charging of admission fees are expected to either reduce or, at most, maintain the amount of visitors to the DHSM at current levels for the foreseeable future.

The visitor traffic generated in Year 2003 and in Year 2008 was directionally distributed, and then the distributed traffic was assigned to the future roadway network according to the preferred plan and various alternatives.

Based on May 14, 1998, observations by SMS Research, Inc., the AM peak hour visitor distribution was judged to be sixty percent to and from the west and forty percent to and from the east of DHSM access. It was assumed that most visitors in the AM peak hour would travel to and from Waikīkī/Honolulu. In the PM peak hour, the incoming visitor distribution was assumed to be fifty percent from the east and fifty percent from the west. The outgoing visitor distribution in the PM peak hour was judged to be seventy-five percent to the west (Waikīkī) and twenty-five percent to the east. It was judged that visitors in the PM peak hour could equally arrive at DHSM from any part of the island via Diamond Head Road, but the majority of visitors leaving DHSM would likely head west to return to Waikīkī. These distributions were applied to the visitor trips generated.

The Years 2003 and 2008 background traffic volumes represent the projected non-visitor traffic at the intersections evaluated by this study. The background traffic volumes do include traffic from other Diamond Head uses such as the State Department of Defense (State DOD) and Emergency Operations Center (EOC).

The background volumes were determined by first applying an annual growth rate of 0.5 percent to existing non-visitor volumes, excluding State DOD and EOC traffic. The 0.5 percent annual growth factor was based on a review of volume growth on selected roadways documented in the City and County of Honolulu *Waikiki Regional Traffic Impact Plan Summary Report* (December 1995). The low growth rate is consistent with development of the area being mature, and significant new development is not expected to occur in the study area. The State DOD and EOC traffic were assumed to remain constant within the future time frame evaluated and were, therefore, not growth factored. (In fact, the State DOD is planning to relocate to Barbers Point, so State DOD traffic is actually expected to decrease significantly in the future). The State DOD and EOC traffic were rerouted, however, to account for the different access schemes proposed by the alternative conceptual plans for the DHSM.

The directional distribution of State DOD/EOC trips was derived from the difference between the existing visitor trips and total trips observed. In the AM peak hour, ninety percent of State DOD/EOC trips were assumed to arrive and depart DHSM to the east, and ten percent was assumed to arrive and depart DHSM to the west. In the PM peak hour, approximately eighty percent of State DOD/EOC trips were assumed to exit DHSM to the east, and the two State DOD/EOC trips (one hundred percent) entering DHSM during the PM peak hour were assumed to originate from the east. It was assumed that most personnel would originate from the east, equally utilizing 18th Avenue and Diamond Head Road.

Future Traffic With the Project

The State DOD/EOC trips were added to the growth-factored components to obtain the total Year 2003 and Year 2008 background traffic.

The site-generated traffic was added to the projected background traffic to obtain the total peak hour traffic volumes for Years 2003 and 2008 for each of the three alternative conceptual plans.

Key intersections were analyzed using the methodologies for unsignalized and signalized intersections outlined in the *1994 Highway Capacity Manual (HCM).* In addition to traffic volumes, intersection analyses considered

elements such as peak hour factors, truck percentages, and roadway grades. Field observations were performed at selected intersections to verify reasonableness of the analysis results.

Anticipated Impacts

It is anticipated that all study intersections will operate well overall at LOS A. Most movements will experience minimal delays, and all movements will operate at LOS E or better.

Additionally, there is little difference between the intersection operations in Years 2003 and 2008. Due to the annual growth, the volumes are slightly higher for the ten-year horizon than the five-year horizon, but the delay increases are minimal.

There is little difference between the intersection operations of various alternatives. The results suggest that implementation of any of the alternatives studied in *the Traffic Impact Analysis for the Diamond Head State Monument Master Plan* report would result in minimal delay increases for vehicles, and the overall levels of service would not be affected.

Mitigative Measures

From the perspective of intersection operations, all of the alternatives studied in *the Traffic Impact Analysis for the Diamond Head State Monument Master Plan* report would result in similar intersection levels of service. The traffic volumes produced by the conceptual plans are similar to each other, and they are superimposed on similar patterns and magnitudes of background traffic on Diamond Head Road. Future intersection levels of service are, therefore, similar and are projected to be acceptable.

The primary traffic-related differences in the conceptual plans pertain to design elements such as the location of DHSM access, visitor access into the crater, and bicycle and pedestrian facilities. From the perspective of transportation issues, all of the alternatives studied in the *Traffic Impact Analysis for the Diamond Head State Monument Master Plan* report are workable when implemented properly. The following discussion summarizes the recommendations common to all conceptual plans and recommendations that apply specifically to each conceptual plan.

Pedestrian/Bicycle Paths

The attached sidewalk on the south (Diamond Head) side of Diamond Head Road is narrow, averaging about three feet in width. Street lighting poles located in the sidewalk area further restrict the sidewalk. Wheelchair ramps are not provided. Most of this sidewalk is constrained from widening by an existing rock retaining wall, varying between three and five feet in height.

The Master Plan and various alternatives included a separated pedestrian/bicycle path, located behind the rock wall. This path would provide a safer and more enjoyable walking, jogging, rollerblading, and biking environment than the attached sidewalk that currently exists on the south side of Diamond Head Road. Moreover, it is proposed that secure bicycle parking be provided at both the Cannon Club and at the entries to the crater. Accommodations will be made for pedestrians to and through both the Kapahulu and Kāhala Tunnels.

It is recommended that Americans with Disabilities Act (ADA)-compliant access be provided from Diamond Head Road to the separated pedestrian path at Makapu‘u Avenue, the KCC Access, and 18th Avenue. These accesses should be coordinated with the State of Hawai‘i Commission on Persons with Disabilities to help ensure compliance with the Americans with Disabilities Act and ADA Accessibility Guidelines.

This proposed path would not preclude the implementation of bicycle lanes on Diamond Head Road as proposed by the *Draft Honolulu Bicycle Master Plan*. In fact, the creation of a pedestrian/bicycle path as part of the DHSM plan will allow the existing attached sidewalk on the south side of Diamond Head Road to be eliminated. It is, therefore, recommended that the pedestrian/bicycle path be an early implementation item for the DHSM. This would

allow the implementers of bicycle lanes on Diamond Head Road to eliminate the existing sidewalk and relocate the street light poles behind the rock wall. In eliminating the sidewalk, it is suggested that the implementers of the bicycle lanes on Diamond Head Road leave one foot of the existing sidewalk to serve as a buffer between Diamond Head Road and the wall, similar to the abutment of a bridge. This would increase roadway width by about two feet, which could then be used as part of the on-street bicycle lanes.

Bus Stop Modifications

The Master Plan and various alternatives relocate DHSM access further to the west. It would make sense to relocate the pair of municipal bus stops located near the existing DHSM access to the west as well, since they appear to be utilized primarily by visitors to DHSM. This pair of bus stops could be relocated nearer to Makapu‘u Avenue. KCC students appear to utilize the existing pair of bus stops near the existing KCC access, and these are recommended to remain. However, it is recommended that the City & County of Honolulu either adjust the location or modify access to the bus stop serving eastbound Diamond Head Road so that ADA compliant access could be provided after elimination of the attached sidewalk on the south side of Diamond Head Road.

Intersection Traffic Control

Relocating the bus stops west to the Makapu‘u Avenue area would increase pedestrian crossing of Diamond Head Road in this area. Diamond Head Road is curvilinear, both in horizontal and vertical alignment, and it may be prudent to provide additional pedestrian crossing protection.

As presented in the existing conditions analysis, the existing peak hour traffic volumes at the Diamond Head Road/Makapu‘u Avenue intersection satisfy the peak hour traffic volume signal warrant as defined by the *Manual on Uniform Traffic Control Devices for Streets and Highways,* Federal Highway Administration, 1988. As a result of annual growth, the future volumes continue to satisfy the peak hour traffic volume signal warrant. Because of the combination of the potential increased pedestrian activity and the existing and future vehicular operations at this intersection, it is recommended that a traffic signal be implemented if a complete engineering analysis and signal design concurs that it is feasible.

As part of the signalization, it is recommended that the crosswalks be provided for pedestrian crossing of Diamond Head Road at the Makapu‘u Avenue/Diamond Head intersection.

The Master Plan proposes to relocate DHSM visitor access to the existing Cannon Club driveways. The Cannon Club is located west of Makapu‘u Avenue on Diamond Head Road, and is currently vacant. Because the Master Plan calls for visitors to be shuttled into Diamond Head crater by a people mover, the Cannon Club will function as a transfer point where visitors will park their cars or tour buses will drop off their passengers.

The proposed Cannon Club entrance/exit is appropriate for visitor and tour bus access given some modifications. The Cannon Club parking lot is configured with two access driveways designed to operate as a one-way entrance and a one-way exit. The flow through the parking lot is counter-clockwise, entering at the west driveway and leaving via the east driveway. The recommended lane configurations for the Master Plan are shown in Figure 23 of the *Traffic Impact Analysis for the Diamond Head State Monument Master Plan*. Given the 25 miles per hour (mph) posted speed limit and existing intersection lane configurations along Diamond

Head Road, it was judged that a shared through/right-turn lane would be appropriate at the entrance to the Cannon Club. Given the downgrade on Diamond Head Road near the Cannon Club, it is recommended to provide a left-turn lane to protect left-turning vehicles from westbound through traffic on Diamond Head Road. This left-turn lane will require some widening of Diamond Head Road. It appears that the widening will have to occur on the south (Diamond Head) side of Diamond Head Road. Exclusive left and right-turn lanes are recommended for the Cannon Club exit approach.

Earlier, the existing DHSM access was proposed to be maintained for use by State DOD/EOC personnel. However, upon further review, it is recommended to close this access and direct State DOD/EOC personnel to a new access located opposite Makapu'u Avenue on Diamond Head Road. It should be noted that the existing DHSM access should be chained, but allowed to be opened by authorized personnel during emergency situations.

Figures 24 and 25 of the *Traffic Impact Analysis for the Diamond Head State Monument Master Plan* illustrate the peak hour traffic volumes for the Preferred Alternative with recommended access modifications. The Makapu'u Avenue/Diamond Head Road intersection was assumed to be signalized based on the desire to improve pedestrian access and because existing traffic volumes satisfy the peak hour traffic volume signal warrant defined by the 1998 *Manual on Uniform Traffic Control Devices for Streets and Highways,* Federal Highway Administration. Given these modifications, an intersection analysis showed that the overall intersection would operate well at LOS B and minimal delays to all movements.

Municipal bus access to the Cannon Club requires further analysis. It would appear the existing pair of bus stops located near the existing DHSM access would be relocated closer to the Cannon Club. However, it is unlikely that the Cannon Club driveways will warrant signalization in the future. If the bus stops are located near the Cannon Club, a situation could be created in which the visitors are required to cross Diamond Head Road at an unprotected crossing to reach the westbound bus stop. There is a significant downgrade on Diamond Head Road in this area and pedestrian safety is a concern. Either measures to slow traffic on Diamond Head Road need to be implemented or alternative municipal bus access needs to be provided.

One alternative is to locate the bus stops in the vicinity of Makapu'u Avenue, and then create a people mover stop near this area for people who ride the municipal buses. As planned the people mover would already have to drive past this area, so an additional stop along its route would probably be acceptable. Additionally, the people mover stop would enable people who walk into the area from the KCC and Kaimukī areas to access the people mover without having to walk down to the Cannon Club.

Conclusion

Based on the analysis of proposed intersections and accesses of the various alternatives studied in the *Traffic Impact Analysis for the Diamond Head State Monument Master Plan*, it was concluded that the existing roadway system could accommodate the traffic generated by the proposed improvements to the DHSM. All conceptual plans improve the handling of DHSM traffic on Diamond Head Road, improve pedestrian and recreational mobility on the northern side of Diamond Head Road, and work well with the recommendations of the *Draft Honolulu Bicycle Master Plan*. In their review of the Draft EIS, the State Department of Transportation wrote that the proposed project "is not anticipated to have an adverse impact on our State transportation facilities."

Given the recommendations made, the visitor and personnel traffic is projected to be adequately accommodated. The existing DHSM access road was recommended for closure (although it would be available for use in emergencies), and the Makapu'u Avenue/Diamond Head Road intersection was recommended as a DHSM access instead of the previously planned (1979) KCC access, which was judged to have sub-standard stopping sight distance. Intersection analyses showed that the intersections would operate well overall given the recommended access modifications for all of the alternatives studied.

7.2.3 Utilities

Crater Interior Improvements. Presently, existing crater interior infrastructure located on the subject property accommodates the existing uses. The State DOD and existing comfort station all use water, wastewater, and electrical/communication facilities. Existing internal roadways service these facilities, however, this roadway system will be extended to provide a complete loop within the crater floor. Some roads and parking areas may be removed, while new roads and parking areas may be necessary.

Modifications to the existing infrastructure will be required for water distribution, wastewater collection and disposal, traffic circulation, parking, drainage and electrical/communication systems.

Crater Exterior Improvements. Crater exterior infrastructure consists of transportation, water, wastewater, drainage, and electrical and communication systems. No significant alterations or expansion of infrastructure is anticipated. Development of parking on the crater side of Diamond Head Road near the existing entry road is potentially the only significant improvement if the use of the existing parking lot at the Cannon Club is not possible and if the proposal of eventually keeping visitor parking to the exterior of the crater is implemented. Intersection improvements will be necessary in either case. Facilities just off the exterior parking may be developed to serve as a staging area for a proposed internal motorized people mover that would transport visitors from the parking staging area into and around the inside of the crater. The new parking and staging area facilities and project entry would be screened and buffered by landscaping and topography to mitigate potential visual impacts from Diamond Head Road looking toward Diamond Head Crater. The project entry would be redesigned to establish an entry statement suitable for such a significant landform of State and National importance.

A description of existing and potential impacts is provided below:

Water

Potable Water. Potable water will be obtained from the Board of Water Supply (BWS). Storage of potable water is provided by BWS's reservoirs, Wilhelmina (2,000,000 million gallon) and Pālolo (two 500,000 gallon). The reservoirs have spillway elevations of 405 feet above mean sea level. Water is transmitted to DHSM via a BWS 12-inch main in Diamond Head Road. An existing 12-inch transmission line connected to the BWS main provides water to DHSM. The transmission main enters the crater through Kapahulu Tunnel, runs behind the former FAA building site, and ends at Battery Birkhimer. Within the crater, existing eight-inch, six-inch, four-inch, and two-inch lines distribute water to various buildings and to Tunnel 407. Water is provided to the Cannon Club by two-inch water line. The average consumption in DHSM from June 1995 to August 2001, according to State DOD records, was 33,000 gallons per day (gpd).

Proposed water system improvements in the crater to provide fire and domestic flow include extending the transmission main from Battery Birkhimer to the visitor/interpretive center and Tunnel 407, adding fire hydrants, and waterlines to the comfort stations. The estimated average potable water demand is expected to be 23,500 gpd. If the landscaped area around the visitor/interpretive center is irrigated with potable water, the additional estimated average demand is 6,900 gpd. Total potable water demand, domestic consumption plus landscape irrigation, is approximately 30,400 gpd.

During their review of the Draft EIS, the Fire Department requested that a private water system where all appurtenances, hydrant spacing, and fire-flow requirements meet Board of Water Supply standards be provided.

The availability of additional water will be confirmed when the building permit application is submitted to the Board of Water Supply for their review and approval. DLNR will coordinate with the City and County of Honolulu to incorporate the proposed project into the County's Water Use and Development Plan. The proposed project will also be incorporated into the State Water Projects Plan.

Non-potable Water. Currently non-potable water for irrigation is not available and landscaped areas are irrigated with potable water.

Approximately 31 acres of landscaped area is proposed. The landscaped area, except for approximately one acre around the visitor/interpretive center, is proposed to be irrigated with non-potable water. It is proposed that irrigation water be provided through the transmission of non-potable water wells outside the crater. DLNR has drilled two exploratory wells on the Kaimuki Middle School grounds to provide non-potable water for the irrigation of the DHSM. Well water will be pumped into the crater through a waterline in Kāhala Tunnel. From the tunnel, non-potable water will be piped to the proposed water feature. The pond, lined with a waterproof membrane, will store irrigation water. From the proposed water feature, water will be pumped to landscaped areas inside the DHSM. Estimated non-potable irrigation demand is 218,000 gpd.

According to DLNR, the wells at the Kaimuki Middle School can produce non-potable water at a rate of 350 gallons per minute (gpm). With two wells being pumped continuously for 24 hours, the wells have a total flow of 288,000 gallons per day. Water quality from the well was at a salinity level that can be used to irrigate salt-tolerant grasses and plants, but probably cannot be used to irrigate the existing plants in the crater.

Future non-potable groundwater improvements that could be developed to supply irrigation water for the proposed project may include construction or improvement of storage and pumping facilities within the crater. Development of groundwater sources is subject to review and approval by the State Commission on Water Resource Management (CWRM)

If a non-potable system is implemented, the potable and non-potable water systems will be carefully designed and operated to prevent cross-connections and backflow conditions. The two systems will be clearly labeled and physically separated by air gaps or reduced pressure principle backflow preventers to avoid contaminating the potable water supply. All non-potable spigots and irrigated areas will be clearly labeled with warning signs to prevent the inadvertent consumption of non-potable water. In addition, non-potable spigots will be installed in secured, below-grade enclosures.

Electrical and Communications

Electric power to Diamond Head is provided by Hawaiian Electric Company (HECo) and telephone service is provided by Hawaiian Telephone Company (HTCo). However, HECo does not own all of the existing power lines.

Because the net level of use within the crater will not be significantly altered compared to current levels, existing electrical and telephone infrastructure will be modified to accommodate the master plan requirements. Based on availability of present service capabilities and planned improvements in the existing electrical

facilities, significant impacts are not expected to result from the proposed action. Similarly, the proposed action should produce no significant impacts to telephone service. However, the proposed Interpretive/Visitor Center will have large electrical/communications loads and HECo and HTCo services will need to be extended to this facility.

The HECo and HTCo services may be modified by relocating the existing overhead lines underground, for aesthetics, then reconnecting the existing facilities that remain. The cost to underground lines for aesthetics will not be borne by HECo. After the FAA relocated outside of the crater, Birkhimer EOC desired to realign existing overhead electrical and communications lines into the aboveground utility conduits along the road to the FAA Link Site. Placing lines underground would help to implement the DHSM objective of restoring the crater to a semi-wilderness condition. HECo suggests that further work on the project be coordinated with HECo's continuing input.

Sanitary Sewer

The interior of the crater has an existing sanitary sewage system that collects sewage from all of the buildings and pipes sewage to a lift station located south of Building 303. The lift station pumps sewage through a 4-inch force main to a manhole located in Kāhala Tunnel. From this manhole, sewage flows in a gravity sewer line to a City and County of Honolulu (C&C) manhole located at the intersection of Paiku Street and 22nd Avenue. The C&C system transports sewage through a series of gravity lines, lift stations and force mains to the Sand Island Wastewater Treatment Plant for treatment and disposal. Sewage from Tunnel 407 is disposed in an existing cesspool located near the tunnel entrance.

Sewage from the Cannon Club flows in a gravity pipeline to an existing C&C sewer line in Wauke Street. No change to the sewage system for Cannon Club is proposed.

Proposed sewage system improvements include new collection system and, to transport sewage out of the crater, a new lift station, force main, and gravity main. The sewage will be collected and piped from the visitor/interpretive center, Tunnel 407, Battery Birkheimer, caretaker's residence or DOCARE office, and comfort stations to a new lift station. The new lift station, proposed to be located south of the visitor/interpretive center, will pump sewage through a new force main to a new manhole in Kāhala Tunnel. From this manhole, sewage will flow in a new gravity sewer line to a C&C manhole located at the intersection of Paiku Street and 22nd Avenue. Estimated sewage generated by the visitor/interpretive center, Tunnel 407, caretaker's residence, and comfort stations is approximately 20,000 gpd.

Drainage System

The existing storm drain system consists of natural drainage ways, culverts, lift stations, and drain lines. Storm water flows from the steep crater walls through culverts under roadways and collects at the low point of the crater south of Building 303. This low point has no natural outlet. Estimated peak storm water flow from a 100-year storm is 1,500 cubic feet per second (cfs). Storm water retained on the crater floor is disposed by evaporation, transpiration, percolation, and, if necessary, pumping. When the water level endangers existing buildings, storm water is pumped through a force main to a gravity storm drain line in Kāhala Tunnel. After leaving Kāhala Tunnel, storm water flows in a gravity storm drain line to a C&C storm drain located at Paiku Street and 22nd Avenue.

The proposed storm drain system include swales to direct storm water, culverts to convey storm water under roads, and force main and gravity drain lines to convey water out of the crater through the installation of a pump station. Estimated peak storm water flow from a 100-year storm is 1,500 cfs, which represents no change from existing conditions. The proposed drainage system for the new crater interior perimeter road includes, swales on the uphill side of the roadways to direct storm water flowing off of the steep crater walls to culverts, which will convey water under the perimeter roadway. Culverts under the remaining roadways are also proposed. As in the existing condition, future storm water within the crater will collect at the low point south of the visitor/interpretive center. Storm water retained on the crater floor will be disposed by evaporation, transpiration, percolation, or when necessary pumped out of the crater. The retained storm water may also be used for landscape irrigation. A storm water pump station will pump storm water through a force main to a manhole in Kāhala Tunnel. From this manhole, storm water will flow in a gravity storm drain line to the C&C storm drain at Paiku Street and 22nd Avenue.

7.3 POTENTIAL USES OF THE MONUMENT

Under Governor Quinn's Executive Order 2000 in 1962, Diamond Head was established as a State Monument with emphasis on preservation. The DLNR Division of State Parks, which was given the responsibility of management in 1975, has considered mainly passive recreation activities, as defined by the Statewide Comprehensive Outdoor Recreation Plan (SCORP), requiring few structural facilities. The Historic Preservation Law (Chapter 6E) Hawai'i Revised Statutes, 1976) constrains most alternatives for use of Diamond Head State Monument to preservation and recreation.

This update is therefore constrained to consider only passive recreational activities and the acceptable intensity of such recreational development and use of the interior of the crater and preservation of the visual exterior of the Diamond Head State Monument.

7.3.1 Recreational Activities

A wide variety of recreational activities – hard court activities, bicycling, horseback riding, golfing, baseball, camping, concerts and picnicking, to mention a few – is usually considered in planning the development of any park. If the activity cannot appropriately be applied to the specific site, however, it is normally eliminated from consideration. Diamond Head State Monument has a further development restraint – preservation and restoration of natural and open-space features.

The Diamond Head State Monument is situated in SCORP Area 21 (Central and East Primary Urban Center), encompassing the eastern portion of the City and County of Honolulu's Primary Urban Center (PUC), which stretches from the Kāhala and Maunalani Heights neighborhoods to Kalihi Valley. Waikīkī, University/Mānoa, and downtown Honolulu are part of this planning area.

Existing recreation facilities and recreation areas include Ala Moana Regional Park, Magic Island, Waikīkī Beach, Kapi'olani Park, Honolulu Zoo, 'Iolani Palace State Monument, Diamond Head State Monument, Ala Wai Golf Course, Ala Wai Boat Harbor, Kaka'ako Park, Nu'uanu Reservoir, Nu'uanu Pali State Wayside, the Honolulu Mauka Trail System (Makiki-Tantalus), and the Sand Island and Wa'ahila Ridge State Recreation Areas.

The objective of the 1979 plan for Diamond Head State Monument was stated as "the establishment of a semi-wild interior park and development of an exterior park for family picnic outings." The objective was then the basis of the approved Diamond Head State Monument Plan as developed by the Diamond Head Citizens Advisory Committee and adopted by the Board of Land and Natural Resources in 1979, and subsequently enacted into law by the Hawai'i State Legislature in 1992. The objectives and policies were reviewed and portions of the policies were amended and approved by the Diamond Head CAC on November 16, 1995, but were not formally adopted by the Board of Land and Natural Resources. A portion of the amended Plan Policies (November 16, 1995) states:

> That all recreational development be directed toward passive, unstructured activities that require minimal development of the crater site. Such development would be limited to an improved trail system and scenic viewing areas, reforestation and natural landscaping with adequate water supply, picnic areas, and meadowlands, and a visitor's interpretive center.

Some of the potentially compatible recreational uses that have been considered for Diamond Head are discussed briefly below:

Picnicking

Picnicking can take place within a semi-wild or developed park area. Fire hazards and containment, however, are important considerations in selecting sites. Support facilities include picnic tables and benches, comfort stations, and landscaping with trees and lawn areas. This activity and its support facilities could be compatible with the objectives for the Monument.

Walking and Jogging

These activities can occur within any park, and in most cases no formal, paved path is required. Since they are widely practiced all over the island and do not require support facilities, these activities would be compatible in Diamond Head.

Hiking

Hiking is an activity compatible in mountainous areas and would be particularly suitable within the crater because of the magnificent panoramic views from the crest. The poor condition of portions of the existing trail, however, with hazards of steps, steep slopes, loose footings, and high use, etc., are issues that should be considered. Also, the friable soil of the crater slopes creates problems (i.e., erosion, crumbly loose surface, etc.), which will require management controls for this type of activity.

With the Kāhala tunnel open to public access every day from 6 a.m. to 6 p.m., hikers and sightseers take advantage of the opportunity to enter and scale the interior slopes to reach the summit of Lē'ahi because of its commanding panoramic views in all directions.

7.3.2 Non-Recreational Activities

There are many potential non-recreational uses of the crater beyond the existing military and Civil Defense functions that are currently allowed. Non-regulated vendors, for example, are considered non-recreational. Such activities are not presently prohibited, but they are discouraged and controlled through requirements for: 1) compliance with DLNR and State Parks Rules and Regulations, and 2) Conservation District and Special Management Area permits.

It should be noted the amended Plan Policies (November 16, 1995) also state that:

3) "That no new permanent buildings or structures be constructed within Diamond Head State Monument unless required for public health, sanitation, or safety of Park users, or for the maintenance and management support of the Monument in accordance with Section 6E-32, HRS, as amended by Act 313, Session Laws of Hawai'i 1992."
4) "That large gatherings and any commercial use not be allowed, and that any use which may detrimentally affect the natural crater environment of Diamond Head State Monument be prohibited, including non-regulated vendors and non-profit activities".
5) "That DLNR acquire all available, unused and surplus Federal lands adjoining or within the Diamond Head State Monument and secure the phase-out of state and Federal Department of Defense and Federal Aviation Administration operations and demolition of their structures within the Monument."
6) "That no civilian aircraft be permitted to fly less than 2,000 feet over Diamond Head State Monument or land anywhere within the Monument, and that no mechanical device create a noise or dust nuisance or endanger people within the Diamond Head State Monument semi-wilderness crater park."

7.4 IMPLICATIONS FOR MASTER PLAN UPDATE

Recreation

Presently the existing park facilities at DHSM are inadequate to accommodate the number and type of visitors entering the crater. Some of the recreational problems include:

- potential for accidents in Kāhala Tunnel (due to the narrowness of the tunnel and the mix of pedestrians and vehicles);
- inadequate number of parking stalls for visitors;
- inadequate number of toilets at the comfort station;
- too many visitors on the existing trail to the summit;
- unauthorized access along the crater rim and along the slopes of the crater;
- periodic need to provide rescues for stranded hikers who are in unauthorized areas; and
- inadequate interpretive signage along the trail and at the trail head.

The planning and management of the DHSM should incorporate possible solutions to the above problems (short of limiting the number of visitors to the Monument). These could include:

- restricting buses and other large vehicles from entering the crater;
- restricting vehicles to one traffic lane with directional control devices and providing sidewalks for pedestrian use within Kāhala Tunnel;
- providing more visitor parking;
- restricting visitor vehicles to the exterior of the crater;
- installing more comfort stations or toilet facilities;
- developing more recreational features (such as enhanced wetland, native dryland forest, picnic areas, hiking trails, and historic military fortifications);
- constructing more trails (to provide access to the new recreational features described above);
- providing more enforcement officials to enforce rules and regulations;
- providing brochures and installing more signage;
- constructing a visitor/interpretive center and other park facility improvements; and
- constructing satellite interpretive facilities.

Utilities

All present electricity and telephone lines along and leading into the crater are buried only through the tunnels; both exterior and interior lines are overhead, creating an adverse visual impact. Placing utilities underground (except to the FAA Link Site) would be highly desirable in any future plans for improvements of the DHSM with the understanding that the cost will be borne by the party requesting the undergrounding of utilities.

Demolition Activities

Prior to any demolition activities, all affected areas will be inspected to determine whether asbestos is present, as required by federal rules (40 Certified Federal Rules, Part 61, National Emission Standard for Hazardous Air Pollutants Asbestos NESHAP Revision; Final Rule, November 20, 1990). Under this NESHAP regulation, the project is required to file with the Noise, Radiation and Indoor Air Quality Branch of the Department of Health an Asbestos Demolition/Renovation notification ten working days before demolition of each building or the disturbance of regulated asbestos-containing materials. All regulated quantities and types of asbestos-containing materials are subject to emission control, proper collection, containerizing, and disposal at a permitted landfill.

Police Protection

Diamond Head falls within the Police Department's District #7, which encompasses the area from Makapu'u to Punahou. There are about five field officers assigned to the entire district, including the beach taskforce and bicycle patrol. Response time fluctuates depending on the location of available field officers at the time of the call. Diamond Head Crater is presently patrolled by both HPD field officers and the bicycle patrol, and by DOCARE personnel.

Proposed improvements will cause an occasional demand for police services, however, personal security could be improved if revenues generated within the crater could support park ranger-type personnel and/or private security guard services. If and when the State DOD leaves the crater, there will be no security at night. To mitigate this impact, proposed improvements could include a live-in caretaker's residence or a DOCARE office.

To minimize criminal activity in the area, the District 7 Community Policing team will be contacted during the design phase of future improvements at Diamond Head. During the comment period for the EISPN, the City and County of Honolulu Police Department wrote, "This project should have no additional impact on the operations of the Honolulu Police Department." In their review of the Draft EIS the Police Department wrote: "In spite of mitigation measures, we anticipate an increase in calls for service to the area during the construction phase of the project because of dust, noise and traffic complications. Then when it becomes operational, we expect that noise and traffic-related problems will generate calls for police service to the area."

Fire Protection

There are two fire stations servicing the Diamond Head Crater. For fires within the crater, the Waikīkī Station (with approximately twelve firefighters) has a response time for one engine company of approximately 2-3 minutes. The Kaimukī station would respond with one engine company and one ladder truck for larger structural fires.

Proposed improvements will cause an occasional demand for firefighting services. Availability of fire protection capability is critical for both structural fires and brushfires that could threaten endangered plant species. Structural fires could be addressed by the incorporation of the latest fire safety system in the design of any new structures.

In addition, the Fire Department requested the following:

"1. Provide a private water system where all appurtenances, hydrant spacing, and fire flow requirements meet Board of Water Supply standards.

2. Provide a fire department access road to within 150 feet of the first floor of the most remote structure. Such access shall have a minimum vertical clearance of 13 feet 6 inches, be constructed of an all-weather driving surface complying with Department of Transportation Services standards, capable of supporting the minimum 60,000 pound weight of out fire apparatus, and with a gradient not to exceed 20%. The unobstructed width of the fire apparatus

access road shall meet the requirements of the appropriate county jurisdiction. All dead-end fire apparatus access roads in excess of 150 feet in length shall be provided with an approved turn-around having a radius complying with DTS standards.

3. Submit construction plans to the HFD and the Department of Planning and Permitting."

Brush fires could be mitigated by the preparation and implementation of fire control measures such as reducing fuel load, the construction of fire breaks and roads, the installation of landscaping, planting fire-resistant plants, and education of visitors to Diamond Head.

In addition, there will be an occasional demand for emergency rescue services. The Fire Department frequently provides emergency rescue service to stranded and injured hikers. According to Fire Department statistics, from 1996 to present, there were 52 rescues made in the Diamond Head Trail area, or approximately 2.5 rescues per month. The Fire Department concurs that providing a ranger to educate hikers on preparedness prior to starting their hikes should assist in preventing most of the rescue calls for this area.

8.0 Master Plan Update

The DLNR Division of State Parks and the Diamond Head Citizens Advisory Committee (CAC) prepared the Diamond Head State Monument Planning Report in June 1979. This Plan was accepted by the Board of Land and Natural Resources in 1979, and subsequently adopted by the Legislature as the official document setting forth the future direction of Diamond Head State Monument (Act 313, SLH 1992).

During the past 19 years since the Plan was prepared and portions implemented, visitor use of Diamond Head State Monument has increased significantly, impacting natural resources, park improvements, and county facilities (road, water, and sewage treatment). The Federal Aviation Administration (FAA), United States Department of the Army (USA), and State Department of Defense (State DOD) lands identified in the 1979 Plan, have been or are being vacated by the respective agencies. The Office of Hawaiian Affairs (OHA) is also now eligible to receive revenues derived from "ceded" lands.

As part of State law under Chapter 6E-32, Hawai'i Revised Statutes, amendments to the document are allowed by the Board of Land and Natural Resources with the review and recommendations of the CAC, organized in October 1977.

In 1996, the DLNR recognized the need to address this situation and requested funding for an update of the 1979 Plan. The update is to include the preparation of plans, and designs for the incremental development of the Monument, including a visitor/interpretive center. The 1997 State Legislature appropriated the requested funds.

This chapter describes the following: the 1979 Development Plan; the 1995 CAC amendments to the Policies for the DHSM; possible alternatives to the 1979 Plan; public feedback on the alternatives; evaluation criteria used in selecting a preferred alternative; selection of the Preferred Alternative; the Updated Master Plan (refinement of the Preferred Alternative); a Conceptual Landscape Plan; Preliminary Cost Estimates; and a Proposed Phasing Plan.

8.1 1979 Development Plan

Since this is essentially an update of an existing plan, any identification of alternative master plan concepts should consider the 1979 Development Plan. This alternative would meet the objective and policies described in Section 1.3. The Diamond Head State Monument Master Plan of 1979 would restore the interior of the crater to an essentially semi-wild state, with reforested areas, an extensive wildland, and meadowlands. This wilderness area would be accessed by the public through a one-way vehicular circulation system that would involve entering from the Kapahulu Tunnel and exiting through the Kāhala Tunnel. An interpretive center, restrooms, and parking area concentrated between the tunnels were also planned. The following summarizes the key elements of the 1979 Development Plan:

Tunnels

The two major tunnels that access the crater would not be physically altered. Traffic circulation would be one-way with entry into the crater via the Kapahulu Tunnel and exit through the Kāhala Tunnel where a pedestrian walkway was also planned. The existing parking and scenic overlook outside the crater adjacent to the Kāhala Tunnel would be improved to handle the "anticipated influx of visitors to the area."

Interior Roadways and Parking

The paved roadway network within the Monument would be limited to corridors required for public access and to mostly existing roads through the area currently restricted only to State DOD. The road from Kapahulu Tunnel would be one-way only to Kāhala Tunnel or

vice-versa. While the 1979 Development Plan only shows the parking lot below Battery Birkhimer, the text describes parking being limited to a few designated parking lots with planned overflows for events on the landscaped open areas.

Interpretive Center

The proposed interpretive center would be located between the two tunnel entrances inside the crater. Its design would reflect a rustic character to integrate into the surrounding natural wilderness concept. The structure would be designed to reveal the panoramic outdoor scene for interpretive and fire watch security purposes. Access to the Center would be provided by the lower parking area (which is the existing parking lot below Battery Birkhimer). The present service road to Birkhimer EOC would be used for handicapped access. Although no interpretive program had been developed, the Plan did recommend that any interpretive program stress the geology, historical use, and interesting flora of the crater.

Parking

The 1979 Development Plan showed parking below the site of the proposed interpretive center, with additional parking at the Cannon Club and outside of Kāhala Tunnel. Presumably, the first choice for visitors would be to park near the interpretive center or in a second overflow lot outside of the Kāhala Tunnel (which would require walking in through the tunnel). If these two parking lots were full or otherwise not available, parking at the Cannon Club would be the third alternative.

Caretaker Residence

To facilitate 24-hour security, a caretaker structure was planned to be unobtrusively located proximate to the proposed Interpretive Center.

Comfort Stations

Sanitary facilities would be provided as minimal support for the daily public use of the Monument. Shown on the 1979 Development Plan were facilities located at the Cannon Club, the existing comfort station location and another at the proposed parking lot below the Kāhala Tunnel. Portable chemical lavatories would supplement the permanent facilities for large events and usage requiring additional facilities.

Exterior Picnic Area

Exterior picnic facilities (site undetermined) were also planned to be geared for large gatherings in areas accessible by automobile. According to the 1979 Development Plan, with careful management, picnic areas outside the crater could be utilized 24 hours a day.

Interior Picnic Areas

As stated in the Plan Objective, family picnics were envisioned as a primary use for the crater. A wooded open space across the road from the Interpretive Center was recommended to serve as a low-density picnic site for visitors and hikers, and as a walk-in site for day users. This area would be designed to integrate facilities into the natural surroundings without introducing a fire hazard. No cooking facilities would be provided and a stone wall would be built as a firebreak.

Dryland Habitat

The proposed dryland habitat element of the plan covered essentially the entire interior of the crater. Natural environmental characteristics would establish distinctive zones consisting of the: (1) existing kiawe forest (to remain intact), (2) dry-lake area (wetland) labeled as "shrubland" on the 1979 Development Plan, (3) meadowlands (existing lawn area), and (4) reforested area. The reforested area would consist of small-tree vegetation reflecting the natural ecosystems for this area. Design of facilities would be just enough to satisfy the basic recreational potential of the area. Service roads, firebreaks, and other fire-control devices would be unobtrusively implemented into the design.

Upper Slopes

This element of the plan addressed primarily Lē‘ahi Summit. As a major hiker destination, a closely monitored management program was recommended because of endangered plants in the surrounding area and the need to refurbish the summit while still maintaining a low profile and rustic character.

Trail System

Two separate trail systems (interior and exterior) were planned to address different needs and purposes. The exterior trail system would have a dual function as a jogging and bicycle path traversing the *mauka* end of the Monument and along the existing trail on the lower ‘Ewa-*makai* slopes. Several access points would be required for neighborhood linkages and security. The trail width would be sufficient to accommodate emergency vehicles.

The interior trail system was limited to the existing trail to the summit of Lē‘ahi, a new trail around the proposed shrubland (wetland), which would continue on the road to Tunnel 407 and from there to the crater rim, and a new trail starting from outside Kāhala Tunnel over the crater rim to the other side of the tunnel. Only trail access to reach panoramic view sites along the crest and Lē‘ahi Summit lookout would be available. The upper slopes with crumbly footing and sparse vegetation, and endangered plants in the area were determined to justify limited access.

Landscaping

- Reforestation and replanting of major areas with hardy, maintenance-free plants to present a rustic natural setting.
- Non-native vegetation such as fountain grass will be monitored and contained or removed.
- Selected natural areas would be established to ensure the survival of native and endangered plants and their habitats.
- Areas with high use would be landscaped and maintained as park areas.

Linear Parkway

Diamond Head Road would be landscaped with trees, grass, and shrubbery. All overhead utility lines and poles would be eliminated.

Project Nursery and Maintenance Yard

This element would be designed to propagate and establish dryland native plants for the Monument. Once the reforestation is completed, the yard would be moved from a temporary facility outside the crater.

8.2 1995 CAC AMENDMENTS TO THE POLICIES FOR THE DHSM

The objective of the final plan for Diamond Head State Monument was stated as, “the establishment of a semi wild interior park and development of an exterior park for family picnic outings.” This objective was the basis of the approved Diamond Head State Monument Plan as developed by the Diamond Head Citizens Advisory Committee and adopted by the Board of Land and Natural Resources in 1979, and subsequently enacted into law by the Hawai‘i State Legislature in 1992. The objectives and policies were reviewed and portions of the policies were amended and approved by the Diamond Head CAC on November 16, 1995, but were not formally adopted by the Board of Land and Natural Resources. The amended Plan Policies (November 16, 1995) are stated below.

“The policies established for the management and development of the Diamond Head State Monument, as outlined below, are directed toward fulfilling the objectives stated above.

1. *That all recreational development be directed toward passive, unstructured activities that require minimal development of the crater site. Such development would be limited to an improved trail system and scenic viewing areas, reforestation and natural landscaping with adequate water supply, picnic areas and meadowlands, and a visitor’s interpretive center. Visual impacts and crater view planes are to be*

given priority consideration in location, design and landscaping.

2. *That any proposed deviation from the adopted Plan for areas within Diamond Head State monument will require an approved Environmental Assessment and Negative Declaration or a full Environmental Impact Statement in accordance with Chapter 343, HRS.*

3. *That no new permanent buildings or structures be constructed within the Diamond Head State Monument unless required for public health, sanitation, or safety of Park users, or for the maintenance and management support of the Monument in accordance with Section 6E 32, HRS, as amended by Act 313, Session Laws of Hawai'i 1992.*

4. *That large gatherings and any commercial use not be allowed, and that any use which may detrimentally affect the natural crater environment of Diamond Head State Monument be prohibited, including non regulated vendors and non profit activities.*

5. *That DLNR acquire all available, unused and surplus Federal lands adjoining or within the Diamond Head State Monument and secure the phase out of state and Federal Department of Defense and Federal Aviation Administration operations and demolition of their structures within the Monument.*

6. *That no civilian aircraft be permitted to fly less than 2,000 feet over the Diamond Head State Monument or land anywhere within the Monument, and that no mechanical device create a noise or dust nuisance or endanger people within the Diamond Head State Monument semi wilderness crater park.*

7. *That all agencies with land fronting Diamond Head Road be urged to coordinate their beautification efforts and that safety features be provided for pedestrian and non motorized transportation around the crater on Diamond Head Road and within the Monument.*

8. *That landscape design, irrigation, installation and maintenance be implemented in full accordance with the "Recommended Guidelines for Landscape Treatment of the Diamond Head Area" as adopted by DLNR in 1982 per Appendix I attached hereto.*

9. *That minimal and uniform signage graphics be provided on an ongoing basis, and that such graphics be designed and made to the highest standards suitable to natural park conditions to meet the needs of the Monument Park for safety, information, ecology, history and goals of the Park."*

8.3 DEVELOPMENT PLAN UPDATE ALTERNATIVES

This year, as part of the Diamond Head Master Plan Update process, a number of alternatives were developed for consideration by the Diamond Head Citizen's Advisory Committee. It should be noted that the alternatives were driven by their abilities to meet both the original and amended objective and policies of the DHSM (as described in Sections 1.3 and 8.2). The CAC narrowed the sites being considered for the visitor/interpretive facility to three locations within the crater. These are:

- Alternative Concept 1 – Visitor/interpretive center near Battery Birkhimer (described in Section 8.3.4);
- Alternative Concept 2 – Visitor/interpretive center near Kapahulu Tunnel (described in Section 8.3.5); and
- Alternative Concept 3 – Visitor/interpretive center near Tunnel 407 (described in Section 8.3.6).

In addition, the following alternatives were considered:

- Alternatives That Do Not Meet Project Objectives (described in Section 8.3.1);
- The "No-Action" Alternative (described in Section 8.3.2); and

- Alternative of a Significantly Different Nature Which Would Provide Similar Benefits With Different Environmental Impacts (described in Section 8.3.3).

8.3.1 Alternatives That Do Not Meet Project Objectives

Over the years, numerous alternative uses for the crater have been proposed. Examples of these potential use alternatives considered have included a zoo, golf course, theme park, active recreation (ballfields/tennis, etc.), camping, and facilities for festivals and other large events. However, introduction of artificial or man-made elements into the crater that would detract from a "semi-wild" interior park were rejected as being inconsistent with the objective and policies established for the crater (1979, and amended in 1995). As described in Sections 1.3 and 8.2, establishment of passive recreational opportunities with interpretive facilities depicting the natural and cultural history of Diamond Head would not be achieved if these uses were implemented.

The alternative of locating the permanent visitor/interpretive center outside of the crater was brought before the CAC in 1998, but was discounted for lack of support. This alternative is significantly different from the location of the visitor/interpretive center shown on the 1979 Development Plan (which is inside the crater).

In addition, the permanent reuse of existing buildings (State DOD Buildings 301, 303, and 304) for a visitor/interpretive facility was also rejected as being inconsistent with the following policy statement: "...secure the phase-out of State and Federal Department of Defense and Federal Aviation Administration operations and demolition of their structures within the monument."

8.3.2 "No-Action" Alternative

The "no-action" alternative would not be consistent with the objective and policies stated in Sections 1.3 and 8.2. This alternative would maintain the site in its present condition with the following negative impacts:

- The site would not be managed in an appropriate manner with non-essential vehicles continuing to enter the crater.
- The endangered plant habitats would continue to be stressed by hikers, fires and alien species.
- State DOD Buildings 301, 303, and 304 facilities would continue to have a detrimental visual impact on the crater floor in their present conditions.
- Pedestrians would continue to have unsafe access via Kāhala Tunnel due to mixed traffic.
- Visitors would have a limited opportunity to experience present closed off areas within the crater including viewpoints, Tunnel 407, and Battery Harlow.
- View opportunities would be limited to the existing trail and the Kāhala Tunnel lookout.
- The quality of visitor experience would deteriorate because visitors would continue to be limited to the already crowded hiking trail to Lēʻahi Summit.
- Limited parking for park visitors.

8.3.3 Alternative of a Significantly Different Nature Which Would Provide Similar Benefits with Different Environmental Impacts

There are improvements that are proposed or underway that are in keeping with the objective and policies described in Sections 1.3 and 8.2, but are significantly less in scope than the 1979 Development Plan (described in Section 8.1). These are:

- Construct trail improvements to minimize erosion.
- Construct a new trail at the summit.
- Install signs along trail and at Kāhala Tunnel Lookout.
- Construct interim interpretive kiosk.
- Construct toll/information booth with landscaping.
- Collect park entry fees

While these actions provide some benefits by reducing project costs (from the alternatives described in Sections 8.3.4, 8.3.5 and 8.3.6),

reducing erosion, improving accessibility, providing information and first aid supplies, and generating revenues, these actions will share many of the negative impacts associated with the "no action" alternative (described in Section 8.3.2):

- The site would not be managed in an appropriate manner with non-essential vehicles continuing to enter the crater.
- The endangered plant habitats would continue to be stressed by hikers, fires and alien species.
- Pedestrians would continue to have unsafe access via Kāhala Tunnel due to minimal walkways.
- Visitors would have a limited opportunity to experience present closed off areas within the crater including viewpoints, Tunnel 407, and Battery Harlow.
- View opportunities would be limited to the existing trail and the Kāhala Tunnel lookout.
- The quality of visitor experience would deteriorate because visitors would continue to be limited to the already crowded hiking trail to Lē'ahi Summit.
- Parking for park visitors would continue to be limited.

8.3.4 Alternative Concept 1 – Visitor/Interpretive Center near Battery Birkhimer

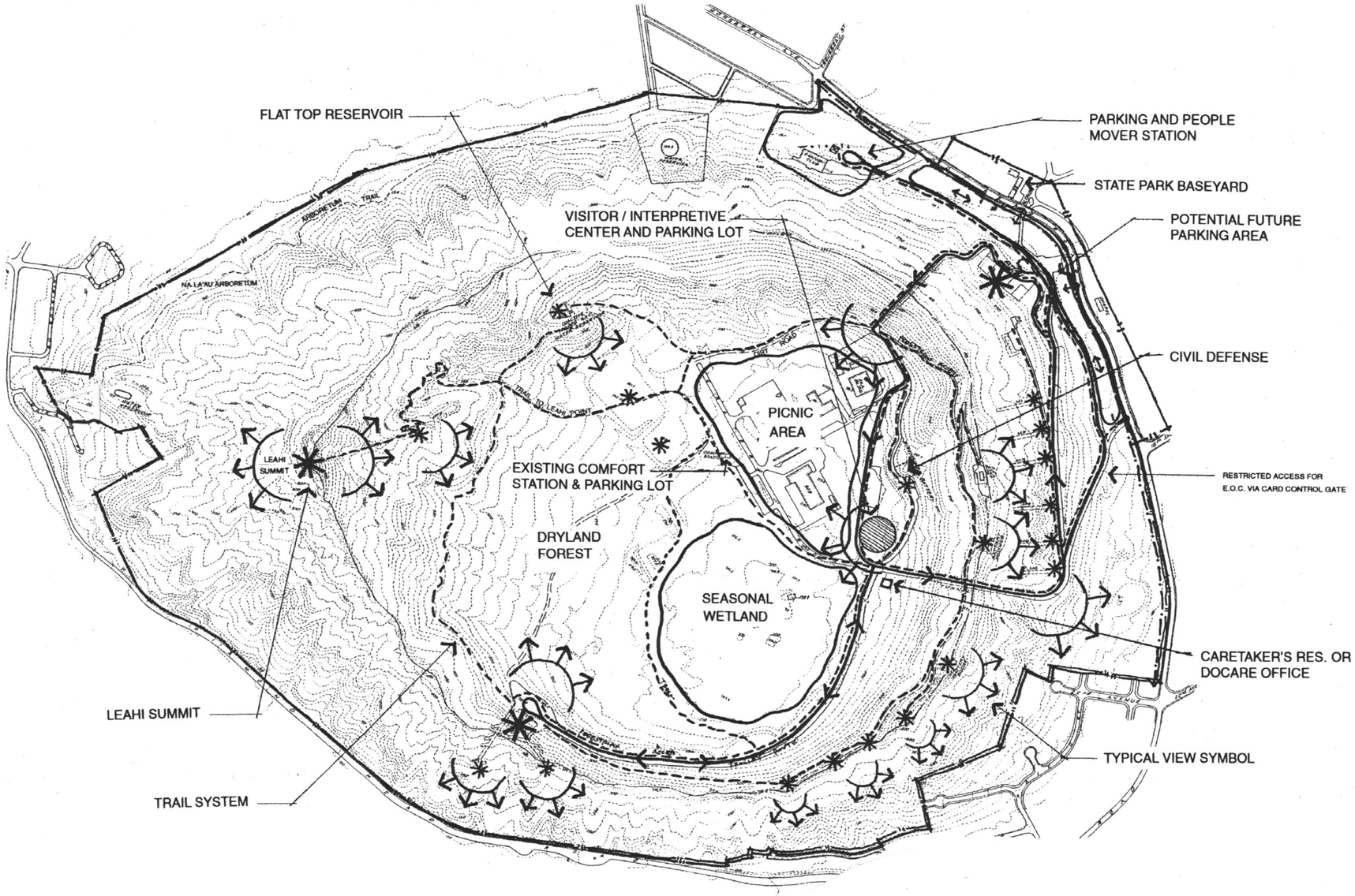
Alternative Concept 1 is similar to the 1979 Development Plan, as many of the major elements of the 1979 plan have also been incorporated into this alternative. For example, common elements include:

- Entry through Kapahulu Tunnel;
- Exit through Kāhala Tunnel;
- A permanent visitor/interpretive facility near Battery Birkhimer;
- A caretaker's residence or State Division Conservation and Resource Enforcement (DOCARE) office;
- Removing State DOD Buildings 301, 303, and 304;
- Improvements to the wetland;
- Proposed trail around the wetland; and
- Proposed picnic area.

As such, this alternative should be considered as an update to 1979 plan rather than a completely new master plan. In the face of a significant increase of visitors to the crater since 1979, the following alternative would reinforce these common elements by:

- In the long-term, moving visitor parking to outside of the crater;
- Establishing a motorized people mover system, when visitor parking is kept to the exterior;
- Utilizing the Cannon Club for food service and/or visitor orientation and providing restroom facilities;
- Opening up Tunnel 407 and Battery Harlow for interpretive purposes and providing restroom facilities;
- Keeping the existing comfort station and parking lot;
- Accommodating pedestrian access through Kapahulu Tunnel;
- Controlling visitor access into sensitive areas (such as the crater rim);
- Protecting the *Schidea adamantis* habitat, and the habitat of other native species;
- Opening the road/trail from the FAA Link Site to the retractable searchlight on the southeastern edge of the crater rim;
- Opening a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407;
- Utilizing Battery Dodge and Hulings and the gun emplacements along the eastern edge of the crater as lookouts;
- Opening a new trail to the flat top reservoir north of the existing trail to the summit;
- Adding comfort stations at the exterior parking facility, at secondary interpretive facilities, and picnic areas; and
- Installing a wastewater lift station.

The elements of this alternative are shown on Figure 17 Alternative Concept 1 – Visitor/ Interpretive Center at Kāhala Tunnel and are described below.



Legend

- View Symbol .....
- People Mover Route .....
- Pedestrian Routes / Hiking Trails .....
- Pedestrian / Bike Path .....
- Major Military Interpretive Feature ..... with Comfort Station
- Minor Military Interpretive Feature .....

PBR HAWAII

0 350 700 FEET

Figure 17
Alternative Concept 1

Master Plan Update

Diamond Head

Entry

In the short term, entry would continue through Kāhala Tunnel. Eventually, if the number of vehicles within the crater was determined to be adversely affecting the visual, noise, and air quality, visitor parking could be relocated to the exterior of the crater. If the Cannon Club can be acquired, then the existing parking lot at the Cannon Club can be utilized as the visitor parking facility. The main entry to the crater, then, would be at the Cannon Club, with a new road built from the Cannon Club to Battery Harlow. If the Cannon Club cannot be acquired, then the main entry would be across the street from the Diamond Head Road entry to Kapi‘olani Community College.

Tunnels

The two major tunnels that access the crater would not be physically altered. Traffic circulation would be one-way with entry into the crater via the Kapahulu Tunnel and exit through the Kāhala Tunnel. Both tunnels would accommodate pedestrian access. The existing parking and scenic overlook outside the crater adjacent to the Kāhala Tunnel would continue to be used. Specifying one-way traffic through the tunnels will allow the striping of a single lane in the middle of both tunnels for vehicular traffic and narrower “lanes” on either side for pedestrians.

Interior Roadways and Parking

The paved roadway network within the Monument would be limited to corridors required for public access and to mostly existing roads through the area currently restricted for use only by State DOD personnel (except if a loop road were added to this alternative). The road from Kapahulu Tunnel would be one-way only to Kāhala Tunnel.

Visitor/Interpretive Center

The proposed visitor/interpretive center would be located between the two tunnel entrances inside the crater. Its design would be designed to integrate into the crater surroundings. The structure would also be designed to reveal the panoramic outdoor scene for interpretive purposes. Access to the Center would be from the existing road to the former FAA site. The existing service road to Birkhimer EOC would not be used.

Parking and People Mover

In the interim, parking would be provided at the existing parking lot near the comfort station and at the various State DOD parking lots as these facilities are phased out. Parking for the visitor/interpretive center would be located below the facility, without obstructing views of Lē‘ahi from the facility. As previously mentioned, when it is decided to move visitor parking to the crater exterior, the first choice would be to utilize the existing entry and parking at the Cannon Club. If the Cannon Club cannot be acquired, then a new parking lot could be built below Battery Harlow (across from Kapi‘olani Community College). When an exterior parking lot is in place, for those who cannot or who do not desire to walk into the crater, this alternative includes the provision of a small, motorized “people mover” similar to those used at Hale Koa Hotel in Waikīkī. Once a visitor reaches the north side of the crater exterior, he or she has the option of walking into the crater via Kāhala or Kapahulu Tunnels, or to pay a fee to board the people mover. The people mover will start from the parking lot (Cannon Club and/or across from Kapi‘olani Community College) and make a stop at Battery Harlow. The people mover will then enter the crater via Kapahulu Tunnel (which affords a higher vantage point than Kāhala Tunnel) and exit via Kāhala Tunnel.

Caretaker Residence

To facilitate 24-hour security, a caretaker residence or State Division of Conservation and Resource Enforcement (DOCARE) office is planned to be unobtrusively located inside the crater next to the Kāhala Tunnel.

Comfort Stations

Sanitary facilities would include the existing comfort station, restrooms at the proposed permanent visitor/interpretive facility, at the

exterior parking facility (either at the Cannon Club or below Battery Harlow), at secondary interpretive facilities (such as Battery Harlow, Tunnel 407 and the Cannon Club), picnic areas, and possibly on the summit trail.

Exterior Picnic Area

No exterior picnic facilities are proposed in this alternative.

Interior Picnic Areas

As stated in the Plan Objective, family picnics were envisioned as a primary use for the crater. When State DOD Buildings 301, 303, and 304 are removed, an open space across the road from the visitor/interpretive center is recommended to serve as a "low-density" picnic site for visitors and hikers. This area would be designed to integrate facilities into the natural surroundings without introducing a fire hazard. No cooking facilities would be provided.

Crater Floor

The portion of the crater floor not occupied by the picnic area is proposed for the establishment of a native dryland forest and the enhancement of the existing wetland. Trails, fire roads, firebreaks, and other fire-control devices would be unobtrusively implemented into the design.

Upper Slopes

Generally, the upper slopes would be off-limits to hikers, except for the summit of Lē'ahi. This would be especially true in the area of the *Schidea adamantis* habitat. The observation area at the summit of Le'ahi would be renovated and restored to a good condition.

Trail System

Unlike the 1979 Plan, no exterior trail system is proposed from Mākālei Place to the Cannon Club because of security concerns raised by area residents. This alternative, however, proposes the enhancement of the walkway along the northwestern edge of the crater along Diamond Head Road for walking and bicycling.

Other than at Lē'ahi Summit, hikers would not be allowed to hike on the crater rim. Instead, former military facilities along the east rim of the crater will be made more accessible by: opening the road/trail from the FAA Link Site to the retractable searchlight on the southeastern edge of the crater rim; opening a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407; and utilizing Batteries Dodge and Hulings and the gun emplacements along the eastern edge of the crater as lookouts. This alternative also includes opening a new trail to the flat top reservoir north of the existing trail to the summit.

Landscaping

- The crater floor would be reforested and replanted with hardy, drought-resistant, maintenance-free, and in some cases, fire-resistant plants.
- Selected natural areas would be established to ensure the survival of endangered plants and their habitats.
- Areas with high use would be landscaped and maintained as park areas.

Linear Parkway

Diamond Head Road would be landscaped with trees, grass, and shrubbery. All overhead utility lines and poles would be placed underground.

Maintenance Yard

The maintenance yard would continue to be located at its present location.

8.3.5 Alternative Concept 2 – Visitor/Interpretive Center near Kapahulu Tunnel

Another alternative was developed for consideration by the Diamond Head Citizen's Advisory Committee. This alternative is similar to the 1979 Development Plan as many of the major elements of the 1979 plan have also been incorporated into this alternative. For example, common elements include:

- Entry through Kapahulu Tunnel;

- Exit through Kāhala Tunnel;
- A caretaker's resident or DOCARE office;
- Removing State DOD Buildings 301, 303, and 304;
- Improvements to the wetland;
- Proposed trail around the wetland; and
- Proposed picnic area.

As such, this alternative should be considered as an update to 1979 plan rather than a completely new master plan. In the face of a significant increase of visitors to the crater since 1979, the following alternative would reinforce these common elements by:

- Constructing a permanent visitor/interpretive facility near the Kapahulu Tunnel;
- In the long-term, moving visitor parking to outside of the crater;
- Establishing a motorized people mover system, when visitor parking is kept to the exterior;
- Providing a road that would circle the interior of the crater to allow those with disabilities to experience more of the crater;
- Utilizing the Cannon Club for food service and/or visitor orientation and providing restroom facilities;
- Opening up Tunnel 407 and Battery Harlow for interpretive purposes and providing restroom facilities;
- Keeping the existing comfort station and parking lot;
- Accommodating pedestrian access through Kapahulu Tunnel;
- Controlling visitor access into sensitive areas (such as the crater rim);
- Protecting the *Schidea adamantis* habitat, and the habitat of other native species;
- Opening the road/trail from the FAA Link Site to the retractable searchlight on the southeastern edge of the crater rim;
- Opening a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407;
- Utilizing Batteries Dodge and Hulings and the gun emplacements along the eastern edge of the crater as lookouts;
- Opening a new trail to the flat top reservoir north of the existing trail to the summit;
- Adding comfort stations at the exterior parking facility, at secondary interpretive facilities, and picnic areas; and
- Installing a wastewater lift station.

The elements of this alternative are shown on Figure 18 Alternative Concept 2 – Visitor/Interpretive Center at Kapahulu Tunnel and are described below.

Entry

In the short term, entry would continue through Kāhala Tunnel. Eventually, if the number of vehicles within the crater was determined to be adversely affecting the visual, noise, and air quality, visitor parking could be relocated to the exterior of the crater. If the Cannon Club can be acquired, then the existing parking lot at the Cannon Club can be utilized as the visitor parking facility. The main entry to the crater, then, would be at the Cannon Club, with a new road built from the Cannon Club to Battery Harlow. If the Cannon Club cannot be acquired, then the main entry would be across the street from the Diamond Head Road entry to Kapi'olani Community College.

Tunnels

The two major tunnels that access the crater would not be physically altered. Traffic circulation would be one-way with entry into the crater via the Kapahulu Tunnel and exit through the Kāhala Tunnel. Both tunnels would accommodate pedestrian access. The existing parking and scenic overlook outside the crater adjacent to the Kāhala Tunnel would continue to be used. Specifying one-way traffic through the tunnels will allow the striping of a single lane in the middle of both tunnels for vehicular traffic and narrower "lanes" on either side for pedestrians.

Interior Roadways and Parking

On this alternative, the existing paved roadway network within the Monument would be supplemented by additional roadway so that a loop road would be available within the crater.

The road from Kapahulu Tunnel would be one-way towards Kāhala Tunnel.

Visitor/Interpretive Center

The proposed visitor/interpretive center would be located near the Kapahulu Tunnel entrance inside the crater. Its design would be designed to integrate into the crater surroundings. The structure would also be designed to reveal the panoramic outdoor scene for interpretive purposes. Access to the Center would be from the proposed loop road.

Parking and People Mover

In the interim, parking would be provided at the existing parking lot near the comfort station and at the various State DOD parking lots as these facilities are phased out. Visitor parking for the visitor/interpretive facility would be very limited due to the topography of the site and the surrounding area. As previously mentioned, when it is decided to move visitor parking to the crater exterior, the first choice would be to utilize the existing entry and parking at the Cannon Club. If the Cannon Club cannot be acquired, then a new parking lot could be built below Battery Harlow (across from Kapi'olani Community College). When an exterior parking lot is in place, for those who cannot or who do not desire to walk into the crater, this alternative includes the provision of a small, motorized "people mover," similar to those used at Hale Koa Hotel in Waikīkī. Once a visitor reaches the north side of the crater exterior, he or she has the option of walking into the crater via Kāhala or Kapahulu Tunnels, or to pay a fee to board the people mover. The people mover will start from the parking lot (Cannon Club and/or across from Kapi'olani Community College) and make a stop at Battery Harlow. The people mover will then enter the crater via Kapahulu Tunnel (which affords a higher vantage point than Kāhala Tunnel) and exit via Kāhala Tunnel.

Caretaker Residence

To facilitate 24-hour security, a caretaker residence or DOCARE office is planned to be unobtrusively located inside the crater next to the Kāhala Tunnel.

Comfort Stations

Sanitary facilities would include the existing comfort station and restrooms at the proposed permanent visitor/interpretive facility, at the exterior parking facility (either at the Cannon Club or below Battery Harlow), at secondary interpretive facilities (such as Battery Harlow, Tunnel 407 and the Cannon Club), picnic areas, and possibly on the summit trail.

Exterior Picnic Area

No exterior picnic facilities are proposed in this alternative.

Interior Picnic Areas

As stated in the Plan Objective, family picnics were envisioned as a primary use for the crater. When State DOD Buildings 301, 303 and 304 are removed, an open space across the road from the visitor/interpretive center is recommended to serve as a "low-density" picnic site for visitors and hikers. This area would be designed to integrate facilities into the natural surroundings without introducing a fire hazard. No cooking facilities would be provided.

Crater Floor

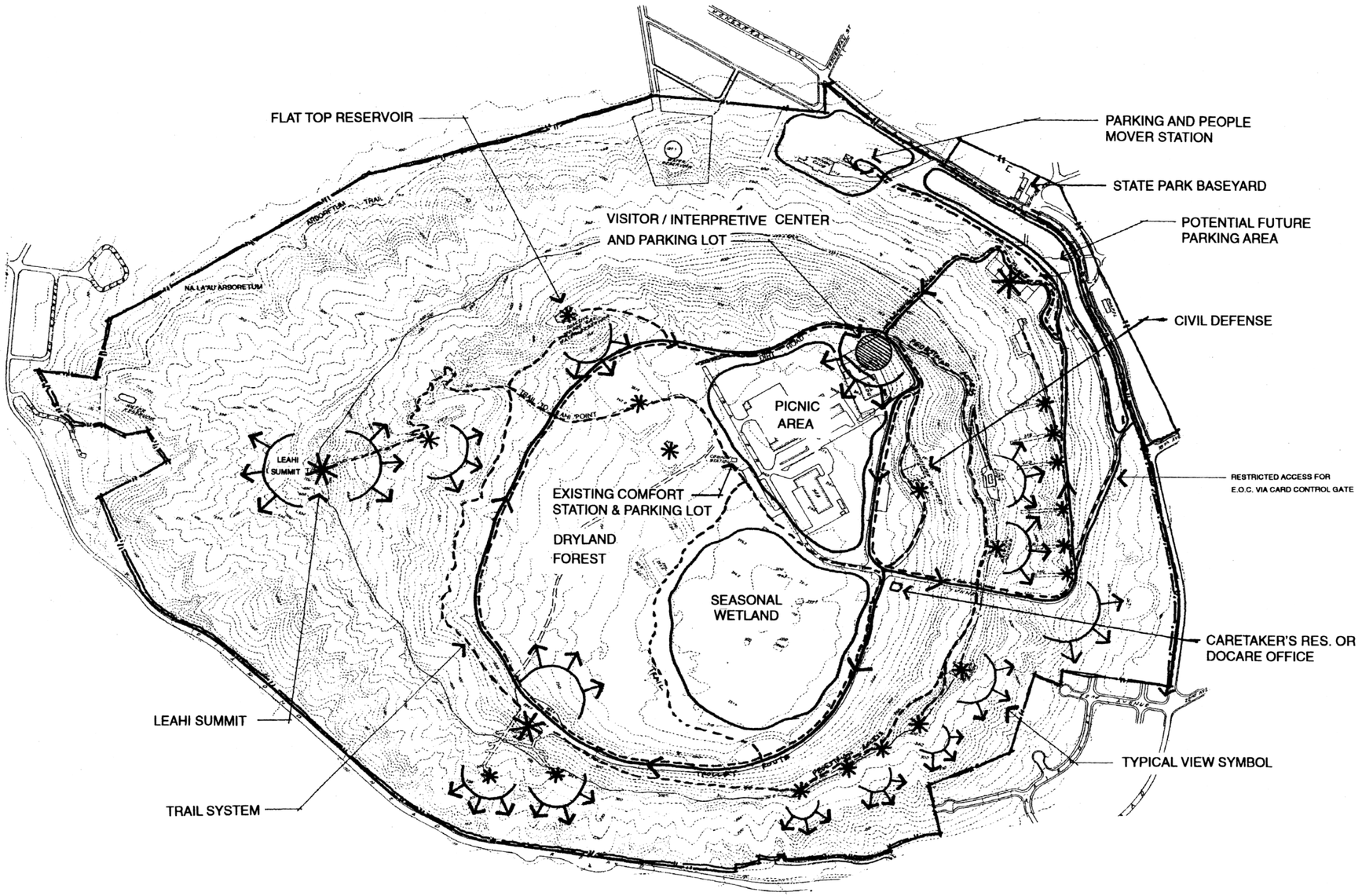
The portion of the crater floor not occupied by the picnic area is proposed for the establishment of a native dryland forest and the enhancement of the existing wetland. Trails, fire roads, firebreaks, and other fire-control devices would be unobtrusively implemented into the design.

Upper Slopes

Generally, the upper slopes would be off-limits to hikers, except for the summit of Lē'ahi. This would be especially true in the area of the *Schidea adamantis* habitat.

Trail System

Unlike the 1979 Plan, no exterior trail system is proposed from Mākālei Place to the Cannon Club because of security concerns raised by area residents. This alternative, however, proposes the enhancement of the walkway along the



Legend

View Symbol .....

People Mover Route .....

Pedestrian Routes / Hiking Trails .....

Pedestrian / Bike Path .....

Major Military Interpretive Feature ..... with Comfort Station

Minor Military Interpretive Feature .....

PBR HAWAII

0 350 700 FEET

Figure 18
Alternative Concept 2

Diamond Head Master Plan Update

northwestern edge of the crater along Diamond Head Road for walking and bicycling.

Other than at Lē'ahi Summit, hikers would not be allowed to hike on the crater rim. Instead, former military facilities along the east rim of the crater will be made more accessible by: opening the road/trail from the FAA Link Site to the retractable searchlight on the southeastern edge of the crater rim; opening a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407; and utilizing Batteries Dodge and Hulings and the gun emplacements along the eastern edge of the crater as lookouts. This alternative also includes opening a new trail to the Flat-Top Reservoir north of the existing trail to the summit.

Landscaping

- The crater floor would be reforested and replanted with hardy, drought-resistant, maintenance-free, and in some cases fire-resistant plants.
- Selected natural areas would be established to ensure the survival of endangered plants and their habitats.
- Areas with high use would be landscaped and maintained as park areas.

Linear Parkway

Diamond Head Road would be landscaped with trees, grass, and shrubbery. All overhead utility lines would be placed underground and poles would be eliminated.

Maintenance Yard

The maintenance yard would continue to be located at its present location.

8.3.6 Alternative Concept 3 – Visitor/Interpretive Center Near Tunnel 407

A third alternative was developed for consideration by the Diamond Head Citizen's Advisory Committee. This alternative is similar to the 1979 Development Plan, as many of the major elements of the 1979 plan have also been incorporated into this alternative. For example, common elements include:

- Entry through Kapahulu Tunnel;
- Exit through Kāhala Tunnel;
- A caretaker's resident or DOCARE office;
- Removing State DOD Buildings 301, 303, and 304;
- Improvements to the wetland;
- Proposed trail around the wetland; and
- Proposed picnic area.

As such, this alternative should be considered as an update to 1979 plan, rather than a completely new master plan. In the face of a significant increase of visitors to the crater since 1979, the following alternative would reinforce these common elements by:

- Constructing a permanent visitor/interpretive facility near the Tunnel 407;
- In the long-term moving visitor parking to outside of the crater;
- Establishing a motorized people mover system, when visitor parking is kept to the exterior;
- Providing a road that would circle the interior of the crater to allow those with disabilities to experience more of the crater;
- Utilizing the Cannon Club for food service and/or visitor orientation and providing restroom facilities;
- Opening up Tunnel 407 and Battery Harlow for interpretive purposes and providing restroom facilities;
- Keeping the existing comfort station and parking lot;
- Accommodating pedestrian access through Kapahulu Tunnel;
- Controlling visitor access into sensitive areas (such as the crater rim);
- Protecting the *Schidea adamantis* habitat, and the habitat of other native species;
- Opening the road/trail from the FAA Link Site to the retractable searchlight on the southeastern edge of the crater rim;

- Opening a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407;
- Utilizing Batteries Dodge and Hulings and the gun emplacements along the eastern edge of the crater as lookouts;
- Opening a new trail to the Flat-Top Reservoir north of the existing trail to the summit;
- Adding comfort stations at the exterior parking facility, at secondary interpretive facilities and picnic areas; and
- Installing a wastewater lift station.

The elements of this alternative are shown on Figure 19, Alternative Concept 3 – Visitor/Interpretive Center at Tunnel 407 and are described below:

Entry

In the short term, entry would continue through Kāhala Tunnel. Eventually, if the number of vehicles within the crater was determined to be adversely affecting the visual, noise, and air quality, visitor parking could be relocated to the exterior of the crater. If the Cannon Club can be acquired, then the existing parking lot at the Cannon Club can be utilized as the visitor parking facility. The main entry to the crater, then, would be at the Cannon Club, with a new road built from the Cannon Club to the existing road below Battery Harlow. If the Cannon Club cannot be acquired, then the main entry would be across the street from the Diamond Head Road entry to Kapi'olani Community College.

Tunnels

The two major tunnels that access the crater would not be physically altered. Traffic circulation would be two-way with entry and exit into the crater via the Kāhala Tunnel. Both tunnels would accommodate pedestrian access. The existing parking and scenic overlook outside the crater adjacent to the Kāhala Tunnel would continue to be used. Traffic through Kāhala Tunnel could be made one-way through the use of signal lights at the tunnel openings. One-way traffic through Kāhala Tunnel will allow the striping of a single lane in the middle of the tunnel for vehicular traffic and narrower "lanes" on either side for pedestrians. Kapahulu Tunnel would be used for emergency vehicles.

Interior Roadways and Parking

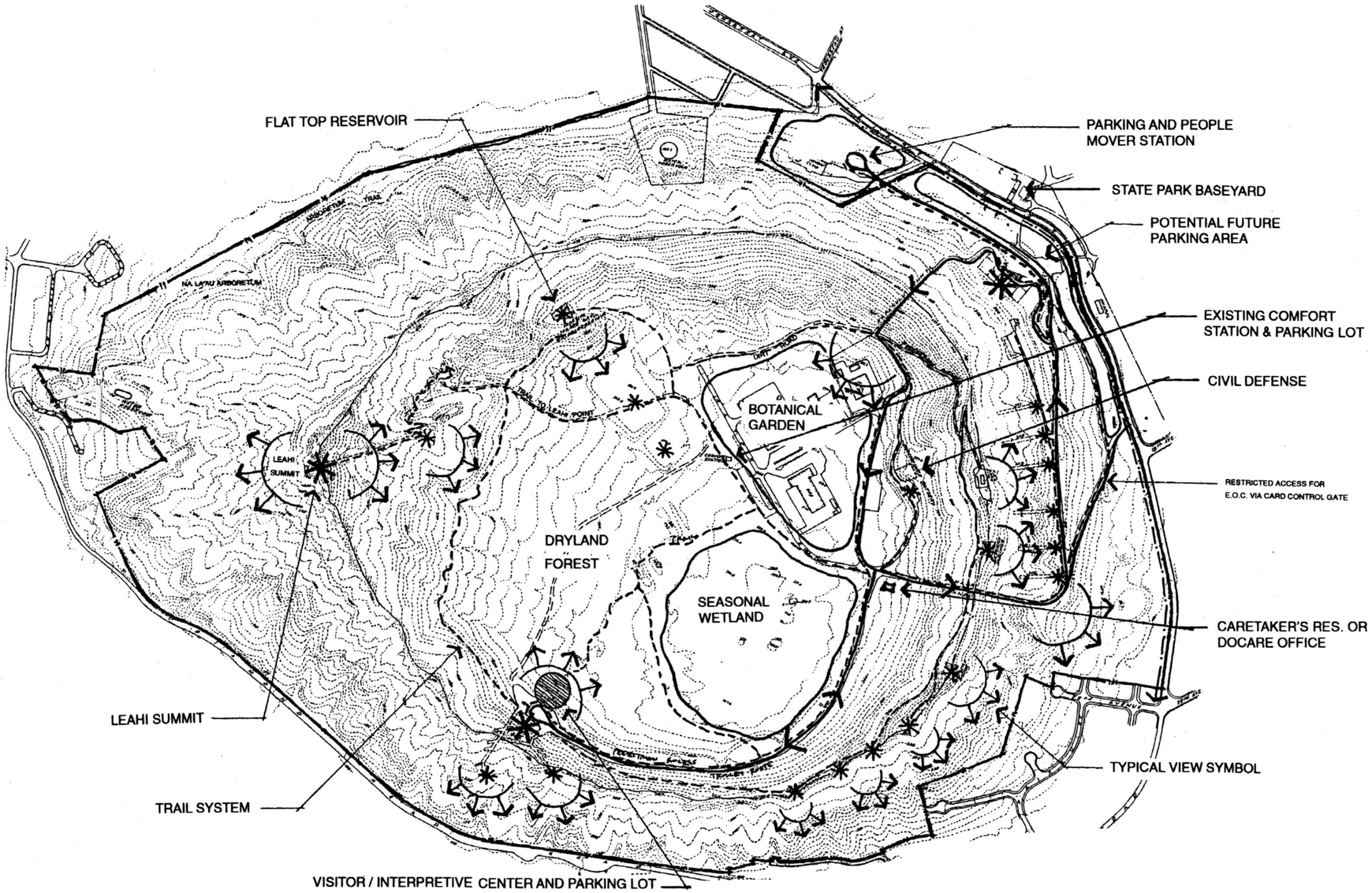
The paved roadway network within the Monument would be limited to corridors required for public access and to mostly existing roads through the area currently restricted only to State DOD personnel (except if a loop road were added to this alternative).

Visitor/Interpretive Center

The proposed visitor/interpretive center would be located opposite the entry to Tunnel 407 inside the crater. Its design would be designed to integrate into the crater surroundings. The structure would also be designed to reveal the panoramic outdoor scene for interpretive purposes. Access to the center would be from the existing road to the Tunnel 407 (and from a loop road, if desired).

Parking and People Mover

In the interim, parking would be provided at the existing parking lot near the comfort station and at the various State DOD parking lots as these facilities are phased out. Visitor parking would be available for the visitor/interpretive facility in the large flat area fronting Tunnel 407. As previously mentioned, when it is decided to move visitor parking to the crater exterior, the first choice would be to utilize the existing entry and parking at the Cannon Club. If the Cannon Club cannot be acquired, then a new parking lot could be built below Battery Harlow (across from Kapi'olani Community College). When an exterior parking lot is in place, for those who cannot or who do not desire to walk into the crater, this alternative includes the provision of a small, motorized "people mover", similar to those used at Hale Koa Hotel in Waikīkī. Once a visitor reaches the north side of the crater exterior, he or she has the option of walking into the crater via Kāhala or Kapahulu Tunnels, or to pay a fee to board the people mover. The people mover will start from the parking lot (Cannon Club and/or across from Kapi'olani Community College) and make a stop at Battery Harlow.



Legend

View Symbol .....

People Mover Route .....

Pedestrian Routes / Hiking Trails .....

Pedestrian / Bike Path .....

Major Military Interpretive Feature ..... with Comfort Station

Minor Military Interpretive Feature .....

PBR HAWAII

0 350 700 FEET

Figure 19
Alternative Concept 3

Diamond Head Master Plan Update

The people mover will then enter and exit the crater via Kāhala Tunnel.

Caretaker Residence

To facilitate 24-hour security, a caretaker residence or DOCARE office is planned to be unobtrusively located inside the crater next to the Kāhala Tunnel.

Comfort Stations

Sanitary facilities would include the existing comfort station, and restrooms at the proposed permanent visitor/interpretive facility, at the exterior parking facility (either at the Cannon Club or below Battery Harlow), at secondary interpretive facilities (such as Battery Harlow, Tunnel 407 and the Cannon Club), picnic areas, and possibly on the summit trail.

Exterior Picnic Area

No exterior picnic facilities are proposed in this alternative.

Interior Picnic Areas

As stated in the Plan Objective, family picnics were envisioned as a primary use for the crater. When State DOD Buildings 301, 303 and 304 are removed, an open space across the road from the visitor/interpretive center is recommended to serve as a "low-density" picnic site for visitors and hikers. This area would be designed to integrate facilities into the natural surroundings without introducing a fire hazard. No cooking facilities would be provided.

Crater Floor

The portion of the crater floor not occupied by the picnic area is proposed for the establishment of a native dryland forest and the enhancement of the existing wetland. Trails, fire roads, firebreaks, and other fire-control devices would be unobtrusively implemented into the design.

Upper Slopes

Generally, the upper slopes would be off-limits to hikers, except for the summit of Lē'ahi. This would be especially true in the area of the *Schidea adamantis* habitat.

Trail System

Unlike the 1979 Plan, no exterior trail system improvements are planned from Mākālei Place to the Cannon Club because of security concerns raised by area residents. This alternative, however, proposes the enhancement of the walkway along the northwestern edge of the crater along Diamond Head Road for walking and bicycling.

Other than at Lē'ahi Summit, hikers would not be allowed to hike on the crater rim. Instead, former military facilities along the east rim of the crater will be made more accessible by: opening the road/trail from the FAA Link Site to the retractable searchlight on the southeastern edge of the crater rim; opening a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407; and utilizing Batteries Dodge and Hulings and the gun emplacements along the eastern edge of the crater as lookouts. This alternative also includes opening a new trail to the Fat-Top Reservoir north of the existing trail to the summit.

Landscaping

- The crater floor would be reforested and replanted with hardy, drought-resistant, maintenance-free, and in some cases, fire-resistant plants.
- Selected natural areas would be established to ensure the survival of endangered plants and their habitats.
- Areas with high use would be landscaped and maintained as park areas.

Linear Parkway

Diamond Head Road would be landscaped with trees, grass, and shrubbery. All overhead utility lines and poles would be placed underground.

Maintenance Yard

The maintenance yard would continue to be located at its present location.

8.3.7 Summary of Common Elements of Alternative Concepts 1, 2 and 3

The common elements of Alternative Concepts 1, 2 and 3 are summarized below:

a. Natural Resources

- Preserve the natural and visual feature of the crater itself.
- Preserve and enhance the flora and fauna of the crater landscape.
- Restore wetland and native dryland forest.

b. Visitors

- Provide additional pedestrian access within the Monument without ruining the natural resources of the crater.
- Improve access to persons with disabilities within the crater.
- Short term: allow visitor parking within the crater.
- Long term: limit vehicular access into crater to service and emergency vehicles.

c. Existing Structures

- Remove State Department of Defense Buildings 301, 303, and 304 and restore the sites when facilities are vacated.
- Preserve structures of military historical value for their interpretive and scenic use.
- Continue operation of State Park baseyard at Makapu‘u Avenue and Diamond Head Road.
- Continue use of antennas.
- Develop, operate, and maintain Battery Harlow as a museum to interpret the military history of Diamond Head/Fort Ruger Military Reservation (but does not duplicate the information exhibited at the U.S. Army Museum at Fort DeRussy).
- Renovate Tunnel 407 as a secondary interpretive facility, if made available by State DOD.
- Acquire and utilize Cannon Club facility.
- Allow Battery Birkhimer to remain as civil defense facility.
- Continue use of the FAA Link site for antenna.

d. View Opportunities

- Provide a variety of vantage and scenic viewpoints for the visitor to appreciate the crater and the surrounding landscape.

e. Access

- Provide controlled pedestrian access through Kapahulu and/or Kāhala Tunnels.
- Build additional pedestrian trails on the crater floor, especially around an enhanced wetland and through a new native dryland forest (as long as it does not threaten these ecosystems).
- Build a new hiking trail on the small ridge next to the abandoned water reservoir inside the crater.
- Allow pedestrian access to the FAA Link Site via guided tours.
- Improve the existing road from Battery Hulings and Battery Dodge to various gun emplacements along the eastern rim of the crater (allow access only via guided tours).
- Build a new trail from the end of the existing road at Battery Dodge to Tunnel 407 (allow access only via guided tours).
- Gradually eliminate visitor vehicular access into the crater with all visitor parking to be eventually accommodated outside. Bus and van access will be the first to be restricted and replaced with a people mover system for the movement of visitors into and out of the crater.
- Move visitor parking to the exterior of the crater (ideally to the Cannon Club, if not, to the area opposite Kapi‘olani Community College).

f. Recreation and Park Programs

- Construct picnic areas.
- Reconstruct sites or features of cultural significance (if present).
- Build visitor/interpretive facility.

- Construct trails and scenic viewpoints.
- Improve walking/running/biking facilities along the east side of the Monument along Diamond Head Road.

8.4 PUBLIC FEEDBACK ON THE ALTERNATIVES

On August 27, 1998, after much consideration and discussion, the CAC voted unanimously in favor of siting the visitor/interpretive center between Kāhala Tunnel and Battery Birkhimer.

An EIS Preparation Notice (EISPN) was filed with the State Office of Environmental Quality Control (OEQC) on August 25, 1998. Notice of the availability of the EISPN was published in the September 8, 1998 issue of the *Environmental Notice*. The 30-day public comment period for the EISPN occurred between September 8, 1998 and October 8, 1998. During this time there was an opportunity for public input on the desirability of the various alternatives considered. Public informational meetings were held on November 23 and November 24, 1998.

Based on the CAC's recommendations and public comments received on the EISPN, DLNR selected a preferred alternative. This preferred alternative (proposed action) was presented in the Draft EIS.

Notice of the availability of Draft EIS was published in the *Environmental Notice* on April 8, 2000 and a second 45-day public comment period began – ending on May 23, 2000. A second set of public informational meetings was held on April 26 and May 8, 2000. Notice of the availability of the Final EIS was published in the *Environmental Notice* on November 8, 2000.

Public hearings will be held in the process of obtaining: 1) Conservation District Use Permit(s) from BLNR; 2) Special Management Area Use Permit(s) and the Diamond Head Special District Major Permit from the City and County of Honolulu; and 3) Well Permit(s) (Well Construction Permit, Pump Installation Permit and Water Use Permit), if necessary, from the State Water Commission.

8.5 EVALUATION CRITERIA USED IN SELECTING THE PREFERRED ALTERNATIVE

Each of the conceptual plans were evaluated based on the following criteria: existing and proposed uses, availability of existing facilities, interpretive and historical value, architecture, and site limitations, including access, transportation, views, aesthetics, development costs, operational costs, and interpretive value.

Public Feedback

Public feedback was sought primarily from three sources: 1) CAC recommendations; 2) comments received on the EISPN during the public comment period; and 3) from presentations made to area neighborhood boards and community association meetings.

Existing and Proposed Uses

This criteria refers to how each alternative relates to surrounding existing and proposed uses.

Architecture

Architecture refers to how the design of the proposed visitor/interpretive center fits the site in which it is located and its overall setting within the crater interior.

Access

In determining the access ratings of the three concepts, three major factors were considered: 1) pedestrian friendliness, 2) access for people with disabilities (in accordance with Americans with Disabilities Act (ADA) standards), and 3) transportation requirements.

- Pedestrian Friendliness relates to how well a plan accommodates the walking visitor or contributes to the ease of walking around the crater without having to hike solely on trails.

- For ADA Compliance, each plan will be evaluated for how it would allow individuals with disabilities to experience the natural features and utilize facilities within the monument.
- Transportation relates to vehicle access considerations within and outside the crater for the movement of visitors.

Views

Views refer to how well a given plan utilizes the interior and exterior views afforded at various locations within the crater, as well as views from outside the crater.

Aesthetics

In determining ratings for Aesthetics, each plan was evaluated based on how well it is in keeping with the desired "semi-wilderness" natural character of the monument.

Development Costs

Development Costs account for all costs associated with the design and construction of all improvements with associated initial provisioning and equipment.

Operational Costs

Operational Costs include labor, contract, utilities, repairs and maintenance, and other related costs needed on a continuing or recurring basis. Operational costs also include payments to OHA from revenues.

Interpretive and Historical Values

Interpretive Value refers to how well a plan lends itself to the interpretation of the natural, cultural and military "story" of the crater.

8.6 SELECTION OF THE PREFERRED ALTERNATIVE

Selection of the Preferred Alternative

Each of the three alternative concepts was evaluated based on the previously described evaluation criteria. The following summarizes the evaluation of the three alternatives.

Selection Criteria	Alternative Concept 1 (Visitor/Interpretive Facility near Kāhala Tunnel)	Alternative Concept 2 (Visitor/Interpretive Facility near Kapahulu Tunnel)	Alternative Concept 3 (Visitor/Interpretive Facility near Tunnel 407)
Public Input	On August 27, the Diamond Head Citizens Advisory Committee voted unanimously to recommend the siting of the visitor/interpretive facility between Battery Birkhimer and Kāhala Tunnel. No input favoring this site was received during the EISPN public comment period.	No input favoring this site was received during the EISPN public comment period.	No input favoring this site was received during the EISPN public comment period.
Existing and Proposed Uses	Based on the proposed circulation system (i.e. entry through Kapahulu Tunnel, exit through Kāhala Tunnel), this alternative provides the most convenient location for visitors to visit the visitor/ interpretive facility because visitors would easily pass/stop at the facility twice when taking the people mover around proposed crater interior loop road. In the short term, its proximity to State DOD facilities will cause a negative visual impact on the visitor/ interpretive facility.	Based on entry through Kapahulu Tunnel, this site is ideally located to capture visitors immediately upon entry to the crater, however, a circulation pattern in the counter-clockwise direction would less likely to capture visitors before departing the crater. In the short term, its proximity to State DOD facilities will cause a negative visual impact on the visitor/ interpretive facility.	In the short-term, this site is the least impacted by the view of the State DOD facilities, since it is located the furthest away. This locational advantage is negated by its less desirability in terms of being readily accessible by visitors, especially by those on foot, since it is the furthest away from Kapahulu and Kāhala Tunnels.
Architecture	As the least sloping of the three sites, this alternative will present the least visual impact (building mass) from the front elevation.	This site is steep and is further constrained by its narrow width.	While this site is steep, the site could be moved to the wide parking lot fronting Tunnel 407 and will not require the construction of roads like the other two alternatives.
Access - Pedestrian Friendliness	This site is close to Kāhala Tunnel, where many of the pedestrians will enter the crater.	This site is close to Kapahulu Tunnel, where presumably most of the pedestrians will enter the crater.	As previously noted, since this site is the furthest away from Kapahulu and Kāhala Tunnels, it is the least accessible for pedestrians.
Access - ADA	As the least sloping of the three sites, this site should be the most accessible to persons with disabilities, especially in the outdoor areas.	The sloping nature of the site will probably require elevators, adding to the cost of construction.	The sloping nature of the site will probably require elevators, adding to the cost of construction.
Access - Transportation	In all three concepts, access to the facility is aligned on the rim-side, so that views towards the interior of the crater is not impacted by roads or people movers. This site will require the construction of a road below the road to Battery Birkhimer (to avoid conflicting traffic during emergencies), across a sloped bank.	Since this site is narrow, a road on the rim-side of the facility will need to built across very steep slopes and mini-ridges. The construction of the road will be expensive and will present a negative visual impact.	This site already contains a road on the rim-side so it is both very accessible by motorized vehicle and will be the least expensive to implement at least based on this particular criteria.
Views	This site presents a similar, unobstructed, frontal view of the summit of Lē‘ahi, as experienced when entering through Kāhala Tunnel.	While this site is located at a higher elevation than Kāhala Tunnel, it does not present a frontal view of the summit of Lē‘ahi.	This site provides a close-up view of the summit of Lē‘ahi and a very interesting view of the Ko‘olau Mountain Range, beyond the northern rim of the crater.

Selection Criteria	Alternative Concept 1 (Visitor/Interpretive Facility near Kāhala Tunnel)	Alternative Concept 2 (Visitor/Interpretive Facility near Kapahulu Tunnel)	Alternative Concept 3 (Visitor/Interpretive Facility near Tunnel 407)
Aesthetics	This site will be the least likely to be seen as one enters the crater from Kapahulu Tunnel.	This site would probably be the most visible site as one enters the crater from Kapahulu Tunnel. Its high elevation would also make it more visible from many areas inside the crater.	This site would appear to be most visible site as one enters the crater from Kapahulu Tunnel, however, its distance from the tunnel will mitigate the impact significantly. Its location and elevation would also make it more visible from many areas inside the crater. Of the three sites, this site would probably be the most visible to residents living on the Koʻolau Mountain Range ridges (St. Louis Heights, Wilhelmina Rise).
Development Costs	This site is the least expensive to build on because of its flatter topography.	Due to the highly sloping nature of the site, and the narrowness of the site that would force the construction of an access road into and along the steep interior crater walls, this site is likely to be the most expensive of the three sites. This is especially the case since most of this area has not been significantly altered and will require grading into original crater soils and rock.	Although this site already includes an access road, this site is sloping and will also be expensive to build, although less expensive than Alternative Concept 2, because most of the slope is presumed to consist of fill material (probably excavated material from Tunnel 407).
Operational Costs	Due to its proximity to Kāhala Tunnel, where service emergency vehicles will be allowed to enter, operational costs for a facility at this site is likely to be the least expensive. Its flatter topography is also likely to present lower operational costs.	While this site is located relatively close to the Kāhala Tunnel, the sloping nature and narrowness of the site will add to the cost of operations.	Since this site is located furthest from Kāhala Tunnel, it is most likely to present the highest operational costs.
Interpretive and Historical Values	This site's main interpretive and historical values include: 1) the frontal view of the summit of Lēʻahi; 2) its proximity to the summit trail; and 3) its proximity to the wetland.	This site's main value is the higher elevation as entry to the crater interior. The site is also located near the road to the FAA Link Site, which is proposed to be an interpretive trail along and below the east crater rim to Tunnel 407.	This site probably presents the best interpretive location due to: 1) its proximity to Tunnel 407 (a feature of historical and scenic value); 2) its proximity to the summit of Lēʻahi; 3) its proximity to proposed trails (connecting to the summit trail and to the road below the east crater rim); 4) the views presented of the Koʻolau Mountain Range; 5) the views of the wetland.

Based on the above evaluation, DLNR has selected Alternative Concept 1 as the preferred alternative. In summary, a visitor/interpretive center located as shown on Alternative Concept 1 would present the following benefits:

- It is the preferred alternative of the Diamond Head Citizens Advisory Committee.
- This alternative provides the most convenient location for visitors to visit the visitor/interpretive facility because visitors would easily pass the facility twice when taking the people mover around proposed crater interior loop road.
- As the least sloping of the three sites, this alternative will present the least visual impact (building mass) from the front elevation.
- As the least sloping of the three sites, this site should be the most accessible to persons with disabilities, especially in the outdoor areas.
- This site presents a similar, unobstructed, a frontal view of the summit of Lē‘ahi, as experienced when entering through Kāhala Tunnel.
- This site will be the least likely to be seen as one enters the crater from Kapahulu Tunnel.
- This site is the least expensive to build on because of its flatter topography.
- Due to its proximity to Kāhala Tunnel, where service emergency vehicles will be allowed to enter, operational costs for a facility at this site is likely to be the least expensive. Its flatter topography is also likely to present lower operational costs.
- This site is closest to the wetland, which would be enhanced as a natural resource and an interpretive feature.

8.7 UPDATED MASTER PLAN

Based on the selected alternative, a number of refinements were made.

The resultant Updated Master Plan is similar to the 1979 Development Plan, as many of the major elements of the 1979 plan have been incorporated into this proposal. For example, common elements include:

- Entry through Kapahulu Tunnel;
- Exit through Kāhala Tunnel;
- A permanent visitor/interpretive facility near Battery Birkhimer;
- A caretaker’s residence (or DOCARE office);
- Removing State DOD Buildings 301, 303 and 304;
- Improvements to the wetland;
- Proposed trail around the wetland; and
- Proposed picnic area.

As such, this proposal should be considered as an update to 1979 plan rather than a completely new master plan. In the face of a significant increase of visitors to the crater since 1979, the following proposal would reinforce these common elements by:

- In the long-term, moving visitor parking to outside of the crater;
- Establishing a motorized people mover system, when visitor parking is kept to the exterior;
- Utilizing the Cannon Club for food service and/or visitor orientation and providing restroom facilities;
- Opening up Tunnel 407 and Battery Harlow for interpretive purposes and providing restroom facilities;
- Keeping the existing comfort station and parking lot;
- Accommodating pedestrian access through Kapahulu Tunnel;
- Controlling visitor access into sensitive areas (such as the crater rim);
- Protecting the *Schidea adamantis* habitat and the habitat of other native species;

- Continuing eco-system restoration work at Battery Harlow
- Opening the road/trail from the FAA Link Site to the retractable searchlight on the southeastern edge of the crater rim;
- Opening a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407;
- Utilizing Battery Dodge and the gun emplacements along the eastern edge of the crater as lookouts;
- Opening a new trail to the flat top reservoir north of the existing trail to the summit;
- Adding comfort stations at the exterior parking facility, at secondary interpretive facilities, and picnic areas;
- Installing a wastewater lift station; and
- Removing the overhead utility lines between Battery Birkhimer and the crater rim and relocating them to the aboveground conduits to the Link Site.

Planting will be coordinated with the State Division of Forestry and Wildlife and the U.S. Fish and Wildlife Service. The areas planted by the State Department of Defense (State DOD) will be evaluated for compatibility with the Diamond Head State Monument Master Plan when areas are turned over to DLNR.

The elements of this proposal are shown on the Proposed DHSM Master Plan Update (Figure 20) and are described below.

Entry

In the short term, entry would continue through Kāhala Tunnel. Eventually, if the number of vehicles within the crater was determined to be adversely affecting the visual, noise, and air quality, visitor parking could be relocated to the exterior of the crater. If the Cannon Club can be acquired, then the existing parking lot at the Cannon Club can be utilized as the visitor parking facility. The main entry to the crater, then, would be at the Cannon Club, with a new road built from the Cannon Club to Battery Harlow. If the Cannon Club cannot be acquired, then the main entry would be opposite Makapu‘u Avenue with parking on the southwest side of the Diamond Head Road/Makapu‘u Avenue intersection.

Tunnels

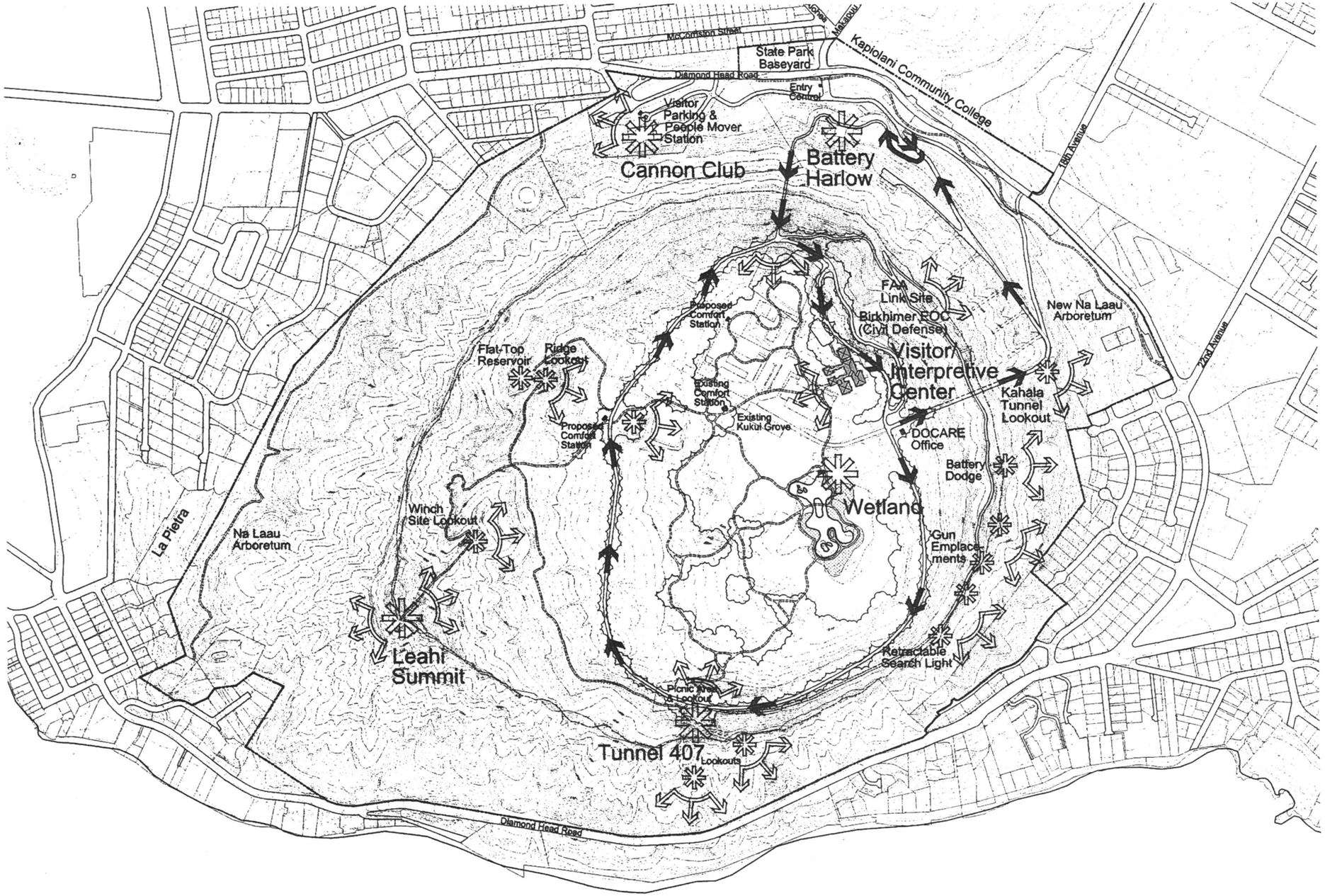
The two major tunnels that access the crater would not be physically altered. Traffic circulation would be one-way with entry into the crater via the Kapahulu Tunnel and exit through the Kāhala Tunnel (except for Birkhimer EOC employees, emergency vehicles and service vehicles). Both tunnels would accommodate pedestrian access. The existing parking and scenic overlook outside the crater adjacent to the Kāhala Tunnel would continue to be used. Specifying one-way traffic through the tunnels will allow the striping of a single lane in the middle of both tunnels for vehicular traffic and narrower “lanes” on either side for pedestrians.

Interior Roadways and Parking

The paved roadway network within the Monument would be mostly limited to corridors required for public access and to mostly existing roads through the area currently restricted only to State DOD personnel. Using existing roadways, a loop road would be completed within the crater interior, with new segments built along the west side from Tunnel 407 to Kapahulu Tunnel. A new road will also be built between the former FAA site to Kāhala Tunnel below Battery Birkhimer. All traffic on this loop road would be one-way in a clock-wise direction.

Visitor/Interpretive Center

The proposed visitor/interpretive center would be located between the two tunnel entrances inside the crater near Battery Birkhimer. The visitor/interpretive center will be approximately 20,000 square feet (SF) with area set aside for a maximum expansion of 5,000 SF. Its design would be designed to integrate into the crater surroundings. The structure would also be designed to reveal the panoramic outdoor scene for interpretive purposes. Access to the Center would be from a new road from the former FAA site. The existing service road to Birkhimer EOC would not be used to access the Center.



Legend

- Views
- Major Interpretive Feature
- Minor Interpretive Feature
- People Mover Route
- Pedestrian Path / Trail
- Crater Rim
- Wetland

PBR HAWAII

0 350 700 FEET

Figure 20
Updated Master Plan

Master Plan Update

Diamond Head

Parking and People Mover

In the interim, parking would be provided at the existing parking lot near the comfort station and at the various State DOD parking lots as these facilities are phased out. Parking for the visitor/interpretive center would be located near the facility, without obstructing views of Lē'ahi from the Center. As previously mentioned, when it is decided to move visitor parking to the crater exterior, the first choice would be to utilize the existing entry and parking at the Cannon Club. If the Cannon Club cannot be acquired, then a new parking lot could be built near the Makapu'u Avenue/Diamond head Road intersection. When an exterior parking lot is in place, for those who cannot or who do not desire to walk into the crater, this alternative includes the provision of a small, motorized "people mover," similar to the one used at Hale Koa Hotel in Waikīkī. Once a visitor reaches the north side of the crater exterior, he or she has the option of walking into the crater via Kāhala or Kapahulu Tunnels, or to pay a fee to board the people mover. The people mover will start from the parking lot (Cannon Club or near the Makapu'u Avenue/Diamond Head Road intersection) and make a stop at Battery Harlow. The people mover will then enter the crater via Kapahulu Tunnel (which affords a higher vantage point than Kāhala Tunnel) and exit Kāhala Tunnel.

Caretaker Residence

To facilitate 24-hour security, a caretaker residence or State Division of Conservation and Resource Enforcement (DOCARE) office is planned to be unobtrusively located inside the crater next to the Kāhala Tunnel.

Comfort Stations

Sanitary facilities would include the existing comfort station, restrooms at the proposed permanent visitor/interpretive facility, at the exterior parking facility (either at the Cannon Club or below Battery Harlow), at secondary interpretive facilities (such as Battery Harlow, Tunnel 407 and the Cannon Club), and picnic areas.

Exterior Picnic Area

Exterior picnic facilities are proposed in the area between the Crater Road and Diamond Head Road.

Interior Picnic Areas

As stated in the Plan Objective, family picnics were envisioned as a primary use for the crater. When State DOD Buildings 301, 303, and 304 are removed, an open space across the road from the visitor/interpretive center is recommended to serve as a "low-density" picnic site for visitors and hikers. Other new picnic sites are proposed near Tunnel 407 and on the upper Pistol Range. These areas would be designed to integrate facilities into the natural surroundings without introducing a fire hazard. No cooking facilities would be provided. Each picnic area would have either stand-alone comfort stations or nearby restroom facilities. Each picnic area would be provided with drinking fountains.

Crater Floor

The portion of the crater floor not occupied by the picnic area is proposed for the establishment of a native dryland forest and the enhancement of the existing wetland. Trails, fire roads, firebreaks, and other fire-control devices would be unobtrusively implemented into the design of the crater floor landscaping.

Upper Slopes

Generally, the upper slopes would be off-limits to hikers, except for the summit of Lē'ahi, where there is an observation area. The observation

area is in need of renovation and needs to be refurbished while still maintaining a low profile and rustic character. Making the upper slopes off-limit to hikers except for the refurbished observation area at the summit of Lē'ahi would aid in protecting the *Schidea adamantis* habitat.

Trail System

Unlike the 1979 Plan, no exterior trail system is proposed from Mākālei Place to the Cannon Club because of security concerns raised by area residents. The master plan update, however, proposes a greater separated multi-purpose bike/pedestrian way along the northwestern edge of the crater along Diamond Head Road.

Other than at Lē'ahi Summit, hikers would not be allowed to hike on the crater rim. Instead, former military facilities along the east rim of the crater will be made more accessible by: opening the road/trail from the FAA Link Site to the retractable searchlight on the southeastern edge of the crater rim; opening a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407; and utilizing Battery Dodge and the gun emplacements along the eastern edge of the crater as lookouts. The master plan update also includes opening a new trail to the Flat-Top Reservoir north of the existing trail to the summit.

Landscaping

- The crater floor would be reforested and replanted with hardy, drought-resistant, maintenance-free, and in some cases, fire-resistant plants.
- Selected natural areas would be established to ensure the survival of endangered plants and their habitats.
- Areas with high use would be landscaped and maintained as park areas.

Linear Parkway

Diamond Head Road would be landscaped with trees, grass, and shrubbery. All overhead utility lines and poles would be placed underground.

Maintenance Yard

The maintenance yard would continue to be located at its present location.

8.8 CONCEPTUAL LANDSCAPE PLAN

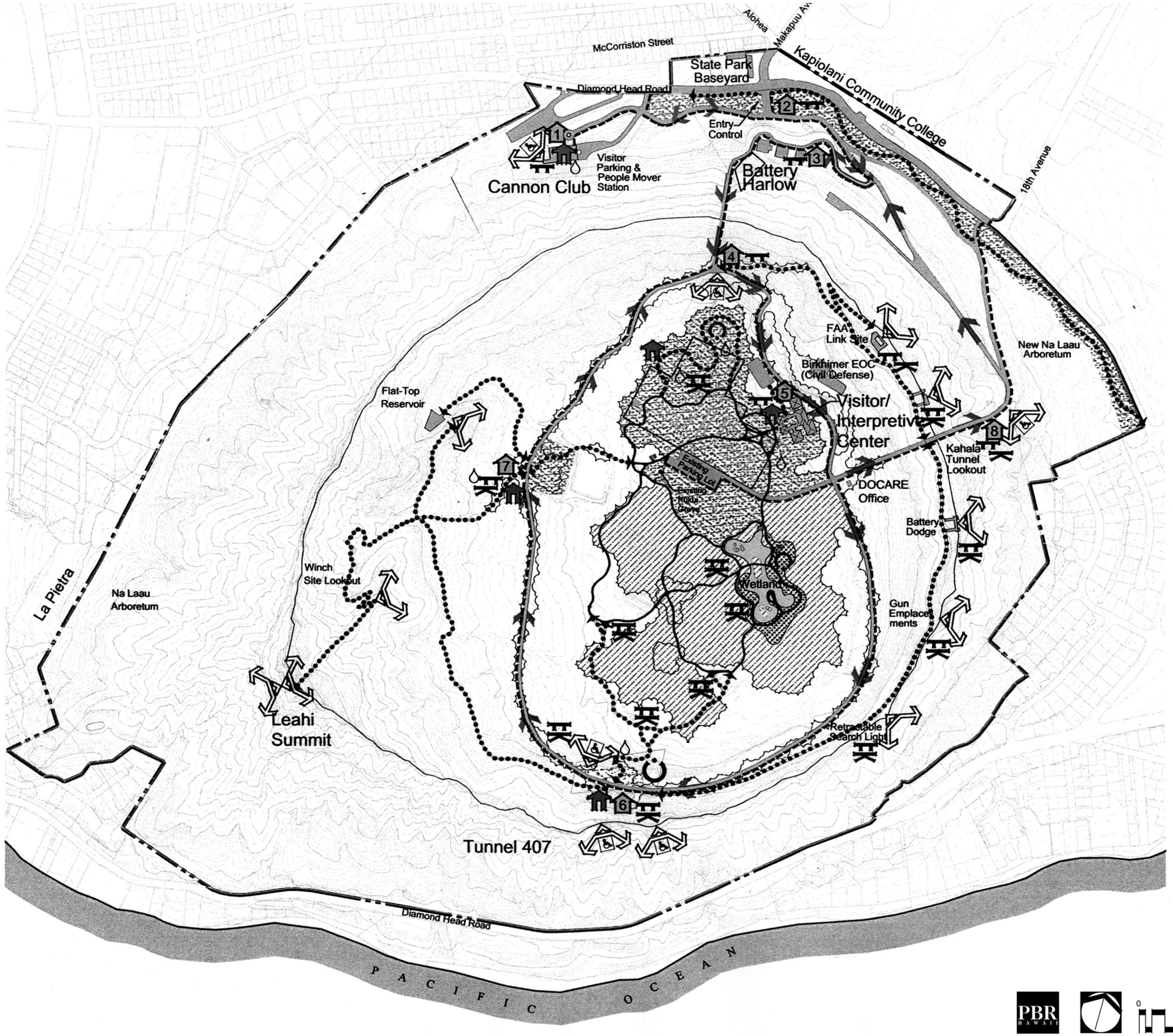
Presently, the flora of Diamond Head crater consists primarily of alien species representing a coastal dryland plant community. The crater slopes and floor are dominated by *kiawe* trees (*Prosopis pallida*) and *koa haole* shrubs (*Leucaena glauca*) with an understory of lantana (*Lantana camara*), and alien grasses (California grass, buffel grass, sour grass, and fountain grass). The existing vegetation has impeded the growth of the existing wetland flora, presenting a fire hazard (especially to native flora habitats) and successful competition against native species.

Currently, an on-going ecosystem restoration is taking place at two sites: 1) Battery Harlow, by Hawaii Army National Guard - Environmental (HIARN - ENV) personnel, and 2) at the Peace Gardens, by Youth for Environmental Service. Thousands of native dryland, coastal plants have been planted at these sites over the past three years and are being maintained by staff and volunteer working groups.

The following concept for the landscape of the crater is planned (Figure 21) and is illustrated in Figures 22 through 25.

It is proposed that a coastal dry mixed community typical of Oahu's south shore flora in the mid to late 19th century be developed within the crater. Such a landscape would have an ethnobotanical interpretive value and grant DHSM visitors a picture of Oahu's landscape of that era. This landscape could be designed to take advantage of and retain desirable existing *kiawe* trees, coupled with the planting of drought tolerant native plant species, i.e. endemic, indigenous and Polynesian introduced plant material.

A series of plant community and maintenance zones will be identified in their relationship to



LEGEND

- PROPOSED WALKWAYS
- PROPOSED ADA COMPLIANT WALKWAYS
- PROPOSED TRAILS
- PROPOSED TRAM ROUTE
- COMFORT STATION
- PROPOSED LOOKOUTS
- PROPOSED ADA ACCESSIBLE LOOKOUT
- PROPOSED OUTDOOR TEACHING SPACE
- PROPOSED PICNIC TABLES
- PROPOSED BENCHES/SEATING
- PROPOSED WATER FOUNTAIN
- PROPOSED LAWN AREAS
- PROPOSED GRASS LANDS
- EXISTING NATURAL VEGETATION (KIAWE, HAOLE KOA, GRASSES)

PROPOSED TRAM STATIONS

1. Cannon Club
2. Park Entry
3. Battery Harlow
4. East Rim Trail
5. Visitor/ Interpretive Center
6. Tunnel 407
7. Leahi Summit Trail
8. Kahala Tunnel Lookout

PBR HAWAII

0 300 600
FEET

Figure 21
Landscape Master Plan

Diamond Head Master Plan Update

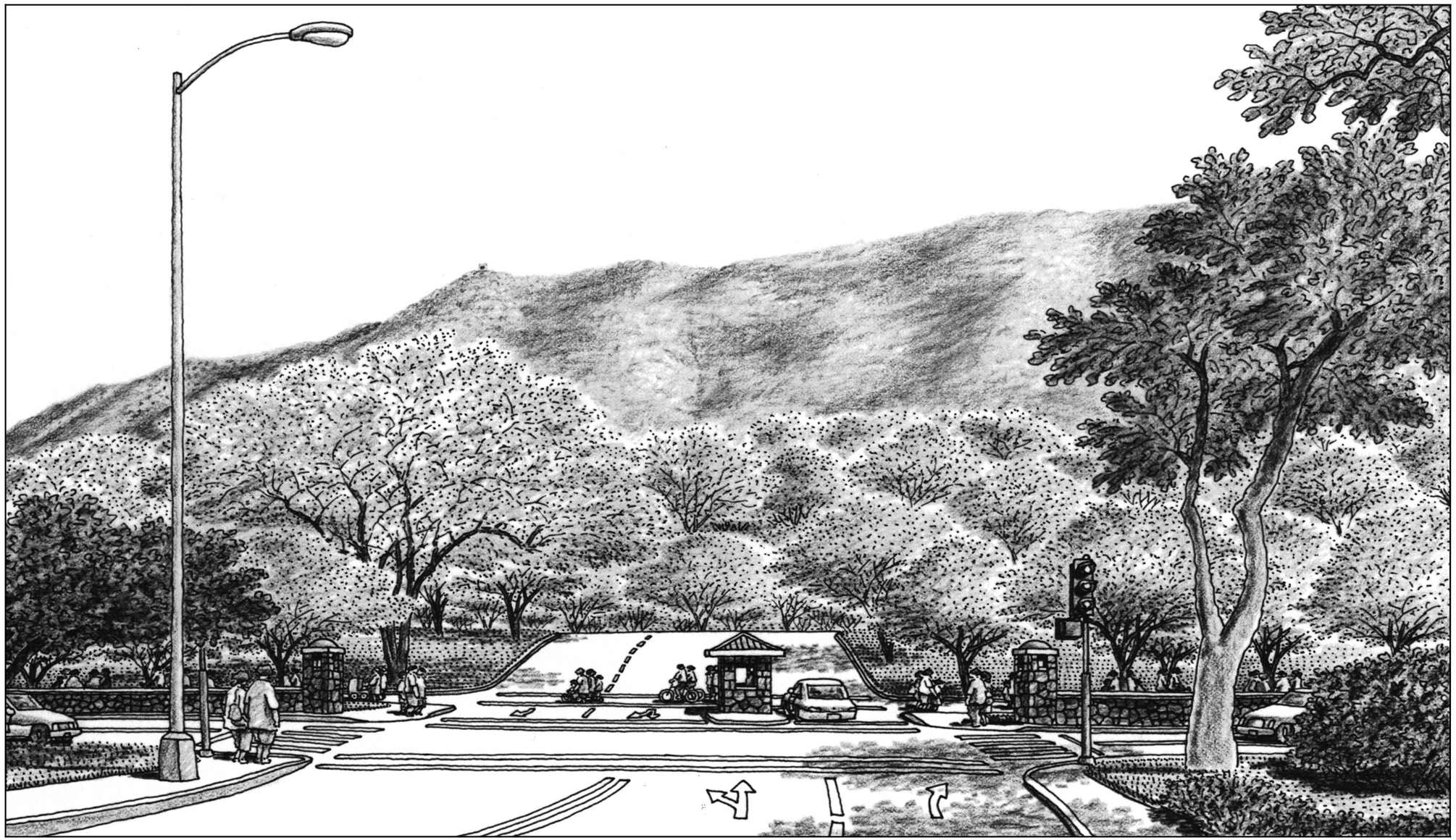


Figure 22
New Entry Rendering

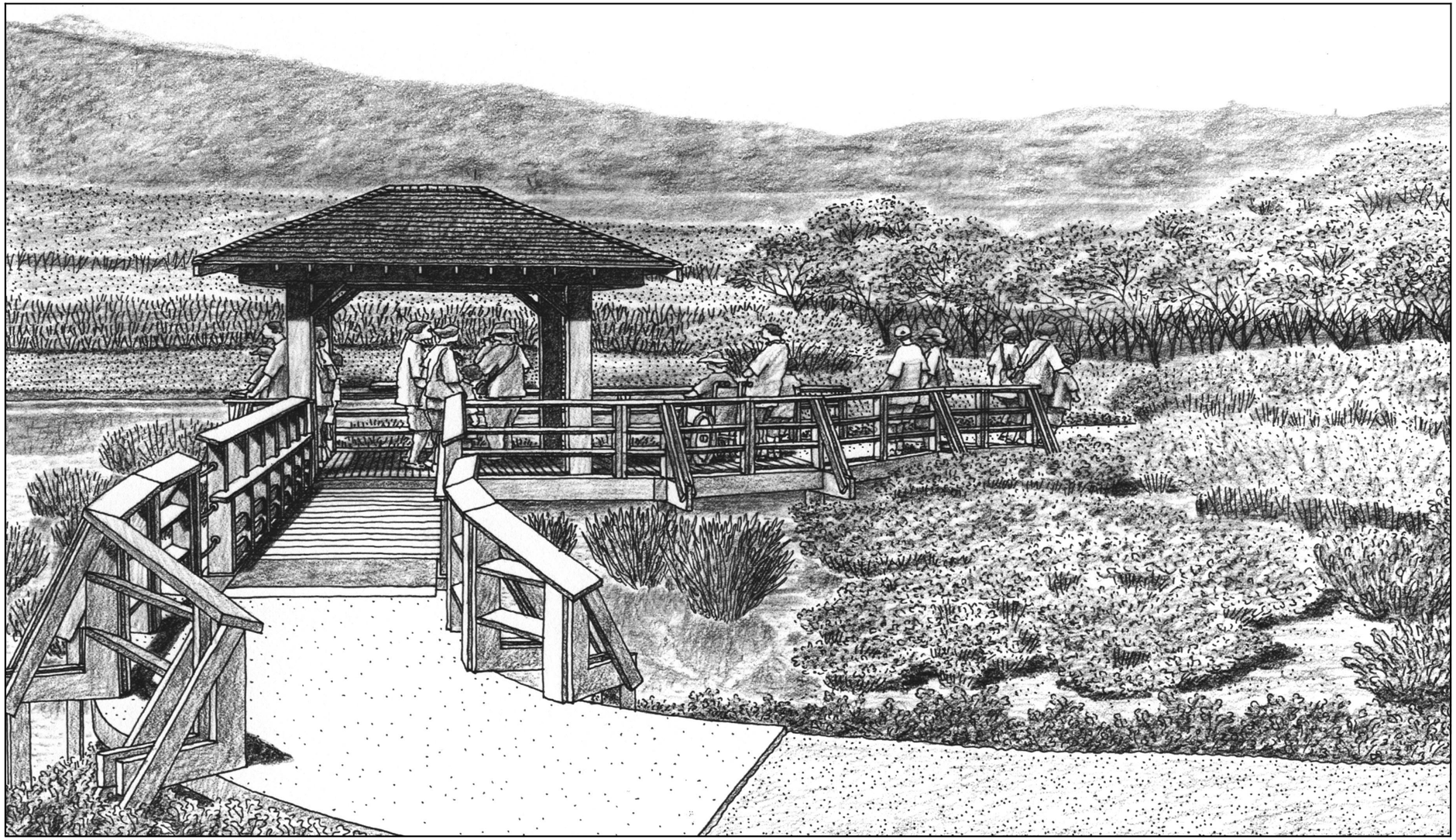


Figure 23
Proposed Wetland Rendering

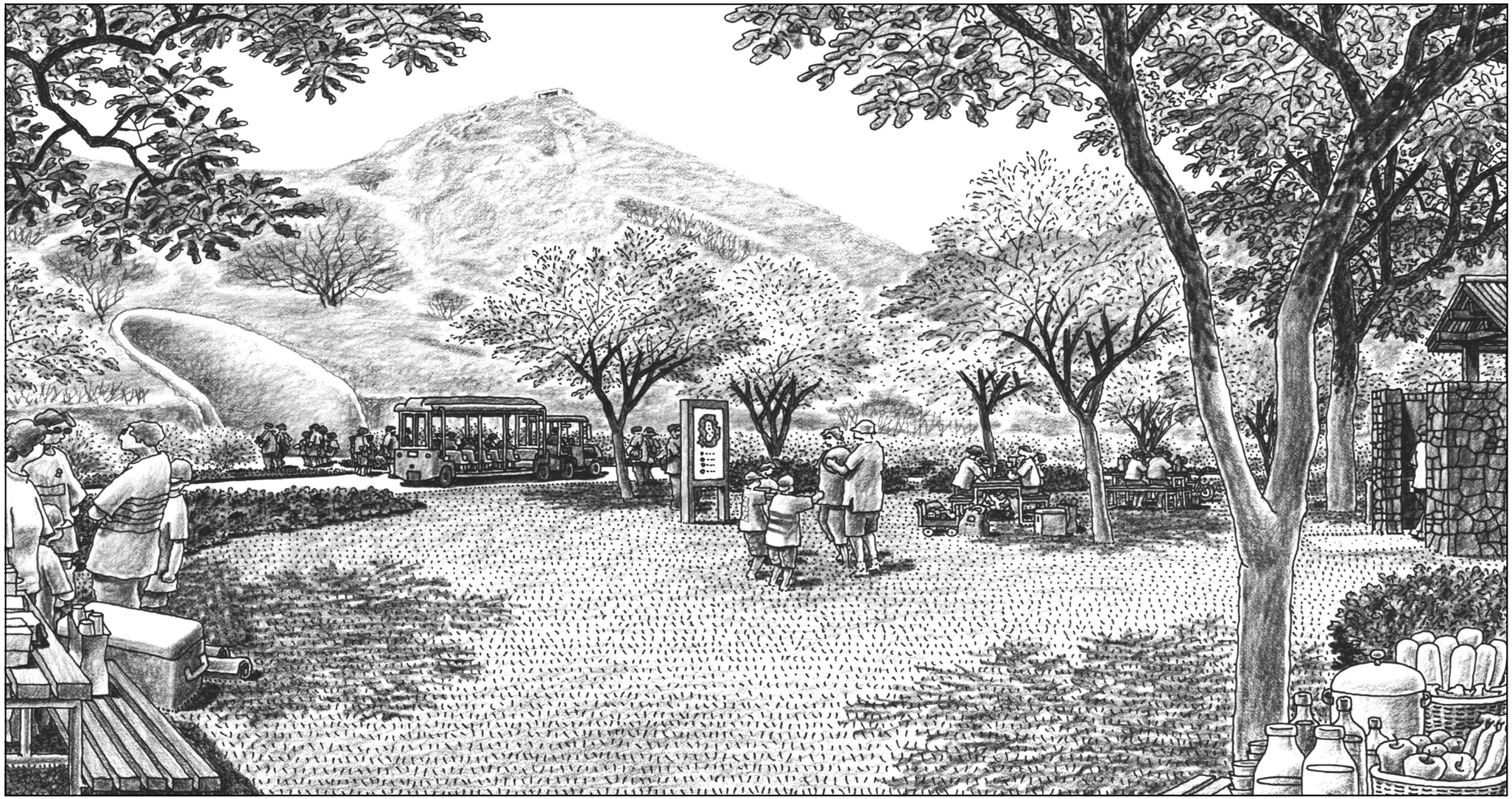


Figure 24
Tunnel 407 Area Rendering

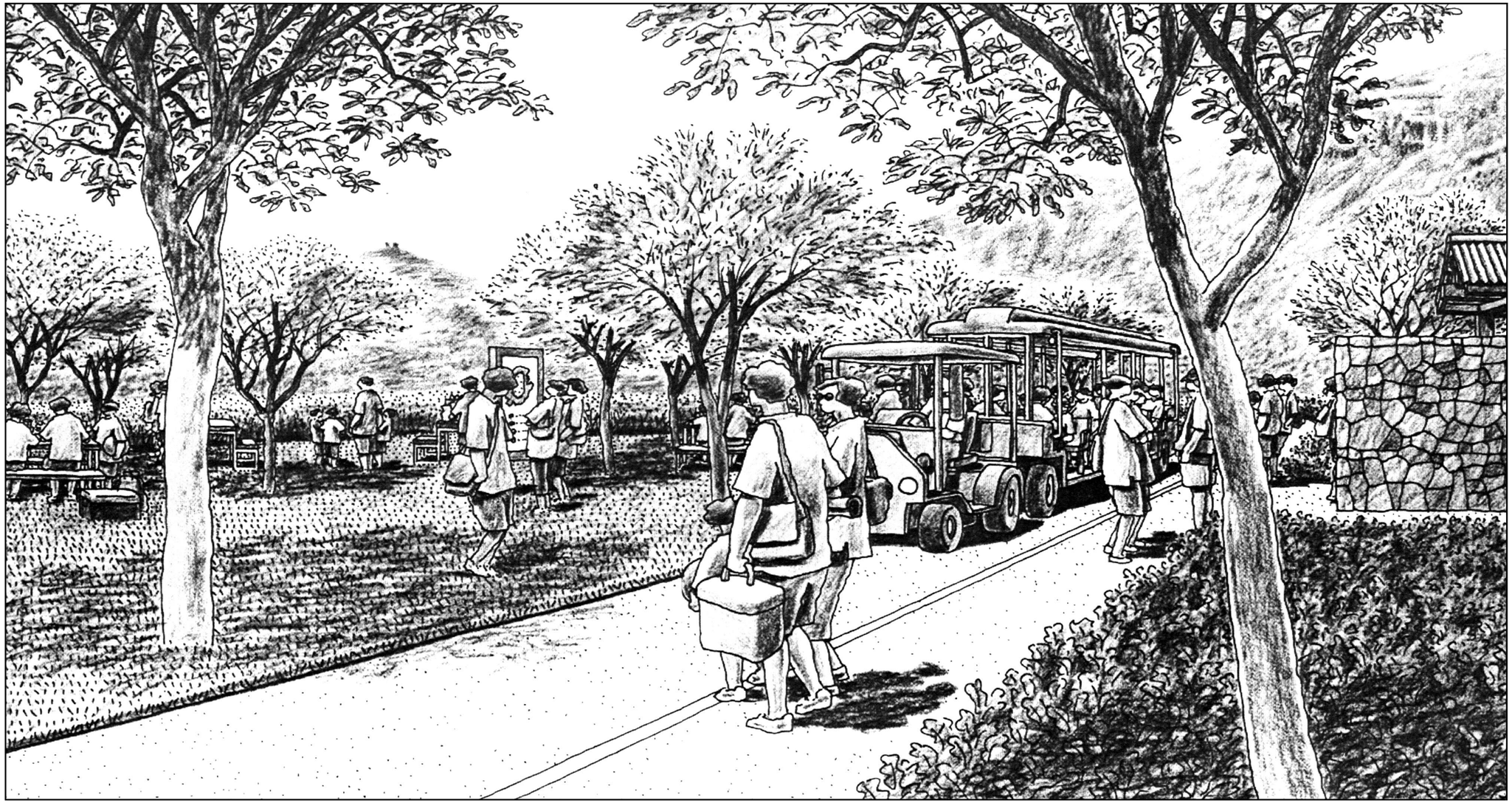


Figure 25
Upper Pistol Range Area Rendering

the Visitor/Interpretive Center. It is intended that the areas furthest from the Visitor/Interpretive Center, and within the proposed internal loop road, be kept in a semi-wild, minimally maintained state. Existing *koa haole*, lantana, and alien grasses should be eradicated and removed after all native plant species have been identified, marked, and protected. For example, it is important to remove alien grass around patches of two native grasslands ‘*emoloa* (*Eragrostis variabilis*) and *kakonakona* (*Panicum torridum*) and throughout *pili* grass stands, and to eliminate alien *Bidens pilosa* and *cynapifolia* around native *Bidens* locations. Existing *kiawe* trees should be tagged for either demolition or to remain (*kiawe* trees specified to remain would be characterized as having an attractive, shade producing canopy). A semi-permanent, underground drip or flood bubbler irrigation system would be installed to serve the existing and proposed trees and shrubs, while a temporary irrigation system would be used to establish grasses and groundcovers. With the understanding of the level of landscape maintenance involved, the crater floor would be lightly landscaped. These plants might include:

a. *Wiliwili*
b. *Lonomea*
c. *Ohe makai*
d. *‘A‘ali‘i*
e. *Naio*
f. *Ma‘o*
g. *Pili*
h. *Uhaloa*
i. ‘*Ilima*
j. *Pa‘u o Hi‘iaka*
k. *Nehe*

Maintained landscape areas would include picnic areas, shaded seating areas, people mover stops, restroom facilities and trailheads. These would have a permanent, underground irrigation system. Plant material could include the above mentioned as well as:

a. *Milo*
b. *Kou*
c. *Hala*
d. Coconut palm
e. *Loulu* palm
f. Taro
g. Sweet Potato
h. Breadfruit
i. *Naupaka*
j. Sugarcane
k. Ti
l. Turf

In the immediate vicinity of the Visitor/Interpretive Center, a permanent irrigation system with any of the above plant material could be installed, with maintained turf areas. This landscape, while drought tolerant, could be more intensively planted for the purpose of educating the visitor. The character of the landscaping at the Visitor/Interpretive Center should be: 1) natural (incorporating native, rare, and endangered plants endemic to Diamond Head, depending on the review and approval of agencies such as the State Division of Forestry and Wildlife and the U.S. Fish and Wildlife Service); 2) informal; 3) compatible with the surrounding vegetation; 4) respectful of the character of the DHSM; and 5) contain lawn, walkways, and shade trees.

The existing and proposed wetlands have the potential of being an exciting botanical study area. Two options are possible. One would include the restoration of the natural hydrology of the existing wetland by eliminating pumping of standing water after heavy rains, controlling alien weeds, replanting with native plant species, and controlling predators (e.g., cats, mongoose) that prey on endangered waterbirds. Allowing for the natural expansion of the wetland following heavy rains may require the realignment or elimination of adjacent trails and roads that are prone to repeated flooding.

The other option is to delineate the boundaries of the existing wetland and to identify and protect endangered plants. In addition, a lined pond of approximately two acres (to double as storage for irrigation water) could be installed, surrounded by a detention basin that will serve as the new drainage feature for the crater interior. This option is contingent on the availability of a source of non-potable groundwater to keep the pond permanently filled. This pond would be very attractive to endangered waterbirds and, if designed with islands, provide protection for the waterbirds from predators. This option may include a surrounding walkway (ADA accessible) and small shelter(s) for viewing and interpretive purposes.

Outside of the crater, in the area between the Kāhala Tunnel and Diamond Head Road, is a large area that had previously been proposed for the construction of a private tennis facility. This site is readily accessible to the surrounding community and to Kapi‘olani Community College. It is proposed that this area be

developed as the new Na La'au Arboretum. The existing Na La'au Arboretum, located outside the crater below Diamond Head peak, is inaccessible and has suffered neglect over many years. As a more accessible site, nearby residents and University of Hawai'i students could implement and provide maintenance for a master planned ethnobotanical garden, using the blueprint of the original Na La'au arboretum. A copy of the Munro Monument could be placed in this location.

General concepts for the landscape include: restoration of native flora, fire control in sensitive areas, access and maintenance.

Restoration of Native Flora. Actions include agency resources and volunteer groups to replant large areas with appropriate native species that were historically present. While care is taken to reestablish pre-existing native plant communities, near buildings and roads, plants from outside communities, e.g., beach *naupaka*, might be selected. Care should be taken that any native plants (particularly endangered species) brought into the crater from the outside are from as genetically similar stock as possible to the plants already there. In general, this translates into using only plants from nearby areas (or at least from O'ahu) where populations are not likely to have undergone significant genetic divergence from Diamond Head populations.

Adequate protection of the *Scheidea adamantis* can only be achieved by establishing numerous populations at different locations in and around the crater. Efforts to restore this plant at the current location have met with failure due to the extreme environmental conditions that exist at the rim. Suitable sites should be close to a consistent water source for drip irrigation so plants will survive and reproduce.

The highly invasive fountain grass community is potentially the most devastating to native dry and mesic ecosystems. This species is one of the worst invaders in the Hawaiian Islands (potentially second behind *Miconia calvescens*) and is targeted for eradication in Diamond Head by the Oahu Fountain Grass Working Group. Recently the U.S. Fish and Wildlife and the State Department of Land and Natural Resources approved additional personnel to assist the Oahu Fountain Grass Working Group in eradicating fountain grass from Diamond Head Crater. The control methods consist of: manual clearing (pulling weeds, clipping of flowering seed heads), chemical application (herbicide Velpar), and incineration of collected material to prevent inadvertent dispersal by field personnel. Focus areas for fountain grass control include Diamond Head trail, where seed can "hitchhike" onto visitors' clothing, and "fringe" areas where fountain grass has been observed moving into new areas.

An effective alien plant control program must consist of replacing the removed alien plants with native plants. This will decrease the potential for the alien plants re-invading the control areas, thereby facilitating a more permanent solution. Simply removing the alien plants will only result in a continuous cycle of control and invasion.

To minimize the potential erosion impact of removing invasive plants, especially fountain grass in steep areas, invasive plants should be removed incrementally and be replaced with native species. This will curtail significant erosion that might occur if large-scale clearing were involved.

Fire Control in Sensitive Areas. Actions include constructing firebreaks, planting fire resistant (and preferably native) plant species, weed control, and prohibition of smoking in the DHSM. This will also require restricting access to formal trails and roads.

As part of Natural Resources Management Plan a fire protection plan should be developed and implemented. In accordance with the recommendations of the Division of Forestry and Wildlife, this plan should include the installation of firebreaks within and around known colonies of endangered species and the removal of flashy fuels.

Living firebreaks could be developed with fire resistant plants. The experimental technology would consist of planting dry-adapted native

plants in hedgerows, approximately 1 meter in width by 100 meters in length. Selective drip irrigation would enable rapid native plant growth. In the event of fire, these fire-retardant plants could potentially: 1) slow the path of the burn, or 2) prevent the fire from "leaping" beyond the firebreaks themselves. Areas that contain fire-adapted grasses should be seeded with *Dodenea viscosa* (a`a`li`i), which will likely replace the existing grasses.

Access. The proposed internal crater loop road will be for people movers and bicycles only. This road will be one-way and should be only wide enough for one-way traffic and to support maintenance and emergency vehicles. More paths should be constructed within the crater floor and these should be designed to general hiking trail standards. The paths through picnic areas and around the wetland should be designed to be ADA-accessible. Pathways in the remainder of the crater could be designed to show native forest succession. Outside the crater, bicycles should not be allowed on any paths or trails other than the multi-use pedestrian bike path proposed along Diamond Head Road.

Maintenance. The majority of the landscape should be designed to be low maintenance, i.e. *pili* with scattered trees. Provisions should also be made to ensure that re-planted areas would be irrigated and maintained, since it is unlikely that the restored habitats will ever be completely self-supporting and maintenance-free.

The Hawai‘i Army National Guard Environmental Staff recommends that drip irrigation systems be used in the absence of a dedicated water source. Permanent systems may be too expensive to install over large areas. Drip emitters would feed a slow water drip (one gal/day) to the root systems of native plants. Selective watering will enhance root development and promote native seedling survival. The overall result is establishment of native plants to prevent alien species encroachment. With such a system, large plant species can be sustained in high evaporative conditions with only a few ounces of water per day.

8.9 PRELIMINARY COST ESTIMATES

Based on the schematic site plans, cost estimates were produced for the proposed improvements to the DHSM.

Approximate Project Costs

The following preliminary cost estimates for the project were prepared by Rider Hunt Levett & Bailey.

Diamond Head State Monument Master Plan
Preliminary Phasing Cost Breakdown

Item No.		Civil	Building	Utilities	Landscape	Other	Total
	Phase One						
1	Keep existing comfort station & parking lot	–	–	–	–	–	–
2	Continue operation of State Park baseyard	–	–	–	–	–	–
3	Continue use of antennas	–	–	–	–	–	–
4	Allow Battery Birkhimer to remain as a civil defense facility	–	–	–	–	–	–
5	Protect the Schidea Adamatis habitat; and other native species	–	–	–	–	–	–
6	Control visitor access into sensitive areas	–	–	–	–	–	–
	Subtotal	–	–	–	–	–	–
	Phase Two						
7	Remove the FAA CERAP Building	–	–	–	–	–	–
8	Build a permanent Visitor / Interpretive facility near Battery Birkhimer and Install a wastewater lift station	$4,620,000	$5,070,000	$775,000	$550,000	$535,000 (*future building*)	$11,550,000
9	Build new road behind the visitor/interpretive center	$200,000	–	$120,000	–	–	$320,000
10	Remove overhead utility lines between Battery Birkhimer and the crater rim: relocate them to the aboveground conduits to the Link Site	$100,000	–	–	–	–	$100,000

		Civil	Building	Utilities	Landscape	Other	Total
11	Open new trails to the flat top reservoir and adjoining ridge north of the existing trail to summit	$15,000	–	–	$65,000	–	$80,000
12	Open road between the FAA Link Site and the Retractable Searchlight along the eastern crater rim and Utilize Battery Dodge and the gun emplacements along the eastern edge of crater as lookouts	$130,000	–	–	$265,000	–	$395,000
13	Build a multi-use path along Diamond Head Road	$740,000	–	–	–	–	$740,000
	Subtotal	$5,805,000	$5,070,000	$895,000	$880,000	$535,000	$13,185,000
	Phase Three						
14	Build a caretaker's residence (or DOCARE office)	$85,000	$325,000	–	–	–	$410,000
15	Open a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407	$35,000	–	–	–	–	$35,000
16	Build a new trail from Tunnel 407 to the summit trail	$20,000	–	–	$55,000	–	$75,000
17	Remove DOD buildings 301, 303 and 304	$1,100,000	–	–	–	–	$1,100,000
18	Renovate and Open up Tunnel 407 and Battery Harlow for interpretive purposes and providing restroom facilities	$410,000	$230,000	$400,000	–	–	$1,040,000
	Subtotal	$1,650,000	$555,000	$400,000	$55,000	–	$2,660,000
	Phase Four						
19	Improve the wetland	$855,000	–	–	$235,000	–	$1,090,000
20	Build a trail around wetland	$1,725,000	–	–	$330,000	–	$2,055,000

		Civil	Building	Utilities	Landscape	Other	Total
21	Build new picnic areas near the visitor/ interpretive center, Pistol Range site and in front of Tunnel 407	$85,000	–	–	–	–	$85,000
22	Install additional pedestrian trails on the crater floor	$185,000	–	–		–	$185,000
23	Add comfort stations at secondary interpretive facilities and picnic areas	–	$450,000	–	–	–	$450,000
24	Install the linear park along Diamond Head Road	$108,000	–	–	$512,000	–	$620,000
25	Install the new Na La 'au Arboretum between the crater Road and Diamond Head Road	–	–	–	$175,000	–	$175,000
26	Install Dryland Forest	–	–	–	$2,685,000	–	$2,685,000
	Subtotal	$2,958,000	$450,000	–	$3,937,000	–	$7,345,000
	Phase Five						
27	Acquire and utilize the Cannon Club for food service and/or visitor orientation and providing restroom facilities	–	–	–	–	–	–
28	Establish a motorized people mover system and move visitor parking to outside of the crater	–	–	–	–	–	–
29	Build the new intersection across from Makapu'u Avenue	$210,000	–	$220,000	–	–	$430,000
30	Allow entry through Kapahulu Tunnel	$85,000	–	–	–	–	$85,000
31	Restrict exits only through Kahala Tunnel	–	$160,000	–	–	–	$160,000
32	Close the existing Crater Road entry from Diamond Head Road	–	–	–	–	–	–
33	Accommodate pedestrian access through Kapahulu Tunnel	$45,000	–	–	–	–	$45,000

		Civil	Building	Utilities	Landscape	Other	Total
34	Continue the loop road in the crater floor (between Tunnel 407 and Kapahulu Tunnel	$965,000	–	$565,000	–	–	$1,530,000
35	Add a comfort station at the exterior parking facility	$290,000	$225,000	–	–	–	$515,000
	Subtotal	$1,595,000	$385,000	$785,000	–	–	$2,765,000
	TOTALS	**$12,008,000**	**$6,460,000**	**$2,080,000**	**$4,872,000**	**$535,000**	$25,955,000

8.10 PROPOSED IMPLEMENTATION PLAN

While the actual schedule for implementation is subject to the availability of funding, there are a number of major considerations that will affect phasing of the DHSM Master Plan Update. These external factors are the relocation of the State DOD to Barbers Point, the securing of a supply of non-potable groundwater for irrigation[7], and the acquisition of the Cannon Club. Based on these factors, the implementation of the project can be envisioned to occur in five phases, these are:

- Phase One (Continue Existing Operations and Implementation of Currently Funded Projects)
- Phase Two (Projects that Can Be Implemented Within the Next 5 Years)
- Phase Three (Projects that Can Only Be Implemented After the Relocation of the State DOD)
- Phase Four (Projects that Can Only Be Implemented After Securing a Supply of Non-Potable Groundwater)
- Phase Five (Projects that Can Only Be Implemented After Securing the Cannon Club)

The proposed phasing of the various elements of the DHSM Master Plan Update are provided below:

Phase One

- Keeping the existing comfort station and parking lot;
- Continuing operation of State Park baseyard at Makapu‘u Avenue and Diamond Head Road;
- Continuing use of antennas;
- Allowing Battery Birkhimer to remain as a civil defense facility;
- Protecting the *Schidea adamantis* habitat, and the habitat of other native species; and
- Controlling visitor access into sensitive areas (such as the crater rim).

Phase Two

- Building a permanent visitor/interpretive facility near Battery Birkhimer;
- Building the new road behind the visitor/interpretive center (to the new parking lot);
- Installing a wastewater lift station;
- Removing the overhead utility lines between

[7] Future non-potable groundwater improvements that could be developed to supply irrigation water for the proposed project may include development of water supply wells, and construction or improvement of storage and pumping facilities within the crater. Development of groundwater sources is subject to review and approval by the State Commission on Water Resource Management (CWRM)

Battery Birkhimer and the crater rim and relocating them to the aboveground conduits to the Link Site.
- Opening new trails to the Flat-Top Reservoir and to the adjoining ridge which are north of the existing trail to the summit;
- Opening the road between the FAA Link Site and the Retractable Searchlight along the eastern crater rim;
- Utilizing Battery Dodge and the gun emplacements along the eastern edge of the crater as lookouts[8];
- Building a multi-use bike pedestrian path along Diamond Head Road.

Phase Three
- Building a caretaker's residence (or DOCARE office);
- Opening a new trail from the retractable searchlight on the southeastern edge of the crater rim to Tunnel 407 (allow access only via guided tours)[9];
- Building a new trail from Tunnel 407 to the summit trail;
- Removing State DOD Buildings 301, 303, and 304; and
- Renovating and opening up Tunnel 407 and Battery Harlow for interpretive purposes and providing restroom facilities.

Phase Four
- Improving the wetland;
- Building a trail around the wetland;
- Building new picnic areas near the visitor/interpretive center, Pistol Range site and in front of Tunnel 407;
- Installing additional pedestrian trails on the crater floor, especially through picnic areas;
- Adding comfort stations at the exterior parking facility, at secondary interpretive facilities, and picnic areas;
- Installing the linear park along Diamond Head Road; and
- Installing the new Na La‘au Arboretum between the Crater Road and Diamond Head Road.

Phase Five
- Acquiring and utilizing the Cannon Club for food service and/or visitor orientation and providing restroom facilities;
- In the long-term, moving visitor parking to outside of the crater;
- Establishing a motorized people mover system, when visitor parking is kept to the exterior;
- Building the new intersection across from Makapu‘u Avenue;
- Allowing entry through Kapahulu Tunnel;
- Restricting exits only through Kāhala Tunnel;
- Closing the existing Crater Road entry from Diamond Head Road (except for emergency vehicles);
- Accommodating pedestrian access through Kapahulu Tunnel; and
- Continuing the loop road in the crater floor (between Tunnel 407 and Kapahulu Tunnel).

[8] The use of Battery Dodge will not occur until the FAA and the Hawaii Army National Guard feel that opening up the existing road to the general public will not impact their facilities or services.

[9] The use of Battery 407 will not occur until the Hawaii Army National Guard no longer requires the use of the tunnel. In the meantime Battery 407 will be assessed for historic architecture in accordance with the Historic Building Survey (HABS) protocols.

9.0 Visitor/Interpretive Center

9.1 INTERPRETIVE PROGRAM PLANNING

9.1.1 Introduction

The 1979 Development Plan for the Diamond Head State Monument set forth several key elements for the park, including an Interpretive Center to enhance the visitor experience. In reality, the crater itself should be viewed as the resource, the classroom, and the interpretive center. The proposed Visitor/Interpretive Center (VIC) facility needs to support this resource by providing both needed and desired visitor amenities, such as restrooms, refreshments, and a gift shop. Exhibits within the VIC need to complement the natural park setting and tell the story of the crater. For example, visitors are intrigued to be in the crater but may not be able to visualize the short, explosive volcanic eruption that created the crater without an exhibit that "recreates" the event. The other key function is to provide an alternate but equal experience for those visitors who may not be able to take the hikes or explore the crater themselves. Providing such an experience may include a video camera at the summit and a video of the hike to the summit.

During the nineteen years since the Diamond Head Master Plan was prepared, the number of visitors to Diamond Head State Monument (DHSM) has increased significantly (from an estimated 41,000 visitors in 1980-1981 to an estimated 800,000 visitors in 1996-1997). In May 2000, State Parks started collecting park entry fees. The revenues and visitor counts from the first year (May 2000 to April 2001) suggest that the number of visitors who disembark from their vehicles, use the park facilities, and hike the trail is probably closer to 600,000 a year. Buses drive through the park, but most do not have their passengers disembark because they do not want to pay an entry fee. State Parks estimates that this type of drive-through visitation represents another 200,000 visitors per year to Diamond Head. In preparing the EIS for the current Master Plan Update, a number of tour companies were interviewed. The great majority of interviewees agreed the major tour companies will simply skip Diamond Head if: (1) outside parking (eventually all visitor parking will be relocated to the Cannon Club) makes it impossible to see Diamond Head quickly as part of a multi-destination tour; and (2) any commercial vehicle fee or other cost is imposed (unless a major change has occurred in the current budget-conscious O'ahu market). As a result, the relocation of parking to the outside of the crater and the collection of park entry fees may actually reduce the number of visitors (primarily those coming on group sightseeing tours) to the crater.

Despite this large number of visitors, interpretive facilities and devices have been limited to signs, brochures, and a small interpretive shelter. In 1998, the Division of State Parks prepared the "Interim Interpretive Plan, Diamond Head State Monument" (Yent 1998). The objectives of this plan were "to inventory the resources in and around the park area, identify the interpretive themes, evaluate both the interpretive potential and sensitivity of the resources, and develop an interpretive program that outlines the most effective interpretive techniques for interpreting the themes while maintaining the preferred visitor pattern." The plan was referred to as "an interim plan because the devices being proposed are intended to provide interpretive services in the interim while a visitor center is planned, designed, and constructed" (Yent 1998). Since the publication of the Interim Interpretive Plan, many of the recommendations for the interpretive program have been or are currently being implemented.

The proposed Visitor/Interpretive Center is envisioned as just one component of a long range Interpretive Plan for the Diamond Head State Monument. The updated Master Plan continues this effort by proposing not just an interpretive center, but also a variety of outdoor recreational experiences that make the crater

more accessible and expands upon the single, steep hiking trail to Lē‘ahi Summit, which is currently available.

9.1.2 Visitor Expectations, Interests, and Needs

Planning for visitors includes identifying the audience, considering motivations and expectations, and projecting and predicting trends. Visitors are individuals, but describing major visitor groups yields potentially useful approximations and allows planners to better identify and serve primary audiences. A demographic study is probably the most important visitor study that can be done in planning for the VIC, and is particularly useful if carried out at regular intervals.

Information a demographic study can provide includes:

1. Who is currently visiting the park and extrapolate who would be visiting a visitor/interpretive center, allowing educational, audience development, marketing, and fund-raising messages to be accurately targeted.
2. What visitors expect from a visit to a visitor/interpretive center, educationally and in terms of facilities and services.
3. How visitors plan their visits and whether a visitor/interpretive center would be seen as part of a sightseeing tour or if it would attract “serious” visitors.
4. Changing trends in the audience and/or visitor expectations.
5. How to best plan permanent exhibitions or special programs to meet visitor’s needs.
6. Areas of support within the community (schools, environmental organizations, eco-tourism companies, etc.).
7. Identify special audience needs (ADA, schools, language barriers, etc.).

To ensure that the long-term interpretive program for Diamond Head is designed to fit the needs of visitors, a survey was conducted in May of 2001 (Appendix B). The purpose of the survey was to collect demographic information along with visitor interests with regard to the monument and their opinions on the park and information presented. Once again, it should be noted that to ensure the continued relevancy of an interpretive program, surveys should be conducted periodically to monitor changes in visitors’ interests.

The survey confirmed that visitors are primarily looking for an outdoor recreational experience. Since an interpretive/educational experience within a building is secondary, it is important to understand the role of a VIC in the overall interpretive program.

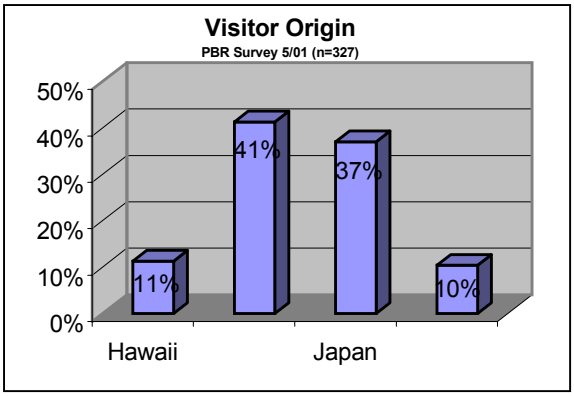
Through analysis of the survey findings and comparison with previous surveys conducted at Diamond Head, trends were identified to help guide the planning process. The survey results confirmed that the majority of park users are non-residents, first-time visitors, and are coming primarily to see the view (PBR 2001, Yent 1998, UH 2001). This information is important in several different areas of visitor center planning. For example, considering that the majority of visitors are first-time visitors, it is more acceptable for Diamond Head’s interpretive program to have a higher number of static, or non-changing, displays than a destination that receives a higher percentage of repeat visitors. Knowing that most park users are first-time visitors to Hawai‘i and the park indicates the need for background information on Hawai‘i’s natural and cultural history as part of the interpretation.

Understanding that the view from the summit is the number one attraction raises many issues. An overall interpretive program might address this by enlarging the lookout viewing area or adding other more easily accessed trails. Beyond dealing with the large number of people trying to access the lookout however, it becomes important for a VIC to address the fact that not all park users are able to reach the summit, due to time or physical constraints. A VIC might address this issue by offering photographs or video footage of the hike and views from the summit of Lē‘ahi. It may also offer more in-depth information about the crater and its history through exhibits, so that those unable to hike to the lookout could learn about the crater and experience it to some degree. This alternate

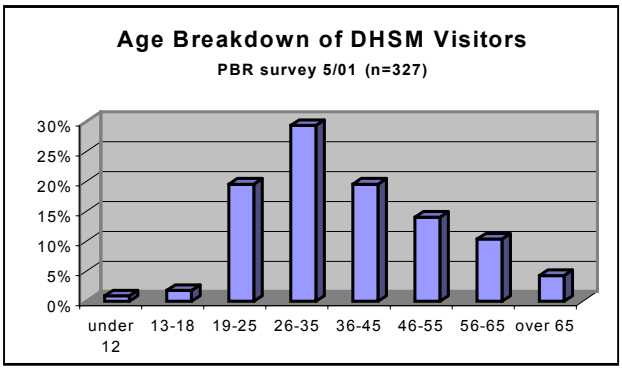
experience could also provide compliance with the Americans with Disabilities Act.

Survey results also indicate that most people spend less than two hours at the park. This would seem to indicate that most people are hiking the trail and spending little other time at the park. A VIC could promote other visitor activities, such as more in-depth information displays, more seating and picnic areas, and other recreational opportunities within the crater. However, a longer visitor stay may require additional parking, amenities, infrastructure, and/or access.

The large number of Japanese visitors (approximately 40 percent) to DHSM indicates a need for VIC information to be presented in both English and Japanese. This practice has already been started in the park, with monument brochures and select sign text currently available in both languages.



Demographic information gained from the survey shows a relatively normal distribution of visitors by age categories, with the majority of visitors between the ages of 26 and 35. While there is a drop-off in the number of visitors under the age of 19, this can be partially attributed to a reluctance of families with children to take the time to complete a survey. While age distribution should be taken into consideration in VIC design, a Center should still be able to offer exhibits to cater to all visitors of as wide an age group as possible. The VIC is also likely to attract educational groups from nearby schools, which would further support the inclusion of exhibits understandable to younger visitors.



The survey also indicated that most people are gaining their information about the park from "word of mouth" and then "books/brochures." This would suggest that many people are visiting the monument with the intent of hiking, but with little background knowledge of the site or trail conditions. The majority of visitors surveyed also claimed they would be interested in learning more about the historical, geological, and flora/fauna aspects of the crater. While the focus of interpretive exhibits should be outdoors, a VIC is the logical place to supplement that information and provide an orientation to the park and the recreational opportunities. Informing visitors on park safety and respect for the crater resources as they enter the park and combining that with signs at lookouts or on trails can enhance the visitor's experience and assist with resource management. Also, as visitors are given more exposure to the importance of the monument, they are more likely to have feelings of ownership or responsibility towards Diamond Head State Monument and its stewardship (preservation).

9.1.3 Goals and Objectives

According to the State's *Diamond Head Interim Interpretive Plan*, "The stated goal in the designation of Diamond Head as a State Monument is the preservation of this significant landmark. This goal includes preservation of historical values, maintenance of the open view corridors to the crater from the exterior, and opportunities for recreational activities. Consequently, the development of interpretive facilities and programs at Diamond Head should be sensitive to the scenic values, the natural

landscape, and the historic character of the crater."

To accomplish this overall goal, an interpretive plan also needs to focus on developing specific objectives. For Diamond Head, the objectives are:

- All visitors will be able to easily find all of the park's facilities upon entering the park property.

- The majority of the visitors will follow instructions and not damage the park and its resources after interacting with interpretive programs and learning respect for the sensitive environment and unique resources at DHSM.

- The majority of visitors will be prepared for the hike to the summit with appropriate gear and good time management, leading to better visitor safety and recreational planning.

- After attending park interpretive programs, the majority of visitors will know that Diamond Head is the result of the island's volcanic history and is shaped by eruption, erosion, and weathering.

- The majority of visitors will understand how the historical efforts of the U.S. to prepare for coastal defense have altered the crater, starting in the late 1800s.

Within the context of the goals and objectives for the Diamond Head interpretive program, the goals for the VIC are:

- To provide visitors to DHSM with an orientation to the crater such that they can plan a visit that meets their interests and expectations. Orientation includes the layout of facilities, the range of visitor opportunities available, and a recommended visitation pattern. Orientation can be provided by staff, videos, signs, and handouts.

- To stimulate visitor interest about the natural and cultural resources that will result in a level of visitor understanding and awareness that translates into visitor behavior that protects and preserves the resources of the crater. These would include issues of resource management such as staying on the trails and reducing the impacts of erosion. Understanding and awareness can be stimulated by exhibits, guided tours, and discussions with park staff.

- To provide basic visitor amenities and services that meet visitor needs and expectations. This would include such elements as restrooms, refreshments, and a gift shop, as well as alternative experiences for those who physically cannot or do not have the time to hike to the summit. (A copy of DLNR's ADA Self-Evaluation and Transition Plan is available online at http://www.state.hi.us/dlnr/ADA/ADA-Act1990-pdf.htm.)

9.1.4 Purpose of the Visitor/Interpretive Center

The VIC is envisioned to be the first major stop for visitors to the inside of the crater. In fact, for those visitors with limited time and/or physical limitations, the VIC may be their only stop within the crater. Therefore, the VIC will serve the following purposes:

- Provide an orientation to the crater and park (often visitors do not realize that they are in the crater).

- Promote visitor safety (provide visitors with more information before hiking).

- Heighten awareness about Hawai'i's unique resources (promote preservation).

- Provide information on recreational opportunities (so visitors can better plan their park visit).

- Provide needed and desired visitor services (restrooms, a gift shop, and refreshments, especially water).

9.1.5 Visitor/Interpretive Center Parameters

As stated in the Section 9.1.1, the crater itself should be viewed as the resource, the classroom, and the interpretive center. Therefore, an actual interpretive center building needs to be especially sensitive to its siting within the crater, and to its contextual relationship to the overall interpretive program of the Diamond Head State Monument.

Site Location

The proposed site for the DHSM VIC is identified in Section 8.6; the Diamond Head Citizens' Advisory Committee (CAC) only reached consensus on the location of this site after a long, exhaustive review process. After reviewing four sites within the crater (a site outside of the crater was rejected), it was agreed that the proposed VIC should be located between the two tunnel entrances inside the crater near Battery Birkhimer. It was also agreed that the VIC would be designed to be compatible with the site and blend into the crater surroundings, minimizing the physical and visual impact on the crater. The proposed structure should be designed to reveal the panoramic outdoor scene for interpretive purposes, and the center should be one-story, above grade (except where below grade basements may be required). There will be plentiful outdoor spaces around and between the parts of the facility for gathering, queuing, and outdoor interpretive displays. Access to the VIC would require a new road from the Kāhala Tunnel. The existing service road to Birkhimer EOC would not be used to access the VIC.

As shown on a base map of the crater (Figure 26), the proposed VIC is sited below Battery Birkhimer in the area currently occupied by a parking lot and a road connecting Kāhala Tunnel and the National Guard facilities. The location of the VIC, nestled below the northeastern wall within the crater, allows for the design of the facility to be oriented on an axis toward Lē'ahi Summit. The finish floor elevation of the VIC is shown at an elevation of approximately 230 feet.

Site Access

Since the VIC would be sited over the existing access road (and parking lot) to the former FAA and the National Guard facilities, a new road separate from the restricted access to Birkhimer EOC is proposed. From the new road, service access to the center would be possible. It is proposed that after the VIC is in place, the existing road to the existing parking lot, comfort station and trailhead be closed. Traffic would instead be directed to a new 80-stall parking lot that would also include a drop-off, four accessible parking stalls, and five bus-sized stalls (Figure 27). New signage and trails would lead visitors from the VIC to connecting trails into the crater and to the summit trailhead. To provide access to the National Guard facilities, it is proposed that the new road be extended beyond the VIC.

Eventually, private vehicular access and parking will be relocated from the interior of the crater to the exterior of the crater, and public access to the crater will be limited to walking and/or via people mover. Until that entrance is open, visitors would still enter the crater through the Kāhala Tunnel, with the VIC being the first facility they encounter. During this interim phase, entrance fees would be collected at the tunnel entrance, with directional signage located to encourage visitors to explore the VIC.

In the long term, when future vehicular access to the interior of the crater is limited and a small, motorized "people mover" system is established (offered as an alternative to walking into the crater), the new road would be an important section of an interior crater loop road. With parking limited to the exterior of the crater (primarily at the Cannon Club), visitors boarding the people mover would enter the crater through Kapahulu Tunnel and would stop at the proposed VIC. The site plan for the Center shows a drop off for the people mover. The people mover would continue on the proposed loop road that would encircle the interior of the crater (Figure 26).

Space Program

To meet the Goals and Objectives (Section 9.1.3) and Purpose (Section 9.1.4), the VIC should be designed to provide the following types of functions:

- Interpretation (including orientation and safety);
- Restrooms;
- Refreshments; and
- Souvenirs/Gifts.

To accommodate these functions and anticipated visitation levels, along with providing for the daily operation of the VIC, CDS International, the conceptual design architect, developed the following preliminary Space Program based on a given size limitation of 10,000 square feet (SF) for the initial phase, with another 5,000 SF for any future expansion.

The Governor, in response to Diamond Head CAC concerns, set this size limitation in 1998. Since that time, the Diamond Head CAC reviewed and approved revised schematic plans, which include modifications made with input from State Parks. The modifications provide for an outdoor lobby/reception area and a larger gift shop. In addition, half of the future expansion space was specifically designated for an auditorium facility.

The movement of visitors through the VIC can be envisioned based on the Proposed Site Plan (Figure 27). From the drop off, visitors would proceed through a trellis entry leading to an outdoor lobby reception area as part of the covered walkway system. From this node, direct access would be available to the office/gift shop building to the right and the main exhibit building to the left. An auditorium facility is planned to the left of the main exhibit building. Restrooms and food service (vending type concession) would be available across an open plaza, along with a future building site if expansion of exhibits is required. This main plaza and viewing lanai would offer unobstructed views of the summit of the crater (Figure 28).

The Reception/Lobby is envisioned as a covered outdoor pavilion with a staffed counter for the distribution of visitor information. Here visitors can get an overview of the key features of the Monument, especially a sense of being in the interior of the crater. From this overview, visitors can design their own "itinerary" of what to do within the crater. This overview would also include information that will ensure visitor safety and rules on proper conduct within the crater. The Entry Pavilion will provide a shaded area for visitors to gather or wait while others are visiting the VIC exhibits and/or the crater.

PRELIMINARY SPACE ALLOCATION (1998)

Space Name	Function Served	SF
Reception/Lobby	Orientation, Visitor Information	600
Exhibits	Interpretation	7,600
Restrooms	Restrooms	1,000
Vending Machines, Drinking Fountain, Public Phone	Refreshments	200
Gift Shop, Storage	Souvenirs/Gifts	200
Business Office	Operations	300
Secretary	Operations	100
	Total SF:	10,000
	Future Expansion	5,000

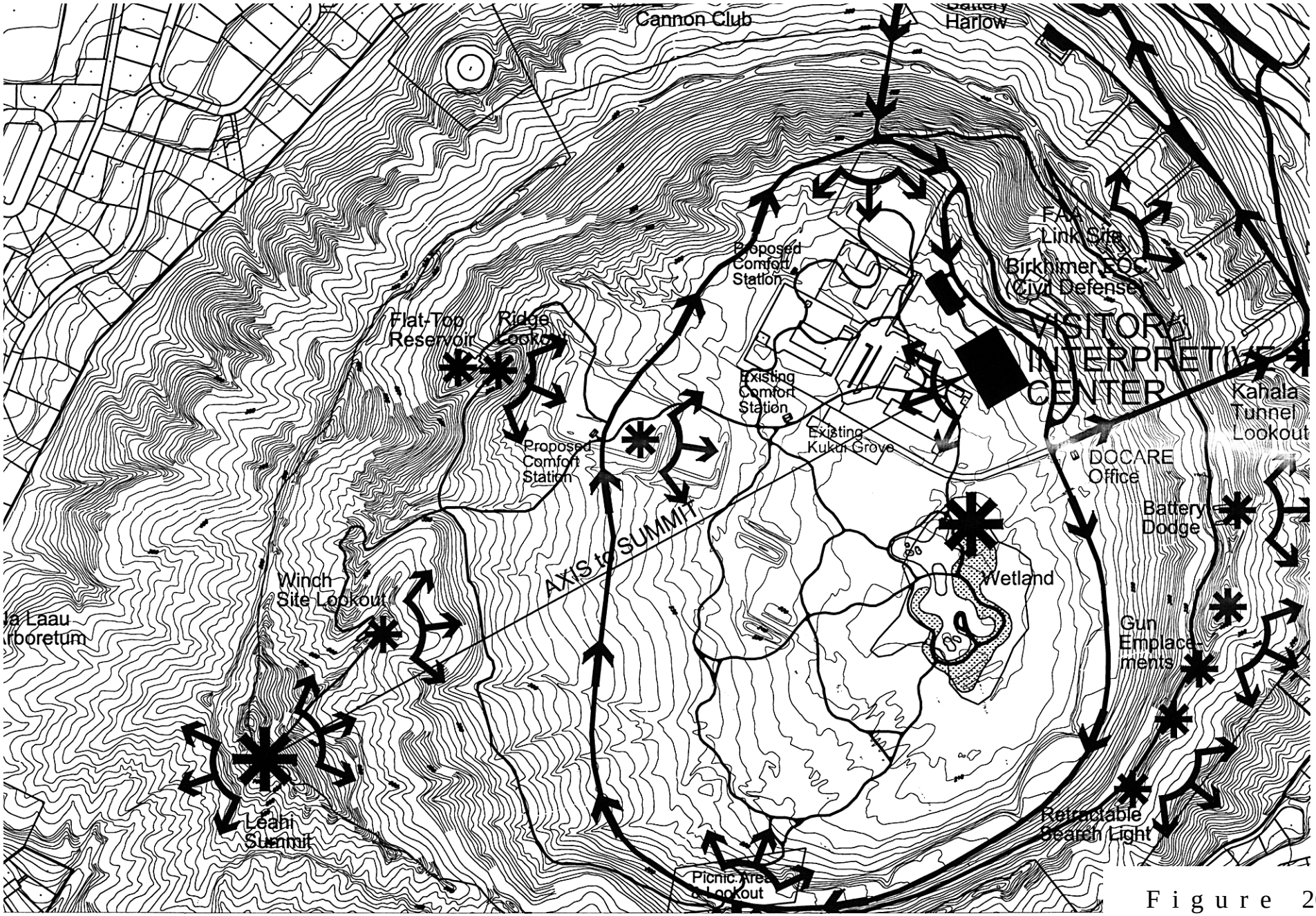


Figure 26

Location of VIC Within Diamond Head Crater

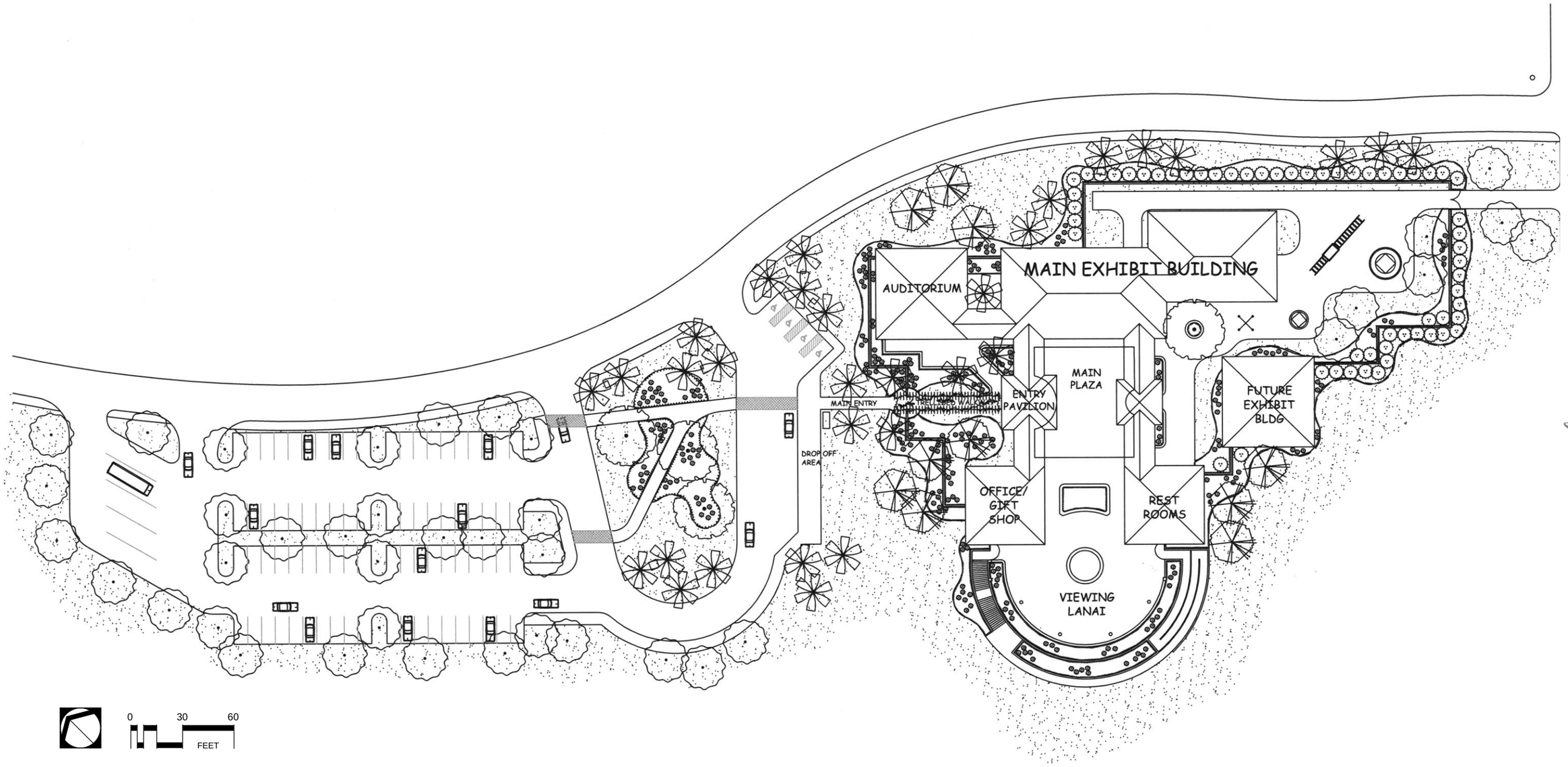


Figure 27
Proposed VIC Site Plan

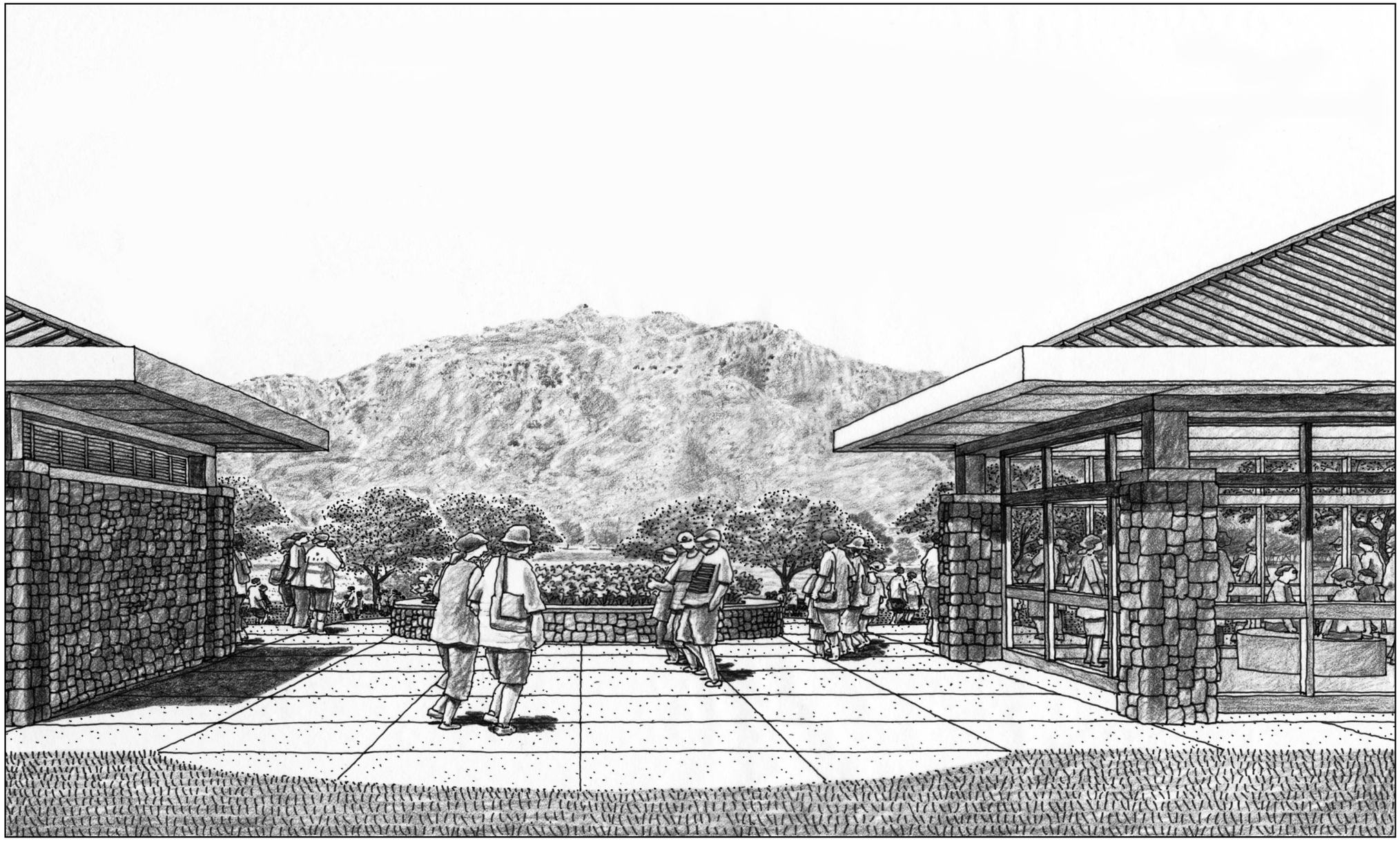


Figure 28
Rendering of View Toward Summit fom Main Plaza

The Main Exhibit Building is intended to complement the overall interpretive program for the Diamond Head State Monument, which includes the crater itself, outdoor signage, brochures, etc. The exhibits should not be designed to duplicate the natural park setting, but to share the story of the crater through graphics, models, and hands-on activities. The exhibits could include more detailed information about orientation within the Monument and safety considerations.

Initially, approximately 5,000 square feet was planned for future expansion of the VIC in anticipation of the need for additional exhibit space. State Parks believes that at least half of the planned expansion space should be set aside for an auditorium. The Auditorium is envisioned as a key component of the DHSM Interpretive Program, and an especially important facility for making the DHSM more accessible to those who have difficulty hiking or those without the time to undertake a hike. The Auditorium will showcase an audio-visual program that will tell the story of Diamond Head and help visitors with orientation when viewing and exploring the crater. As a sheltered and air-conditioned venue, the Auditorium also provides an alternate location for longer interpretive programs or special presentations should inclement weather hamper the use of the exterior gathering spaces included in the VIC.

Since the crater is relatively dry and hot, there is a need to provide refreshments for visitors. This need is proposed to be satisfied with drinking fountains and vending machines located near the restroom facilities.

The Gift Shop, with educational and souvenir items, would be located adjacent to the Office for efficiency with staffing, air-conditioning, and security concerns.

The clustering of small buildings to make up the VIC facility provides for all the necessary functions while addressing the Diamond Head CAC concerns of minimizing the physical and visual impact on the crater. The proposed schematic plans for these buildings, which were developed from the initial conceptual layout, include the following interior spaces.

ADJUSTED SPACE ALLOCATION (2002)

Building / Space		**NSF**	**Building** / Space		**NSF**
Main Exhibit Building		**7,840**	**Restrooms**		**1,190**
Exhibit Area	6,835		Women	460	
Kids' Zone	475		Men	420	
Storage	530		Custodial Closet	50	
			Refreshment Area	260	
Office / Gift Shop		**1,490**	**Auditorium**		**2,150**
Office	360		Lobby	460	
Restroom	50		Audience	1,180	
Gift Shop	860		Stage	310	
Storage	130		Presentation Storage	100	
Mech./Elec./Tele.	90		Mech./Elec./Tele.	100	

Total Net SF: 12,670

9.2 SCHEMATIC ARCHITECTURE

As previously noted, having separate functions housed in different structures reduces the scale of the VIC and the open space design promotes the panoramic outdoor views of the crater for interpretive purposes. The exterior design and building materials of the structures, set by the conceptual design architect, are both simplistic and bold, and are well suited for the crater location. The interior architecture should complement this setting, while meeting the specific needs of the functions housed within each structure.

9.2.1 Architectural Character

The architecture of the VIC needs to be sensitive to the history and environment of the Diamond Head State Monument. In response to these needs and the stated functions of the Center, CDS International designed building forms that relate to a Hawaiian sense of place. (For exterior elevations see Figures 29A-29D.)

Roof Form

The proposed roof form provides the main unifying element throughout the one-story structures. The square floor plans of the smaller buildings lend themselves to pyramidal roof forms, and all the roofs would have matching slopes of approximately 2.5:1. Given that the height limit of the City and County of Honolulu's Diamond Head Special District is set at zero (0) feet, any structure would exceed the limit; and while the existing buildings within the crater have flat, industrial type roofs, the proposed sloping roofs with wide overhangs provide a more Hawaiian style architecture. Rather than mimicking the historic military structures of the crater, the VIC should create its own image, relating more to the natural history and climate of the crater. The deep overhangs would provide shade for visitors while enhancing the indoor-outdoor quality of the VIC.

Exterior Building Materials

The indoor / outdoor connection important to the interpretive nature of the crater, would be emphasized with floor to ceiling glass on walls looking out into the crater. The glass areas could be framed with dark bronze aluminum rails and mullions that would withstand the climate better than wood detailing. Oversized lava rock pillars are envisioned at the corners of the buildings to emphasize their pavilion-like qualities as well as provide an interpretive connection with the crater. Matching dark bronze aluminum louvers and accessories would complete the easily maintained, long lasting exterior surfaces of the buildings.

9.2.2 Building Design

Working with State Parks, PBR Hawaii developed schematic floor plans for each proposed building. The focus was on meeting the goals and objectives of the VIC and providing low maintenance, long-lasting finishes.

Entry / Lobby Pavilion

The main entry will lead through a trellised walkway directly into a covered pavilion (Figure 27). This pavilion will be a focal point of the covered walkway system linking the facilities of the VIC. An information counter will be located here, directly in line with the entry. This circular counter will provide a location for distribution of printed materials and for one-on-one interaction with a knowledgeable guide. Although under the roof of the pavilion, this counter will need to be made of durable materials and able to withstand the elements. The base should match the exterior finish of the building walls, and the countertop should provide a smooth surface for writing, leaning and interacting. Under the counter, cabinets would store printed maps, educational material, and information on the different opportunities available within DHSM. The flooring of the entry pavilion, and throughout the covered walkway system, should be a durable concrete with an upgraded non-skid finish. The ceiling of the walkways and pavilion should be an exterior finish system to cover wiring for electrical and telecommunication needs.

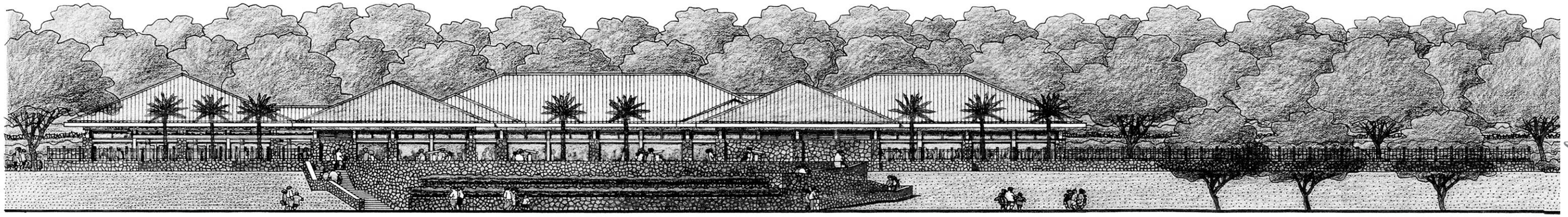


Figure 29A
VIC West Elevation

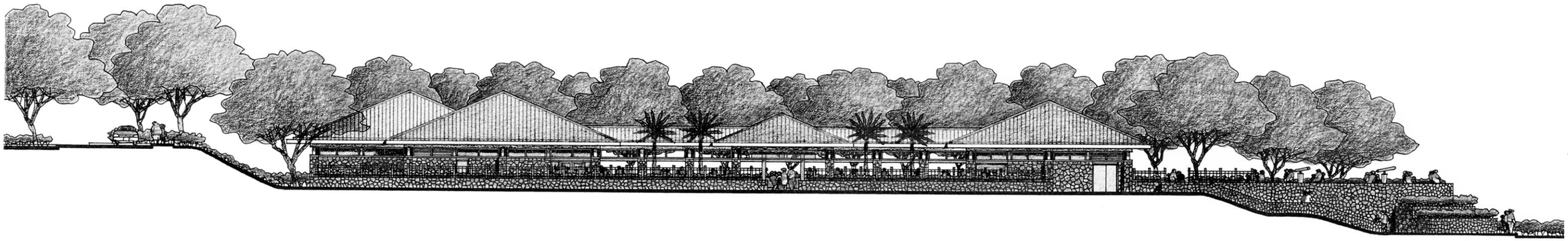


Figure 29B
VIC North Elevation

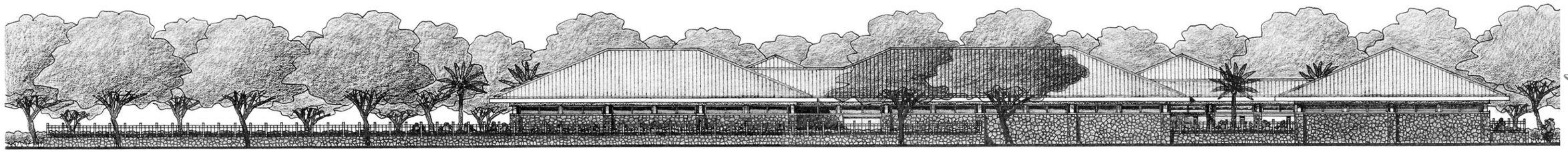


Figure 29C
VIC East Elevation

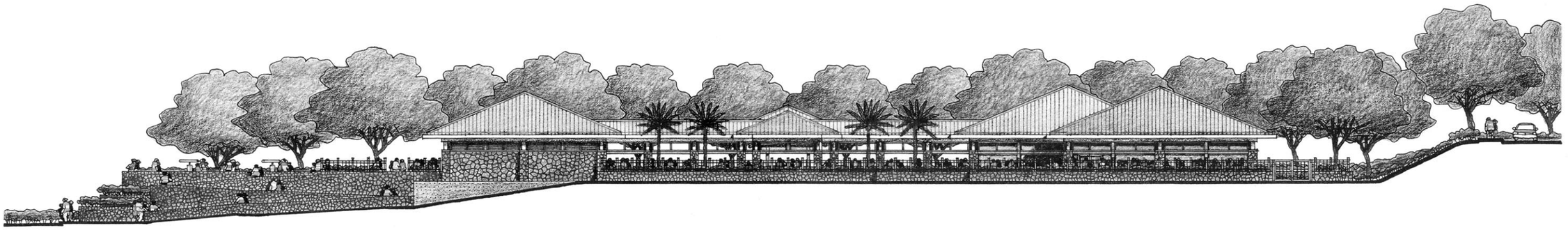


Figure 29D
VIC South Elevation

Office / Gift Shop

The building to the right of the entry houses the gift shop and business office for the VIC. The daily operational management of the VIC may require a director and secretary. The entry and information booth would be visible from the office. The gift shop faces the viewing lanai and there is a covered walkway from the entry pavilion. Floor to ceiling glass would allow for views out to the crater and also allow for displays of items within the shop. In order to allow the gift shop to be staffed by a single person, a u-shaped cashier counter would be located for complete visual control. The staff would have access to a storage room directly behind the counter. Completing the spaces in the building are a singular restroom for use by the staff and a mechanical room for air conditioning, electrical and telecommunication equipment (Figure 30A).

Main Exhibit Building

The major exhibit building is located to the east of the main plaza and has floor to ceiling glass along its western walls in order to take advantage of the summit views and to provide a connection to the natural environment of the crater. The building will be air-conditioned and include many features of the interpretation program (see Section 9.3.2 Indoor Interpretive Exhibits). The interior finishes will be durable and low maintenance, such as quarry tile flooring and upgraded hardware. The building will include special ceiling treatments to complement the interpretive exhibits within. A large storage room and double door service entrance are included for the maintenance of the building and its exhibits. Doors to this building were located, as shown on the plan, to encourage visitors to view both the indoor and outdoor exhibits (Figure 30B).

Restrooms / Refreshment

The restroom building is located opposite the gift shop building, both of which frame the view of Lē‘ahi summit from the main plaza and exhibit building. The restrooms would be scaled to handle maximum crowds and still conform to the overall water and sewer capacity limitations within the crater. In addition to providing necessary toilet facilities and a custodial closet, this building has space for drinking fountains and vending machines or a small food service counter. The exterior walls of this building would need to be solid, preferably lava rock to match the pillars of the other, more transparent, buildings; while the interior finishes would need to be durable, water-resistant, and low maintenance. Overhead roll down screens could be included to secure the food service or vending area, while allowing full time access to the drinking fountains (Figure 30C).

Auditorium

The auditorium would provide an air-conditioned space for approximately 150 people. It is envisioned to have a large screen and small stage area with bench seating for the audience. A carpeted floor and acoustical ceiling treatment would be provided for the auditorium. The wall between the auditorium and the lobby waiting area would provide acoustic separation and allow space for interpretive themes (such as historic Diamond Head photos). The west facing exterior walls would be glass to maximize views and provide visual security into the lobby. A storage room and mechanical/electrical/telecommunications room would also be included in this building (Figure 30D).

9.2.3 Other Design Considerations

One of the stated goals of the VIC is to offer an experience for visitors who may not be physically able to climb to the summit or explore the crater in depth. Therefore, the VIC provides both indoor and outdoor exhibits along with features such as viewscopes on the viewing lanai. The overall design of the VIC would be barrier-free, including wheelchair access to all facilities, assistive technologies where required, and an accessible ramp from the viewing lanai down to the start of crater trails below the facility (Figure 31).

The security of the VIC was taken into consideration during the conceptual design phase, and an enclosing fence is shown. Although the crater is to be closed at night, this fence, with accompanying gates and screen

walls, would provide a physical barrier from "after hours" intruders. This enclosing element also allows for the buildings themselves to be very open to the courtyard – for easy visitor flow and to remind all that the crater itself is the monument.

Final design of the facility should consider energy-efficient features, such as those facilities at Zion Canyon Visitor and Transportation Center in Springdale, Utah. Energy-efficient features could include a photovoltaic system, maximum day lighting, high-efficiency air conditioning units/chillers, natural ventilation, optimized overhangs, high-efficiency glazing and insulated roofs to reduce cooling loads, and energy-efficient lighting. Other elements that should be incorporated in the design are water-efficient fixtures and green or recycled building materials. Recycling receptacles should be located near the refreshment area.

9.3 INTERPRETIVE EXHIBIT PLANS

Many people visit Diamond Head to experience a volcanic crater, to hike to Lē'ahi Summit, and to take in the panoramic views from the summit. According to State Parks, these aspects of Diamond Head draw an estimated 800,000 visitors a year to the crater. With a growing number of visitors, the potential for visitors to adversely impact the crater's geological, biological, and historical resources increases. Therefore, the interpretive plan needs to focus on awareness and appreciation of the natural and cultural history of the crater.

9.3.1 Interpretive Themes

In the *Interim Interpretive Plan*, State Parks identified five major categories of interpretive themes. The categories are: Geological, Biological, Cultural (Hawaiian Pre-Contact), Cultural (Post-Contact), and Scenic. The themes are summarized below:

I. Geological Themes

1) Lē'ahi illustrates one phase of volcanic activity that created the island of O'ahu and its topographic features.
2) Lē'ahi represents a typical tuff cone shaped by erosional forces.

II. Biological Themes

1) The plants and animals found in Lē'ahi have adapted to a dry, semi-arid climate.
2) The wetland environment on the crater floor is an exception to the dry, arid environment of much of the crater.
3) There are a few remnants of the native ecosystem at Lē'ahi that consist of rare and endangered plant species.
4) The plant community that dominates Lē'ahi crater today consists of recent, alien, introduced species.
5) As with the flora, the fauna of Lē'ahi reflects the loss of the native species and replacement by alien species.

III. Cultural Themes: Pre-Contact

1) The name Lē'ahi has two translations that may be clues to the cultural importance of the site.
2) The prominent seaward peak of Lē'ahi provided panoramic views of southeast O'ahu and was also a navigational landmark, visible from sea.
3) The presence of numerous *heiau* on the outer slopes of Lē'ahi suggests that the crater may have been linked to the religious significance of the area.
4) Besides being a royal center, Waikīkī was an important site for many of the battles on O'ahu.

IV. Cultural Themes: Post-Contact

1) Lē'ahi played a critical role in the defense of O'ahu's shoreline during the 20th century because of its strategic location.
2) Construction in a volcanic crater required innovative engineering and construction techniques.

V. Scenic Themes

1) Lē'ahi serves as a backdrop to Waikīkī.
2) The panoramic views of O'ahu's south shoreline are the basis for the military importance of Diamond Head.

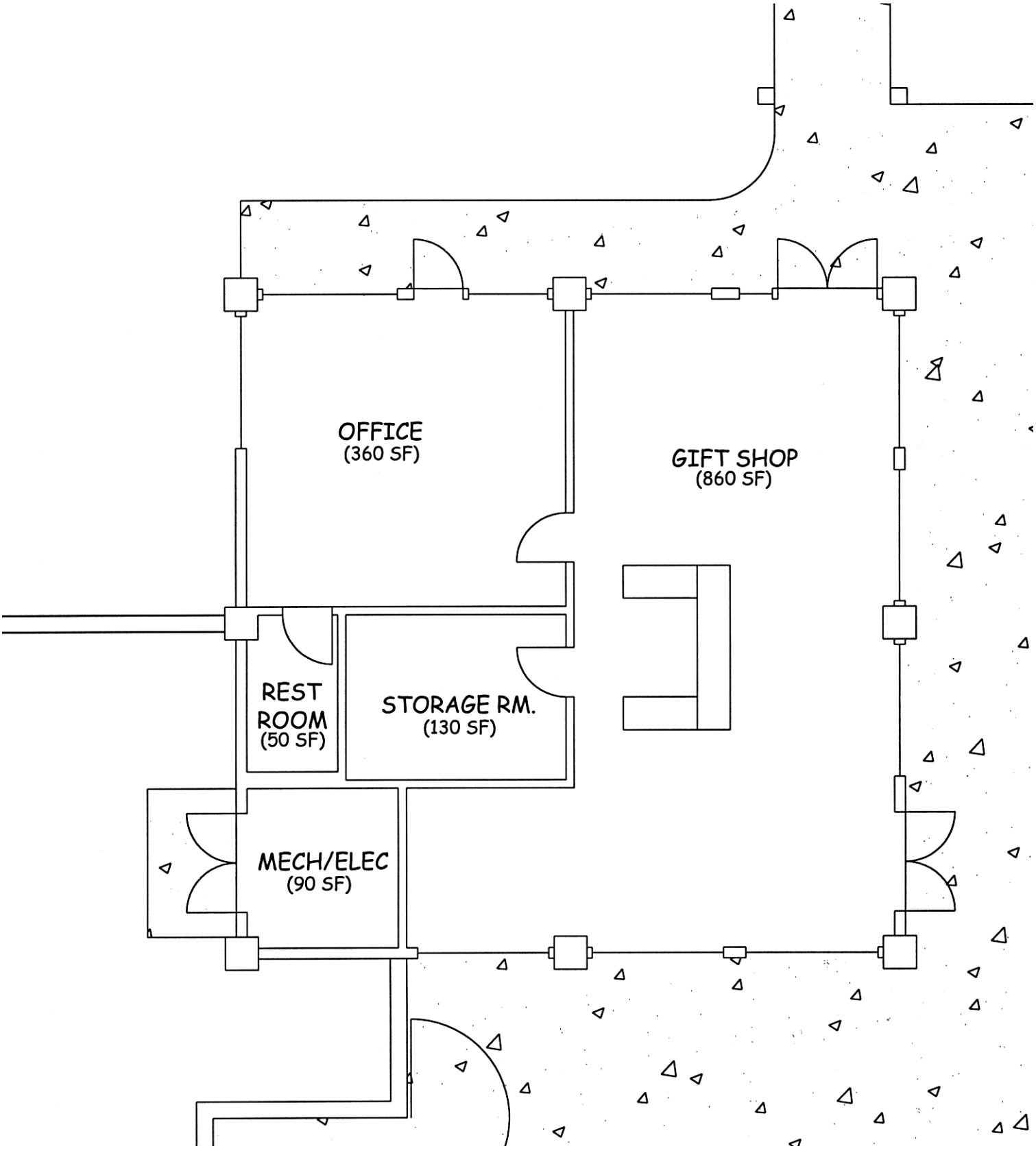


Figure 30A
VIC Office / Gift Shop

0 4 8
FEET

Diamond Head

LEGEND for Interior INTERPRETIVE EXHIBITS

1. FAQ BOARD/ MAIN ENTRY
2. GEOLOGY INTRODUCTION
3. CREATION OF O'AHU
4. ERUPTION & EROSION WITH SOIL COLUMN
5. DRYLAND FOREST
6. NATIVE HAWAIIANS (AD 800–1800)
7. CONTACT (AD 1800)
8. MILITARY (AD 1900–1950)
9. LIFE AT FORT RUGER
10. POST–MILITARY PARK & RESTORATION (1970–PRESENT)
11. LIFE IN THE CRATER TODAY
12. GEOLOGY
13. DIAMOND HEAD "LOGOS" & SYMBOLISM
14. OTHER INFORMATIONAL DISPLAY/SIGNAGE

A. 3–D MODEL: O'AHU BEFORE HAWAIIANS
B. 3–D MODEL: CRATER AND WAIKĪKĪ AD 1500
C. 3–D MODEL: S.E. O'AHU, FTS. RUGER AND DERUSSY
D. INTERACTIVE GAME
E. COMPUTER STATIONS
F. BENCH SEATING
AREAS OF EXHIBIT COUNTERS/TABLES

STORAGE (530 SF)

KIDS' ZONE (475 SF)

SERVICE ENTRY

DOOR TO OUTDOOR EXHIBITS

RAILROAD WIT CART

(6,835 SF)

SLIDING DOORS

"WELCOME TO LĒ'AHI" PANORAMIC PHOTO

OTHER PANORAMIC PHOTO/DISPLAY

WALL OF TUFF

WINCH

LOW PLANTER W/SEATWALL (TYPICAL)

INFO BOOTH

INTERPRETIVE DISPLAY

0 8 16 FEET

Figure 30B
VIC Main Exhibit Building

Diamond Head

Master Plan Update

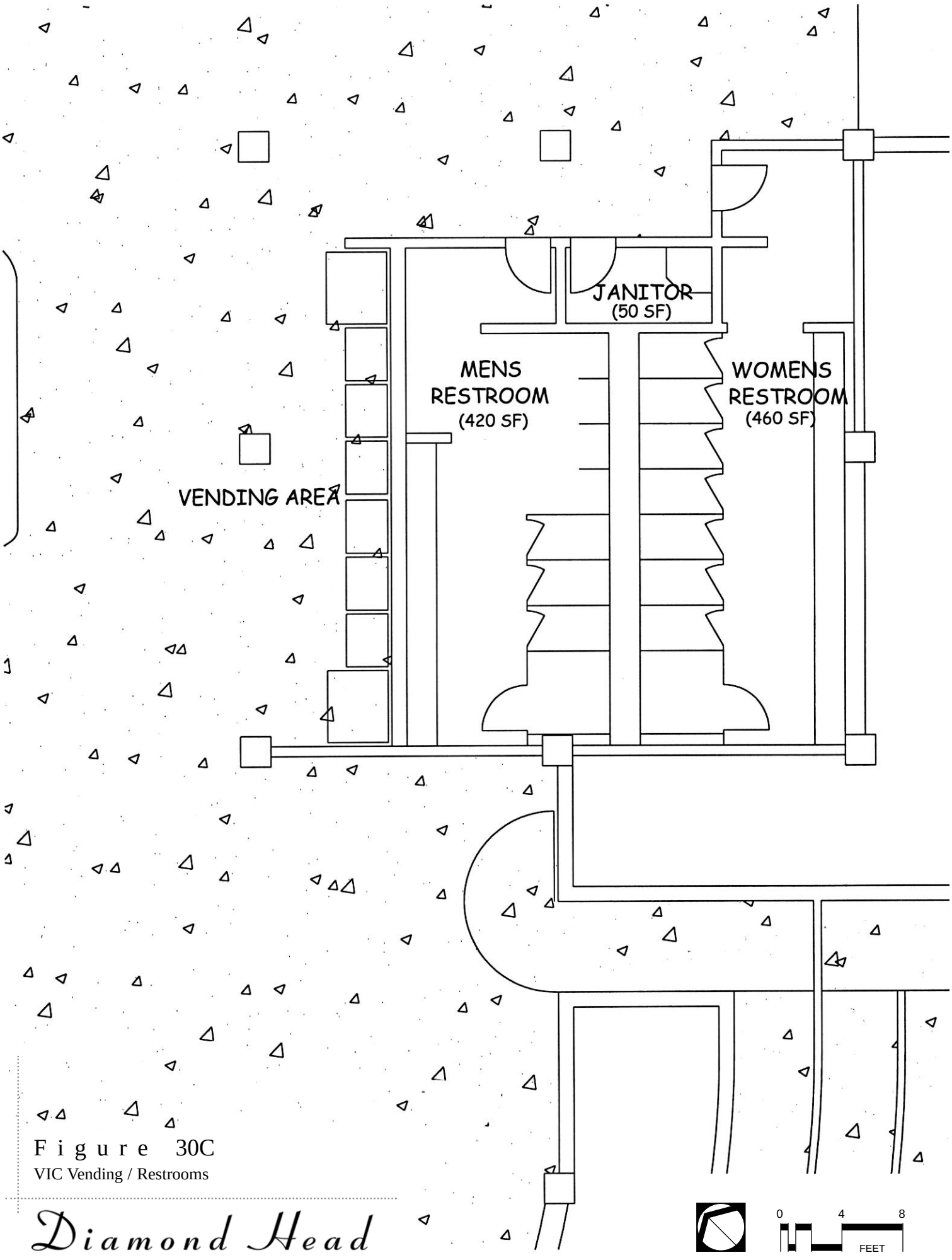
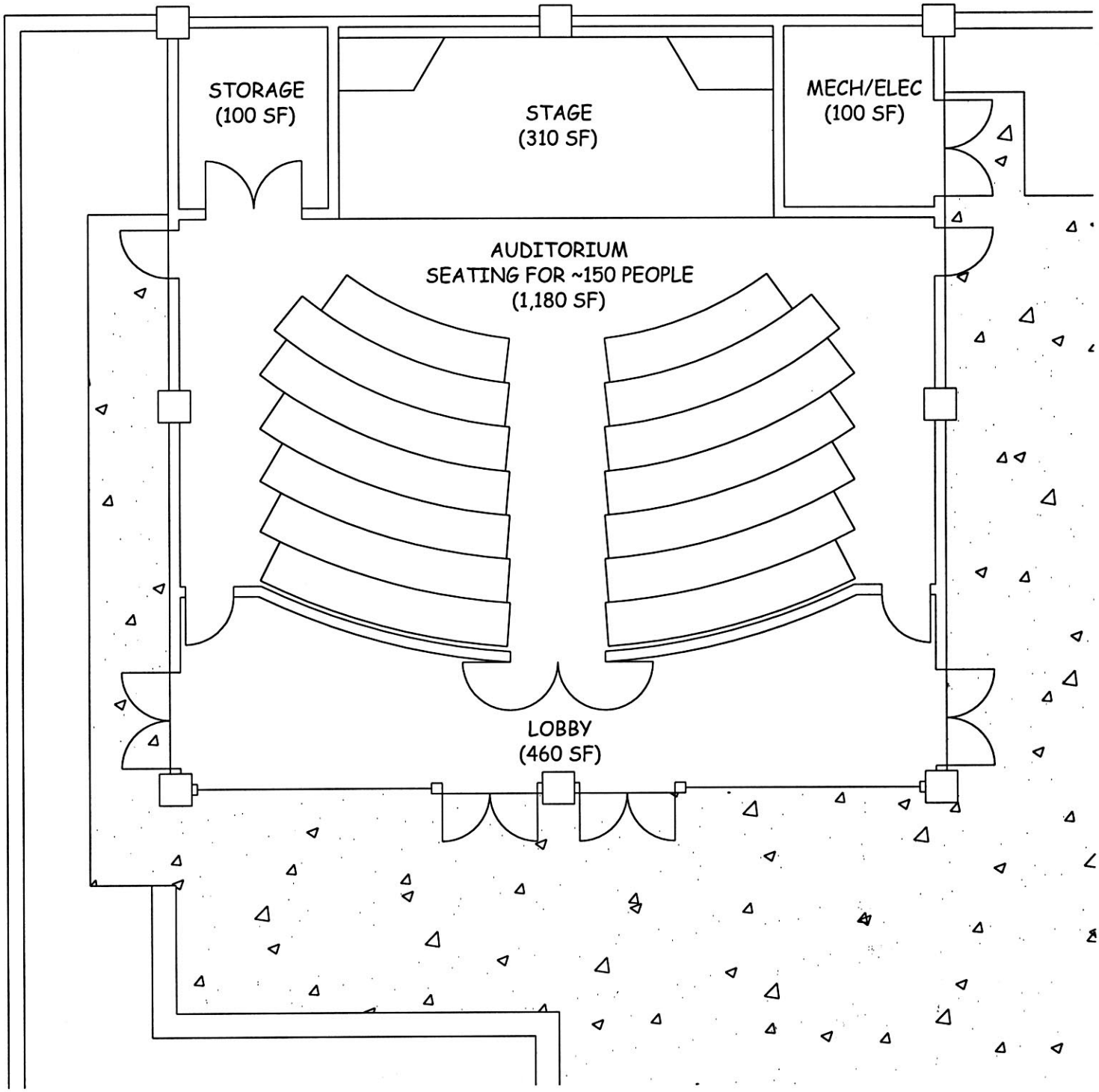


Figure 30C
VIC Vending / Restrooms

Diamond Head



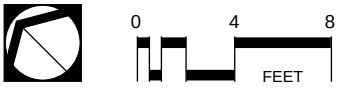


Figure 30D
VIC Auditorium

Diamond Head

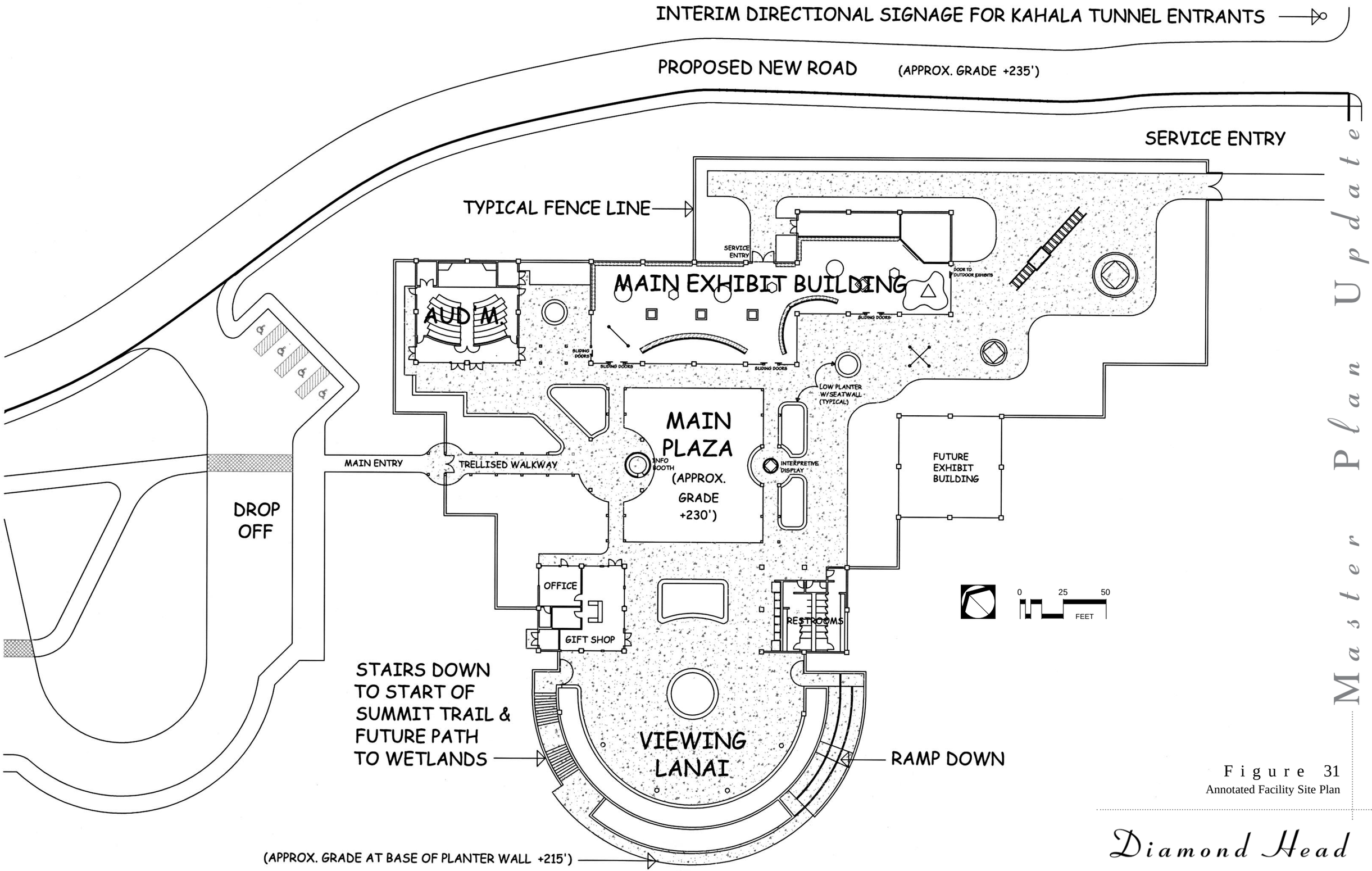


Figure 31
Annotated Facility Site Plan

3) From the summit of Lē‘ahi, the panoramic view encompasses the crater landform and a number of the landmarks that illustrate the geological history of O‘ahu.

These themes are reflected in the outdoor exhibit panels that were installed at the interpretive shelter and trailhead in 1999. In addition to developing these themes for the exhibits within the VIC, the interpretive program will include a series of outdoor exhibits located throughout the monument, as the crater itself is the main attraction. It is envisioned that the VIC will serve as an anchor to the entire interpretive experience of DHSM, especially for those with limited time or for those unable to hike to the summit of Lē‘ahi.

The interpretive programming for DHSM should be formulated to appeal to a wide range of lifestyles, ages, abilities, and to both visitors and residents. Taking into consideration the general market characteristics of audiences to interpretive facilities, it is envisioned that the “permanent” interpretive program for DHSM should include a variety of experiences and exhibits, both outdoor and indoor. Obviously outdoor experiences will make up the majority of the programming, since the primary attraction of the park is the “novelty” of being inside a crater, and the view offered from the lookout.

9.3.2 Indoor Interpretive Exhibits (Main Exhibit Building)

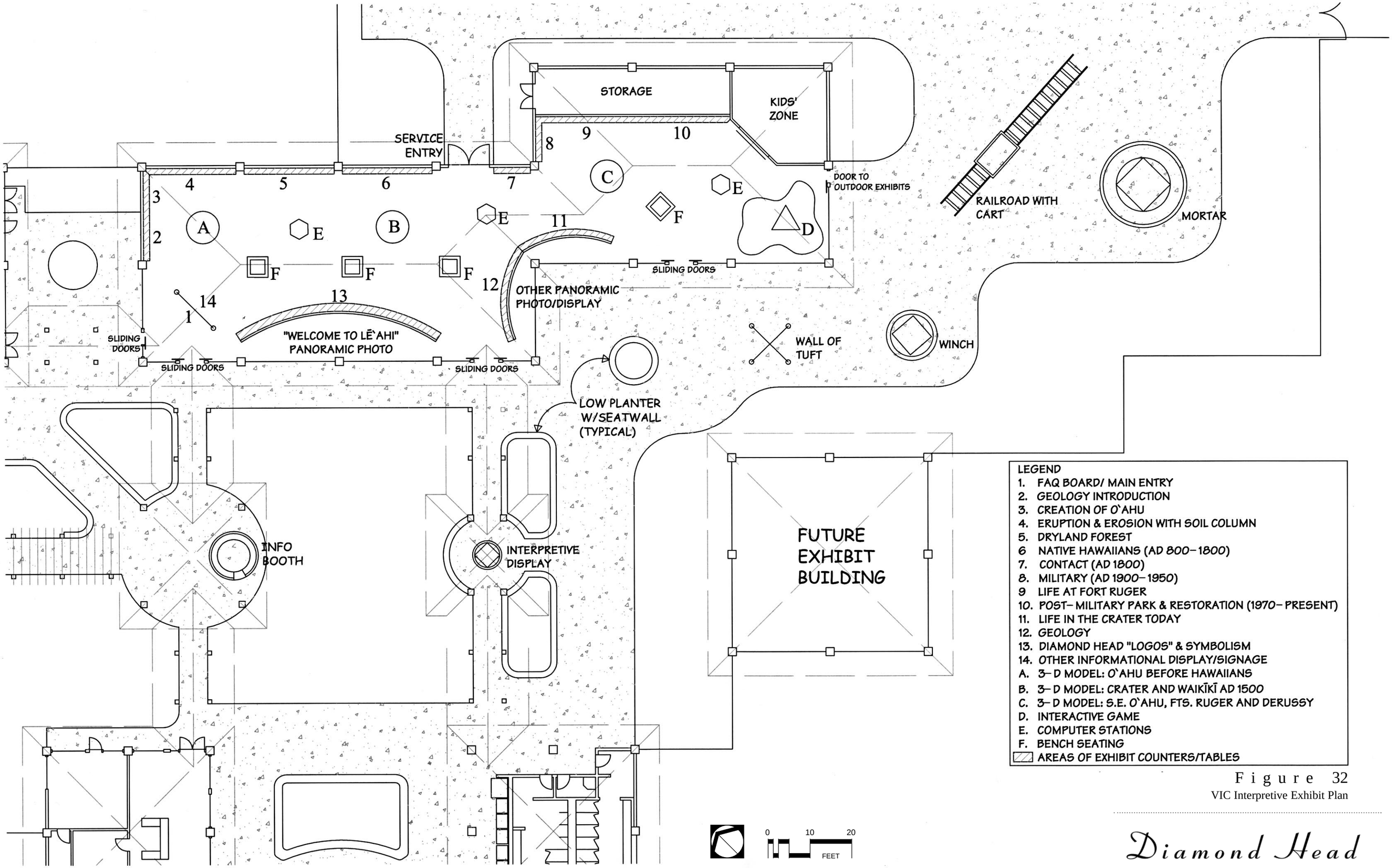
The proposed layout for the main exhibit building of the VIC is based on integrating the interpretive themes summarized above into a unique presentation on the overall story of Diamond Head. State Parks evaluated each theme for the amount of information available and its significance to the natural and cultural factors affecting the crater’s landscape over time. It was felt that the stories of Waikīkī and aspects of the military use of the crater are better told elsewhere, and the main focus of the VIC should be the stories of geology and natural history, with the cultural and military history woven in.

Figure 32 shows how the presentation would place the geological and human events of Diamond Head within a timeline of Hawaiian and world history. This timeline format could be emphasized with a “Time Line Band” running at a height of 5’-6” to 7’ along the solid north and west walls. This band could have dates and graphics of what else was going on in the world during the time periods emphasized in the exhibits below. These exhibits would include wall graphics such as historic photos, original artwork, and cross-sectional models mounted on the wall from a height of about 3’ up to the Time Line Band. Below these exhibits would be transparent display cases with actual artifacts and replicas from the various time periods. The display cases would need to be built to match the actual exhibits to be housed within them. The table on the following page provides an overview of suggested themes and elements for each of the different time divisions and the respective panel locations shown in Figure 32.

Freestanding 3-D models and computer stations will be spaced throughout the Main Exhibit Building complementing the timeline presentation. As noted in the above table, the 3-D model at the beginning of the timeline would show what O‘ahu looked like before Hawaiians settled on the island, the model near the Hawaiian historical period would show what Lē‘ahi and Waikīkī looked like at the peak of Hawaiian civilization, and the third model near the military timeline would show the various forts and military facilities and how they related to one another. The computer stations would provide a variety of interactive learning activities and displays such as videos, computerized animation and modeling, and games that can be changed and updated over time. In addition, the computer stations could be used to show live video feeds from cameras placed throughout the crater so that those unable to hike the trails can see what the views are like in real time. The computer stations could also be used to link to other related facilities such as the Hawai‘i Volcanoes National Park on the Island of Hawai‘i or they could show live geologic monitoring of Lē‘ahi itself.

PROPOSED TIMELINE PRESENTATION

TIME	THEME	ELEMENTS
(Panel 2)	Geology Introduction	- types of volcanoes, land formation
2.5 million years ago (Panel 3)	O'ahu took form with the eruption of 2 volcanoes and subsequent erosion.	- eruption graphics - 3D model of O'ahu with volcanic sites
300,000 years ago (Panel 4)	Diamond Head crater was created on a brief, explosive eruption late in the geological history of O'ahu.	- graphics of eruption (cross-section) - story of Pele - soil column - computer station with volcanic simulations - counter display of different volcanic eruptions / lava / composition
100,000 years ago (Panel 4)	The crater was shaped by erosional forces (wind, rain, surf).	- graphic of erosion (loss to summit) - changing sea level
2,500 years ago (Panel 5)	Hawaiian plants and animals entered the crater, creating a dryland forest centered around a lake.	- rendering of wetland environment - renderings of native birds - renderings of key plants - impact of climate – rain pattern
A.D. 800 (Panel 6)	Hawaiians settled Waikīkī and created a thriving coastal settlement based on taro cultivation and marine exploitation.	- concept of *ahupua'a* - wetland of Waikīkī - use of crater
A.D. 1400 (Panel 6)	The abundance of Waikīkī attracted the *ali'i* who lived, ruled, and worshipped here.	- rendering of Waikīkī as royal center -3D model of crater & Waikīkī showing locations of *heiau* and cultural sites
A.D. 1880 (Panel 7)	With the event of Western Contact, Diamond Head took on new importance for its panoramic views.	-importance of Honolulu and Waikīkī in exploration and trade (anchorages) -story of Diamond Head Charlie
A.D. 1900 (Panels 8, 9)	Diamond Head figured prominently in the military's coastal defense of O'ahu.	- 3D model of crater, Fort Ruger to Fort DeRussy with interactive element (triangulation, coastal defense network) - cut-away of fire control station - life of men who served at Fort Ruger (photos, oral histories)
1970s (Panel 10)	While still largely a military reservation, the public was allowed to enter the crater.	- park use (trail) - Crater festivals - Hawai'i National Guard story
Present (Panel 10)	Bringing the crater back to its natural state.	- Plans for restoration of natural environment



LEGEND

1. FAQ BOARD/ MAIN ENTRY
2. GEOLOGY INTRODUCTION
3. CREATION OF O`AHU
4. ERUPTION & EROSION WITH SOIL COLUMN
5. DRYLAND FOREST
6 NATIVE HAWAIIANS (AD 800–1800)
7. CONTACT (AD 1800)
8. MILITARY (AD 1900–1950)
9 LIFE AT FORT RUGER
10. POST–MILITARY PARK & RESTORATION (1970–PRESENT)
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C. 3–D MODEL: S.E. O`AHU, FTS. RUGER AND DERUSSY
D. INTERACTIVE GAME
E. COMPUTER STATIONS
F. BENCH SEATING

AREAS OF EXHIBIT COUNTERS/TABLES

Figure 32
VIC Interpretive Exhibit Plan

Visitors would enter the Main Exhibit Building from the northwest corner where they would be greeted by a freestanding graphic display board, or an interactive computer exhibit modeled on "Diamond Head Charlie," where the ten most frequently asked questions could be answered. From this point the timeline would serve as a directional tool, leading the visitors throughout the building. Seating opportunities would be provided for quiet observation and resting, at different locations in the building.

A "Kid's Zone," is envisioned for the southeast corner of the building, allowing for visual supervision but with a certain amount of acoustical separation. This area could contain interactive displays and exhibits geared specifically for children such as stamps, books and computers. The area by the windows in the southwest corner is envisioned to be a 3-D exhibit focusing on "Life in the Crater Today." This exhibit could highlight the changes in the environment as a result of climate and introduced flora and fauna (birds, mongoose, *kiawe*, *koa haole*).

The west walls of the building would be glass, to keep the focus on the natural setting throughout the exhibit. A freestanding curved wall could be centered in front of the west wall facing the main plaza. The concave side of this wall, facing the main plaza, would be a panoramic or oblique aerial photograph of Diamond Head with the words "Welcome to Lē'ahi." The interior side of this curved wall could be dedicated for wall graphics and display cases focusing on the many uses of the world famous name and logo of "Diamond Head."

As previously noted, the Auditorium is envisioned as a key component of DHSM Interpretive program, and an especially important facility for making the DHSM more accessible to those who would have difficulties hiking or those without the time to undertake a hike. The Auditorium would provide air-conditioned space for approximately 150 people, easily accommodating school groups. The Auditorium will showcase an audio-visual program that will tell the story of Diamond Head and help visitors with orientation when viewing and exploring the crater. The wall between the auditorium and the lobby waiting area would allow space for interpretive themes (such as historic photos of Diamond Head). The west facing exterior walls would be glass to maximize views.

9.3.3 Outdoor Interpretive Exhibits (within the VIC)

As shown on the Annotated Facility Site Plan (Figure 31), outdoor exhibit areas within the VIC could contain some large "hands-on" exhibits that would relate to the geological formation and military history of the crater. These exhibits could include the following:

- 3-D Scale Model of Diamond Head Crater: built of weatherproof material and located in the center of the Viewing Lanai, this model would help visitors to orient themselves before venturing further into the crater.

- Wall of Tuff: this vertical exhibit would include layers of volcanic ash, rubble and coral as deposited in the crater during the eruption. It would be a touch and feel exhibit including an area to determine "how tough is tuff" (fingernail tests of tuff).

- Winch: this scale model could be a functioning replica of the type of winch used to build and supply the Fire Control Station at Lē'ahi summit. This model could be interactive.

- Railroad Track with Cart: this movable device on a portion of track would provide the opportunity to experience the effort required to push supplies and equipment that were used to build the structures within the crater.

- Mortar: a reproduction of a full-size mortar as used at Battery Harlow could provide hands-on history lessons and photo opportunities.

- Viewing Scopes: located at the western edge of the viewing lanai, at least two (at different heights for accessibility) and ideally four, scopes would be permanently

mounted to focus in on the crater rim, summit, and interior.

- Interpretive signs: three interpretive signs can be installed on the curved wall at the edge of the Viewing Lanai to direct visitors on their visit of the crater. One sign on the left to focus on the walk/tour to the wetland with restored dryland forest; one in the center to describe the walk/hike to the summit; and one on the right to concentrate on the walk to the Hawaiian plant garden, picnic area, and other visitor attractions.

9.3.4 Cost of Exhibits, Design and Build Process

The cost of the interpretive exhibits will depend on the final contract with an interpretive exhibit designer, and construction costs at the time of fabrication and installation. In abstract terms, it should cost the least amount necessary to do it right. Based on information from firms that specialize in exhibition design and fabrication, the budget for permanent exhibits for the Diamond Head VIC should be approximately $250 to $300 per square foot for the fabrication and installation (or a range of $1,880,000 to $2,250,000) along with another 20 to 25 percent of the construction cost for the design of the exhibits (a range of $380,000 to $570,000). The complexity of exhibits within this cost range would include a diverse assortment of items from conventional cases and mounted photographs to interactive exhibits and special A/V effects.

According to Veverka (1994), the average time for most new exhibit projects (depending on the size of the exhibits) is about 9-12 months for planning and design and another 9-12 months for construction and installation. In preparation for this professional process, State Parks has developed the goals and objectives, established the main themes for the interpretive exhibits, and gathered much of the necessary research on the stated themes.

9.3.5 Educational Component

Many visitor and/or interpretive centers engage in educational programming that goes beyond the exhibits. Visitors enjoy personal presentations that enable them to ask questions. People also have different learning strategies and preferences. Some people learn best by reading the materials, others by listening, or by "doing." It is important for the success of the interpretive program to use several different interpretive techniques. These programs include:

- Tours and hikes, both guided and self-guided options
- Lectures, classes and workshops
- Films
- Outreach programs
- Websites

Educational programming can be done in conjunction with schools and community groups. In a small facility, educational activities can be planned and carried out by staff or a cooperative agreement. For example, Hui O Laka, a non-profit organization which has a management lease agreement with State Parks at the Kōkeʻe State Park on Kauaʻi, offers interpretive programs for pre-school to high school groups that schedule visits ahead of time. Kōkeʻe State Park's programs include educational games, guided hikes and educational worksheets that supplement their park exhibit information. The Park also offers interpretive guides within the museum/gift shop to provide information to all visitors, interpret the displays and assist visitors with purchases. Part-time employees, retirees and volunteers frequently are involved in carrying out these types of educational activities. A large pool of volunteers may be necessary; this is especially true when meeting the needs of students. Teachers and students are better served when the ratio of students to interpreter does not exceed ten.

Some opportunities for more extensive educational activities might include nature trails, pre- and post-visit school materials, book and film loans, printed literature, speaker's bureau, and community events. The auditorium facility proposed for the VIC, besides including an orientation video program, could possibly be used for evening talks or special programs. However the focus of the activities should be

outdoors since the Monument is primarily an outdoor experience and inclement weather is rare.

The interpretive program for the VIC should consist of two elements: 1) regularly scheduled programs, such as guided tours for daily visitors; and 2) special programs for target audiences, such as schools or the hearing-impaired, on a pre-arranged basis. Both types of programs should focus on occurring outdoors. It is envisioned that regularly scheduled (and special) programs could occur at the following locations within the Monument:

- On the people mover (especially for those who just want to ride through the Monument or those individuals who are physically disabled);
- At specific sites (Battery Harlow, Tunnel 407, VIC, proposed wetland);
- On the existing trail to Lēʻahi Summit; and
- On the proposed Eastern Crater Rim Trail.

Most of the above sites are located outdoors and thus the crater will serve as an outdoor classroom for the VIC.

9.4 CONCEPTUAL LANDSCAPE PLAN

The Master Plan Update sets a direction for changes to the existing flora of the crater to more closely resemble a coastal, dry, mixed plant community, which may have been typical of Oʻahu's south shore landscape at the time of Western contact, circa 1800. A hierarchy of landscaped areas and maintenance zones would be designed based on the different uses proposed for the various areas within the crater. For example, the VIC would qualify as a high use area and therefore would require a permanent irrigation system and more intensively planted and maintained areas. Less frequented areas would be designed as xeriscapes that do not require permanent irrigation systems or frequent maintenance.

9.4.1 Planting Materials

The five characteristics of the conceptual landscape plan for the VIC are to keep the landscaping: 1) natural, incorporating native, rare and endangered plants endemic to Diamond Head, depending on the review and approval of agencies such as the State Division of Forestry and Wildlife and the U.S. Fish and Wildlife Service; 2) informal; 3) compatible with the surrounding vegetation; 4) respectful of the character of the DHSM; and 5) contain lawn, walkways and shade trees (Figure 33).

The following landscape categories, with acceptable plant materials listed, would be included around and within the VIC:

Planters / Seating Areas / Retaining Walls
Native Accent Shrubs and Groundcover
- Ti
- ʻIlima
- Pāʻū o Hiʻiaka
- ʻĀkia
- Pōhinahina
- Pōhuehue

Surrounding Pedestrian Areas
Native Canopy Shade Trees
- Wiliwili
- Lonomea

Medium Canopy Shade Trees
- Kou
- Alaheʻe
- Manele

Lawn
- Common Bermuda

Entry to VIC
Native Vines to climb trellis
- ʻĀwikiwiki

Building / Fence Edges
Medium Canopy Accent Trees
- Milo
- Hala
- Lama

Large Single Trunk Palm
- Loulu

Screen Plantings
- *Kokiʻo* (hibiscus)

Foundation Shrubs and Groundcover
- ʻAʻaliʻi
- Naio
- Maʻo
- Kuluʻi

9.4.2 Hardscape Design

Exterior plazas and walkways within the VIC would complement the informal, natural character of the landscape design. The intensive use of the VIC requires a more structured outdoor setting than elsewhere in the crater to meet the interpretive goals while protecting the natural environment.

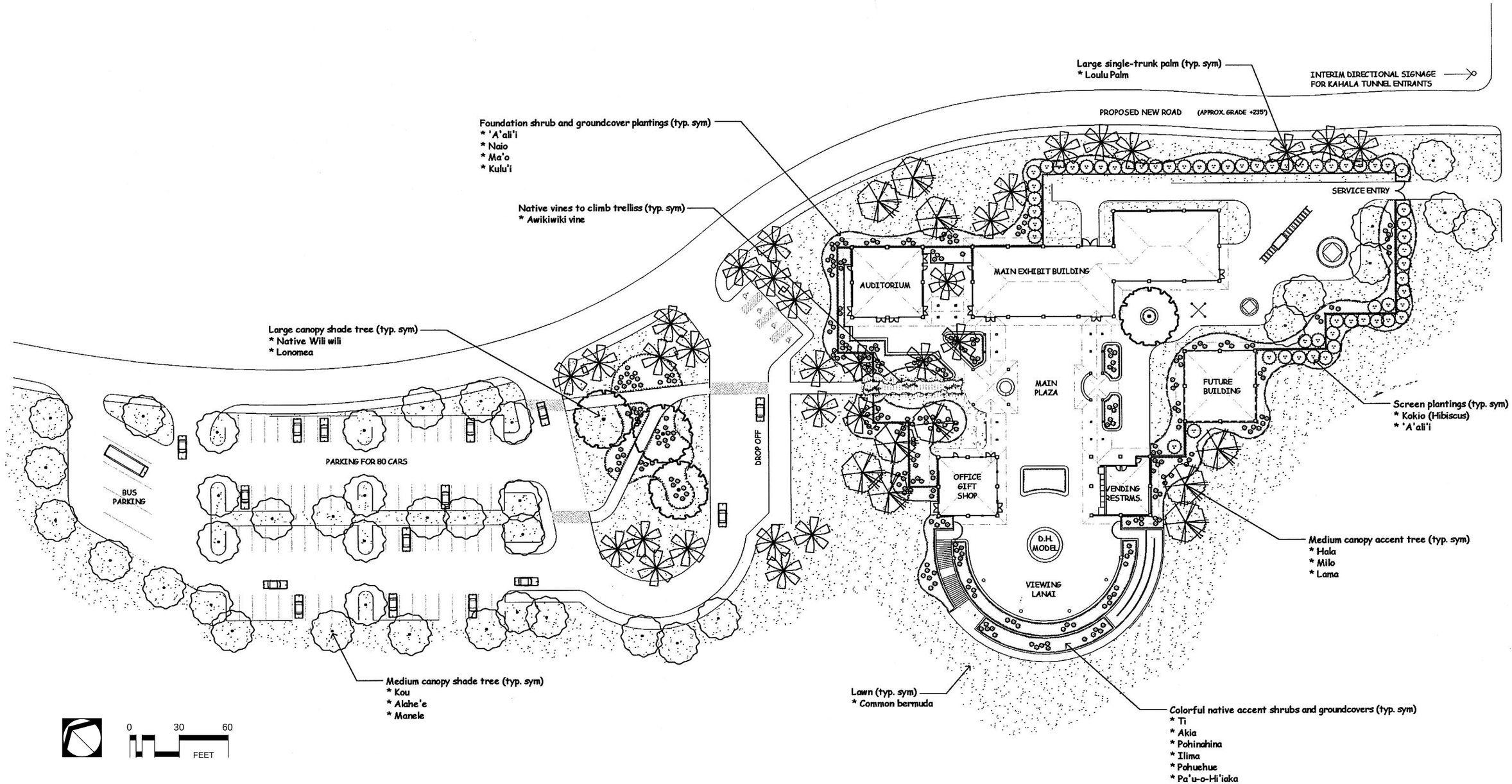
The main plaza, beyond the entry pavilion, could be paved with a concrete pattern that incorporates native Hawaiian designs or designs relating to Diamond Head, and built to accommodate drainage. This plaza, sized to accommodate guided lecture groups or to set up chairs and tables for special events, allows for a high volume of pedestrian traffic to all parts of the VIC. Its central location, surrounded on three sides by buildings and covered walks, opens to the viewing lanai to the west. The curved form of the viewing lanai would be centered on the axis of the main plaza and towards the Lēʻahi summit across the crater floor.

Informal seating areas would be provided throughout the VIC. Planter designs provide many opportunities for seating at different locations and for different purposes. Areas near building entries would have seating for queuing, while seating in other areas would provide opportunities for individuals to rest during their visit to the VIC. The retaining wall fronting the viewing lanai could provide informal seating. Shade trees have not been incorporated into the landscaping in these areas in order to provide an unobstructed view to Lēʻahi summit.

9.5 COST ESTIMATE / IMPLEMENTATION

9.5.1 Cost Estimate

Appendix C contains a cost estimate for the proposed Visitor/Interpretive Center as described in this report. The estimate does not include the off-site improvements listed below which would need to be completed prior to the start of the VIC project. Those costs are



Master Plan Update

Figure 33
VIC Conceptual Landscape Plan

itemized within the DHSM Master Plan Update Report. The budget for the interpretive program would also be in addition to the estimate in Appendix C.

9.5.2 Visitor/Interpretive Center Development Considerations

Development of the VIC will require the following off-site improvements:

- The construction of a new access road to service the National Guard facilities;
- The relocation of the National Guard Accounting Department and Supply departments;
- The demolition of Building #303 (Figure 16);
- Moving the fencing from around Building #303 to a reduced National Guard "compound";
- The installation of wastewater lift station;
- The installation of utility lines such as potable water, wastewater collection, electrical, telephone;
- The installation of a waterline from a new non-potable source outside of the crater to the existing "flat-top" reservoir within the crater for irrigation of the Phase I area.

9.5.3 Phasing

The development of the VIC could be phased as follows:

Phase I: Off-site improvements as described above in Sections 9.5.1 and 9.5.2.

Phase II: Building 1 (offices, gift shop); Building 2 (restrooms, vending machines, public phone, drinking fountain); Building 3 (exhibits); Building 4 (auditorium).

Phase III: Building 5 (exhibit expansion).

10.0 Environmental Impacts

Chapter 343, Hawai'i Revised Statutes, requires that an EA or an EIS be prepared for the proposed development at DHSM. Several factors trigger this: 1) the use of State land and State funds; 2) the existence of historic resources listed on the National Register of Historic Places; 3) development on conservation district land; 4) development within the Special Management Area; and 5) the possible need for a Well Permit (Well Installation Permit, Pump Installation Permit and Water Use Permit) from the State Water Commission.

An Environmental Impact Statement Preparation Notice (EISPN) was filed with the State Office of Environmental Quality Control (OEQC) on August 25, 1998. Notice of the availability of the EISPN was published in the September 8, 1998 issue of the *Environmental Notice*. The 30-day public comment period for the EISPN occurred between September 8, 1998 and October 8, 1998. During this time there was an opportunity for public input on the desirability of the various alternatives considered. Public informational meetings were held on November 23 and November 24, 1998.

Notice of the availability of the Draft EIS was published in the *Environmental Notice* on April 8, 2000 and a second 45-day public comment period began—ending on May 23, 2000. A second set of public informational meetings was held on April 26 and May 8, 2000.

Notice of the availability of the Final EIS was published in the *Environmental Notice* on November 8, 2000, and the Final EIS was accepted by the Governor on January 25, 2001.

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Appendix A

Infrastructure Master Plan Report

Diamond Head State Monument
Master Plan

Infrastructure Master Plan

November 2001

Prepared For:
PBR Hawaii, Inc.

Prepared By:

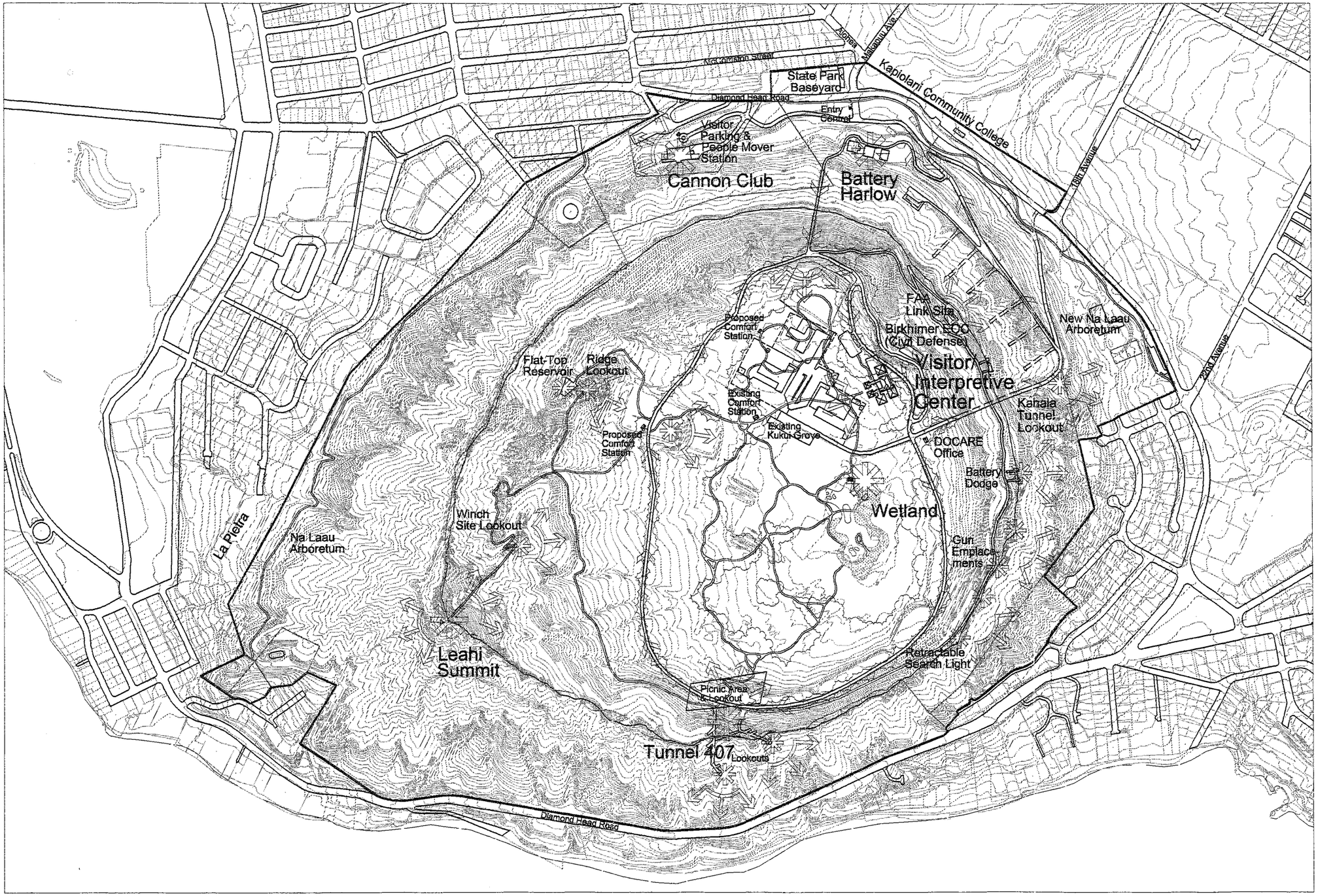
MITSUNAGA & ASSOCIATES, INC.
747 AMANA STREET SUITE 216
HONOLULU, HAWAII 96814
TELEPHONE (808) 945-7882 FAX (808) 946-2563
Architecture • Planning • Engineering

Table of Contents

INTRODUCTION

Diamond Head State Monument Master Plan includes improvements to the interior and exterior of Diamond Head Crater. These improvements include a visitor/interpretive center, people mover system, parking lot on crater exterior, improved hiking trails, and various infrastructure improvements, Figure 1.

This report describes design criteria and improvements to potable water, sanitary sewer, drainage, irrigation, roadway, electrical, and hiking trails to accommodate the proposed Master Plan.



Legend

- Views
- Major Interpretive Feature
- Minor Interpretive Feature
- People Mover Route
- Pedestrian Path/Trail
- Crater Rim
- Wetland

DIAMOND HEAD MASTER PLAN

DIAMOND HEAD STATE MONUMENT VISITOR/INTERPRETIVE CENTER

Mitsunaga & Associates, Inc.

Figure 1

POTABLE WATER SYSTEM

I BACKGROUND

Potable water is provided to Diamond Head State Monument by the water system of the Board of Water Supply (BWS).

The BWS storage reservoirs at Wilheimina (2.0 million gallon tank) and Palolo (two 0.5 million gallon tanks), spillway elevation 405 feet mean sea level, services Kaimuki, Kahala, and Diamond Head areas. The BWS system consists of transmission lines and grids of 8" water lines in the Kaimuki/Kahala area that distributes water from the reservoirs to a 12" main in Diamond Head Road. The elevation of the water main at the current connection to Diamond Head State Monument is approximately 150 feet. The service pressure is approximately 100 pound per square inch (psi).

II EXISTING DEMAND

Domestic water is currently supplied to the Department of Defense Buildings 301, 303, 304, Battery Harlow, Tunnel 407, Cannon Club, FAA, State Parks, Maintenance Base Yard and Civil Defense (Battery Birkhimer). Water is also supplied to the Diamond Head State Park for domestic and irrigation consumption. According to the Water Meter Readings from June 1995 to August 2001, the average demand was approximately 33,000 gallons per day (gpd).

III EXISTING SYSTEM

In the early 1990's, the Department of Land and Natural Resources (DLNR) constructed a potable water system providing service to the crater interior. A 12" transmission line and various distribution lines servicing the crater facilities were installed. The 12" transmission line connects to the 12" BWS water main in Diamond Head Road, near Kapiolani Community College (KCC). This transmission line runs from the BWS 6" meter on Diamond Head Road to the top of Kapahulu Tunnel.

Water lines up to 8" serve the various facilities within the crater. A 2" line services Tunnel 407, 4" lines services Building 301, 303, and 304, and a 6" line services FAA. An 8" line is connected to fire hydrants along Crater Road. A 2" line to the Cannon Club is connected to the 12" transmission line in the road to Kapahulu Tunnel. This connection is near Battery Harlow. See Water General Plan, Appendix C, for the layout of the existing domestic water system.

IV PROJECTED DEMAND

Projected water demands were based on the Board of Water Supply System Standards, Volume 1, estimated visitors, estimated employees, and estimated irrigation demand. The average daily domestic water demand for the visitor/interpretive center, Civil Defense, Tunnel 407, Battery Harlow, Battery Birkhimer, irrigation, and caretaker's residence or DOCARE office is:

Visitors	21,000 gpd
Employees	500 gpd
Battery Birkhimer	2,000 gpd
Irrigation (1 acre around visitor/interpretive center)	6,900 gpd
Total	30,400 gpd

See Appendix B for calculations. Average daily demand is 22 gallons per minute (gpm), maximum daily demand is 33 gpm and the peak flow is 66 gpm. Fire flow requirement is 2,000 gallons per minute. The most critical area for fire flow is at Tunnel 407, because of its elevation and remote location.

V PROPOSED SYSTEM IMPROVEMENTS

Potable water is required at the Visitor Center, comfort stations, Civil Defense, caretaker's residence or DOCARE office, and Tunnel 407. Fire hydrants are proposed near the visitor/interpretive center, caretaker's residence or DOCARE office, and Tunnel 407.

One acre of landscaping around visitor/interpretive center is proposed to be irrigated with potable water and all other landscaping with non-potable water. Non-potable water is discussed in a later section.

The proposed water system improvements includes new 12" transmission line, new 16" transmission line, and new 8", 6", 4", and 2" distribution lines to service new and existing facilities. The new 12" connects to the existing 12" line at the south end of Kapahulu Tunnel and provides service to the visitor/interpretive center. The new 16" transmission line is proposed to connect the new 12" line to Tunnel 407 to provide domestic and fire flow. See Figure 2 for proposed water system.

The proposed water system improvements are estimated to cost $746,000. See Appendix A for an itemized cost estimate.

DIAMOND HEAD STATE MONUMENT
VISITOR/INTERPRETIVE CENTER

KAPIOLANI COMM. COL.

MAKAPUU AVE

DIAMOND HEAD ROAD

18th AVENUE

TRUE NORTH

BATTERY HARLOW

CANNON CLUB

EXISTING 12" WATER LINE

CONNECT TO EXISTING

KAPAHULU TUNNEL

12" LINE

6" LINE

HYDRANT

FAA LINK

CRATER ROAD

COMFORT STATIONS

2" LINE

BIRKHIMER BATTERY

16" LINE START

KAHALA TUNNEL

AVENUE

4" LINE

VISITOR CENTER

22nd

CARETAKER'S RESIDENCE OR DOCARE OFFICE

HYDRANT

16" LINE

PAIKAU

POND

LEAHI POINT

HYDRANT

KAHALA AVE

TUNNEL 407

0 100 200 300 400 500 1000 1/4 MILE

Water System Plan

Mitsunaga & Associates, Inc.

Figure 2

SANITARY SEWER SYSTEM

I BACKGROUND

Wastewater disposal and treatment of sewage from the Diamond Head State Monument will be provided by the City and County of Honolulu municipal system.

The Diamond Head State Monument sewer system connects to the City and County's 8" sewer line at the corner of Paikau Street and 22nd Avenue. Sewer is transmitted through a series of pump stations, force mains, and gravity lines to the Sand Island Wastewater Treatment Plant, for treatment and disposal.

II EXISTING DEMAND

Existing sewer flows are not available. Sewer flows can be estimated by assuming 80% of water consumption is wastewater. Given this assumption, the current wastewater flow is about 26,000 gallons per day (gpd).

III EXISTING SYSTEM

The sanitary sewer system for the crater interior is connected to Department of Defense (DOD), Federal Aviation Administration (FAA), Civil Defense (Batter Birkhimer), and the Diamond Head State Park comfort station. Sewage from Tunnel 407 is disposed in a septic tank/cesspool system located adjacent to the tunnel entrance. A sewer line from Cannon Club connects to a City and County sewer line on Diamond Head Road.

Sewage from the various facilities flows to a sewage lift station located south of building 303. The lift station pumps the sewage through a 4" force main to a manhole in Kahala Tunnel. From this manhole, sewage flows in a gravity sewer line to a City and County manhole at the intersection of Paikau Street and 22nd Avenue. See Sewer General Plan, Appendix C, for layout of the existing sewage system.

IV PROJECTED FLOW

Design sewer flows were base on design criteria established by Department of Wastewater Management, City and County of Honolulu, estimated visitors and estimated employees. Projected average daily flow is 20,000 gpd and peak flow is 324 gallons per minute (gpm). See Appendix B for calculations.

V PROPOSED SYSTEM IMPROVEMENTS

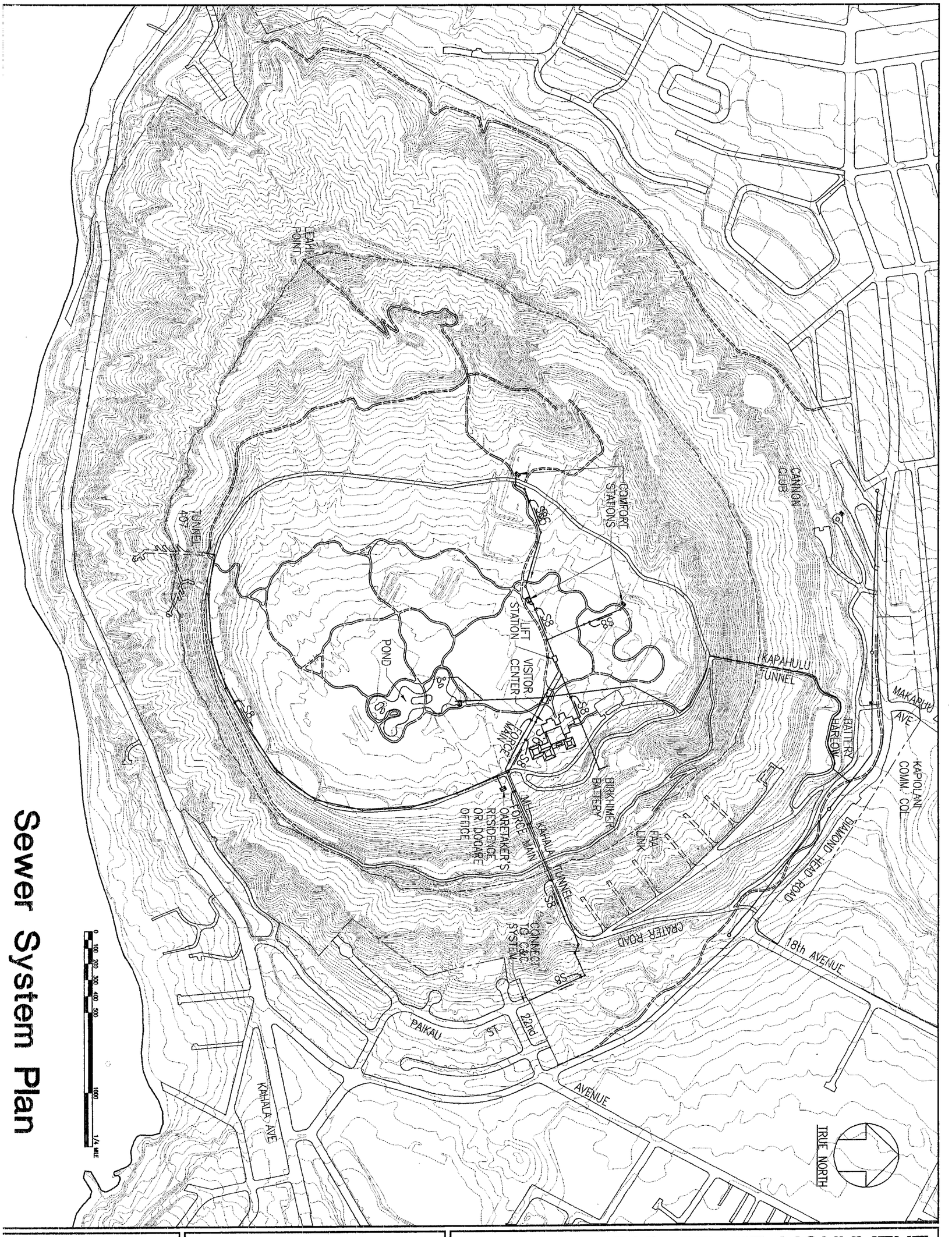
A new sanitary sewer system servicing all facilities within the crater is proposed. This new system provides service to the visitor/interpretive center, Civil Defense, comfort stations, caretaker's residence or DOCARE office, and Tunnel 407, Figure 3.

All facilities within the crater drain through 6" or 8" pipe to a new sewage lift station located west of the visitor center. A new lift station pumps sewage through a 6" force main to a manhole located at the west end of Kahala Tunnel. An 8" gravity line connects to the City and County sewer system at Paikau Street and 22nd Avenue. The sewer line in Paikau Street has adequate capacity to convey the projected design flow. The new lift station will be designed to pump sewage at a rate that can be handled by the existing City and County sewer system.

The proposed sanitary sewer system improvements have an estimated cost of $761,000. See Appendix A for an itemized cost estimate.

The sewer line proposed to connect Tunnel 407 to the lift station may not be the ideal alternative. Aside from construction costs, the proposed 8" sewer line may experience low wastewater flows, which may cause sedimentation in the line and a septic condition. However, based on the projected flow in the 8" sewer line will have adequate velocity to prevent sedimentation.

An alternative to provide sanitary sewer service to Tunnel 407 would be to treat and dispose of sewage with septic tank and leach fields. This alternative would eliminate the 8" drain line to the lift station. Cost comparison between constructing the 8" sewer line and septic tank and leach fields should be made during the design phase. There is not enough information to estimate the sewage flow from Tunnel 407 and the percolation rate of the soil to size the septic tank and leach fields at this time. The septic tank and leach field alternative requires approval by the Department of Health. The Department of Health indicated they would review this proposal when construction documents are submitted for review.



Sewer System Plan

Figure 3

Mitsunaga & Associates, Inc.

DIAMOND HEAD STATE MONUMENT
VISITOR/INTERPRETIVE CENTER

DRAINAGE SYSTEM

I BACKGROUND

The interior of Diamond Head Crater has no natural drainage outlet to the ocean. Storm water flows down the steep crater walls to the low point in the crater. Without proper disposal of storm water, flooding may occur.

II EXISTING RUNOFF

Quantities of storm water runoff were estimated using the Storm Drainage Standards of the Department of Public Works, City and County of Honolulu. Existing topographic maps were used to determine the tributary areas for each drainage area.

Design of culverts is based on a 10-year storm. Design of pump station, force main, and drain line is based on 100-year storm. The total drainage area of the interior of the crater is 250 acres. Peak discharge for a 100-year storm is estimated at 1,500 cubic feet per second (cfs).

III EXISTING SYSTEM

The existing system consists of natural drainage ways, culverts, lift station, and drain lines. Culverts convey runoff under paved surfaces, which prevent flooding of roadways and build-up of debris on the roadways. Storm water runoff collects at the low point in the crater. When water levels rise to a level that threatens roads and buildings, a diesel powered lift station is activated. The lift station pumps water through a 14" diameter force main. The force main is located in the Kahala Tunnel and ends at a manhole at the east end of Kahala Tunnel. From this point, water drains through a 14" diameter gravity line to a City and County of Honolulu drainage manhole at Paikau Street and 22nd Avenue. See Drainage General Plan, Appendix C, for location of existing drainage system.

IV PROJECTED RUNOFF

No change in storm water runoff (1,500 cfs for a 100-year storm) is projected.

V PROPOSED SYSTEM IMPROVEMENTS

It is proposed that all existing culverts be left in place, new culverts added, and to convey storm water out of the crater a new lift station, force main, and gravity drain line be constructed, Figure 4.

DIAMOND HEAD STATE MONUMENT VISITOR/INTERPRETIVE CENTER

MAKAPUU AVE
KAPIOLANI COMM. COL.
BATTERY HARLOW
DIAMOND HEAD ROAD
18th AVENUE
TRUE NORTH
CANNON CLUB
KAPAHULU TUNNEL
CRATER ROAD
FAA LINK
COMFORT STATIONS
BIRKHIMER BATTERY
CONNECT TO C&C MANHOLE
AVENUE
KAHALA TUNNEL
22nd
VISITOR CENTER
FORCE MAIN
CARETAKER'S RESIDENCE OR DOCARE OFFICE
LIFT STATION
POND
PAIKAU
CULVERT, TYP.
LEAHI POINT
TUNNEL 407
KAHALA AVE.
0 100 200 300 400 500 1000 1/4 MILE

Drainage System Plan

Mitsunaga & Associates, Inc.

Figure 4

New people mover roadways are proposed in the interior of the crater. 24" culverts are proposed along this road to carry storm water under the roadway.

The proposed irrigation improvements include a pond at the low point in the crater to store irrigation water. This pond will also serve as a holding basin for storm water. It is assumed that the water surface elevation of the pond is 200 feet above mean sea level. For a 100-year flood, the water surface would rise to about 205 feet above mean sea level and flood approximately 5 acres of the floor of the crater. A lift station with a pumping capacity of 3,000 gallons per minute would take approximately 26 hours to remove the storm water and restore the pond to its normal water surface elevation.

The new lift station (adjacent to the proposed pond), 12" force main, and 18" gravity line to pump water out of the crater is proposed. The lift station would pump storm water through a 12" force main, to a manhole east of Kahala Tunnel. The lift station will be designed to pump storm water at a rate that can be handled by the existing City and County storm drain system. From this manhole, an 18" gravity drain connects to the City and County of Honolulu manhole at Paikau Street and 22nd Avenue.

The proposed drainage system improvements have an estimated cost of $765,000. See Appendix A for an itemized cost estimate.

NON-POTABLE WATER SYSTEM

I BACKGROUND

Department of Land and Natural Resources (DLNR), Engineering Branch, have drilled two exploratory wells on the Kaimuki Middle School grounds to provide non-potable water for irrigation of the State Facilities in the Diamond Head Monument. According to the DLNR, the wells can produce non-potable water at a rate of 350 gallons per minute (gpm) with two wells being pumping continuously for 24 hours, total flow of 288,000 gallons, and 600 gpm with two wells being pumping for 8 to 10 hours per day, total of 324,000 and 360,000 gallons respectively.

II EXISTING DEMAND

Existing irrigation demand is unknown.

III EXISTING SYSTEM

Currently, all irrigation needs are met by the existing potable water system. The existing irrigation system is unknown.

IV IRRIGATION DEMAND

Irrigation demand for irrigation is approximately 210,000 gallons per day (gpd) to irrigate 31 acres of landscaped area. Evaporation from the pond on the crater floor is estimated at 8,000 gpd, based on 0.25 inches of evaporation per day for acres on pond. Total non-potable demand (irrigation plus evaporation) is estimated at 218,000 gpd.

V PROPOSED SYSTEM IMPROVEMENTS

A proposed non-potable water system, which includes non-potable wells, pumps, transmission lines, and a storage pond, are shown in Figure 5. Also shown in Figure 5 are irrigation pump station and irrigation transmission mains.

Two wells on the Kaimuki Middle School will provide non-potable water to irrigate landscaped area in the Diamond Head Monument. The wells will be outfitted with pumps to pump water in a 6-inch diameter pipe into the crater through Kapahulu Tunnel and to a pond on the crater floor. The pond will be lined with a waterproof membrane.

From the storage pond, a pump station will pump irrigation water to the various landscaped areas within the crater and to the landscaped buffer along Diamond Head Road. Irrigation transmission mains sizes will be 6-inch diameter pipe from the pump station to the Visitor

Center, 4-inch diameter pipe from the Visitor Center to approximately 900' west of the Visitor Center and from the Caretaker's Residence to Diamond Head Road, and 2 ½-inch diameter pipe along Diamond Head Road and going west along the trail from the approximately 900' west of the Visitor Center.

The pump station will be a self-contained prepackaged vertical turbine duplex pump station with each pump capable of 200 gallons per minute at 105 pounds per square inch (psi) discharge pressure utilizing 25 horse power electric motors operating at 480volts, 3-phase. This will provide a minimum of 60 psi at the higher elevations and will be pressure regulated to meet the optimum pressure for the sprinkler types when needed.

All piping will be PVC. Piping will be sized to insure maximum velocity within the piping network does not exceed 5 feet per second.

All sprinklers will be current manufacturer pop-up sprinklers to minimize damage due to mowing equipment and to maximize the visual esthetics. All spray head sprinklers will be matched precipitation rate sprinklers and will feature pressure-regulated bodies to insure all sprinklers operate within the recommended pressure range despite the up stream pressure. In lawn areas the sprinklers will be a minimum 4" pop-up height and in ground cover areas, the sprinklers will have a minimum of a 12" pop-up riser. All rotary sprinklers will be a heavy-duty turf rotor suitable for parks and other heavy usage areas.

The sprinklers will be controlled by a pressure regulated electrically actuated contamination proof remote control valve. All valves will be wired to controller near the site being irrigated. Each controller will be a hybrid solid-state controller housed in a stainless steel pedestal mounted enclosure. Each controller will have an individual rain sensor mounted on the exterior of the cabinet to minimize irrigation when natural precipitation warrants

The proposed non-potable water system is estimated at $2,387,000. See Appendix A for an itemized cost estimate. Estimated cost of the proposed irrigation system:

Estimated Pump Station cost:

Pump Station	$ 38,000
Pump Station Enclosure	$ 13,000

Estimated Irrigation Piping cost:

6-inch diameter main 2100 l.f. @ $30/l.f.	$ 63,000
4-inch diameter main, 3600 l.f. @ $25/l.f.	$ 90,000

2 ½-inch diameter main 3900 l.f. @ $20/lf	$ 78,000
Total estimated irrigation cost:	$ 282,000

From the pond, a pump will distribute the irrigation water to landscaped areas in the Diamond Head State Monument. Pumps, irrigation lines, and appurtenances required to distribute irrigation water from the pond to various locations on Diamond Head State Monument is not covered in this report.

Note: Irrigation system narrative, layout and cost provided by Irrigation Hawaii Ltd.

DIAMOND HEAD STATE MONUMENT
VISITOR/INTERPRETIVE CENTER

KAPIOLANI COMM. COL.
MAKAHIU AVE.
BATTERY HARLOW
DIAMOND HEAD ROAD
18th AVENUE
TRUE NORTH
W6
WELL "A" (#1647.04)
WELL "B" (#1647.05)
CANNON CLUB
KAPAHULU TUNNEL
12½
CRATER ROAD
FAA LINK
COMFORT STATIONS
BIRKHIMER BATTERY
KAHALA TUNNEL
VISITOR CENTER
CARETAKER'S RESIDENCE OR DOCARE OFFICE
16
14
22nd
5'
PAIKAU
POND
8'
IRRIGATION PUMP STATION
LEAHI POINT
TUNNEL 407
KAHALA AVE
0 100 200 300 400 500 1000 1/4 MILE

Irrigation System Plan

Mitsunaga & Associates, Inc.

Figure 5

ROADWAY SYSTEM

I BACKGROUND

The proposed roadway improvements are based on conceptual plans provided by PBR Hawaii and recommendations stated in a traffic study prepared by Parsons Brinckerhoff, Inc., October 1998.

The proposed roadways will conform to applicable engineering design guidelines and recommendations by Parsons Brinckerhoff, Inc. The proposed people mover roadways also consider trolley limitations and pedestrian traffic.

II EXISTING ROADWAYS

Access to the crater is via Crater Road. Crater Road starts at Diamond Head Road near 18th Avenue and enters the crater through Kahala Tunnel. After entering the crater, Crater Road leads to the visitor parking, located near the Department of Defense (DOD) buildings.

A series of roads service various facilities in the crater. All roads are paved with asphalt concrete, with exception to the road leading to Tunnel 407, and vary in width and grade. The road to Tunnel 407 is partially paved.

Visitors enter the crater by bus, car, or walking. Vehicles drive from Diamond Head Road to the crater interior and park in the parking lot or on the roadside. Since no sidewalks or dedicated pedestrian paths are present, pedestrians entering the crater must walk on the roadways.

Employees of DOD, Federal Aviation Administration (FAA), and Civil Defense utilize roadways that service their respective facilities. Access to the crater interior for employees is Kahala Tunnel.

IV PROPOSED IMPROVEMENTS

Improvements include a new people mover roadway, emergency access, parking at Cannon Club, and a multi-user pedestrian/bicycle pathway is along Diamond Head Road, Figure 1. Improvements to various sections of Diamond Head Road are recommended in Diamond Head State Monument Master Plan Traffic Impact Analysis, October 1998, prepared by Parsons Brinckerhoff.

The people mover roadway alignment is provided by PBR Hawaii. The people mover road uses new and existing roads. Visitors board the people mover at the Cannon Club and are taken into the crater through Kapahulu Tunnel, circle the crater floor, and exit the crater

through Kahala Tunnel. A typical people mover roadway is proposed to have 12-foot pavement and 4 foot shoulders on each side to accommodate emergency vehicles. Grades have a minimum of 1% and a maximum of 8%. Guardrails are provided where needed.

Temporarily, visitor parking is proposed next to the visitor/interpretive center.

Permanent visitor parking is proposed at the Cannon Club parking lot if the site can be acquired. If the Cannon Club cannot be acquired, an alternate location would be near the intersection of Diamond Head Road and Makapuu Avenue. The Cannon Club parking lot can accommodate approximately 80 cars. Improvements to the Cannon Club involve re-paving of existing parking lot and construction of new parking stalls.

The multi-user pedestrian/bicycle path is proposed to run along Diamond Head Road, from the Cannon Club to 22nd Avenue. The path is proposed to be 12 feet wide and paved with asphalt concrete.

The proposed improvements to the people mover roads, parking lots, and pedestrian/bicycle paths have an estimated cost of $3,552,000. See Appendix A for an itemized cost estimate.

The Parsons Brinckerhoff's report recommends a traffic signal, widening of Diamond Head Road at the intersection of Diamond Head Road and Makapuu Avenue, and left turn lanes into Cannon Club, Makapuu Avenue, and the crater emergency access road. The proposed intersection and roadway improvements have an estimated cost of $670,000. See Appendix A for an itemized cost estimate.

SITE WORK AND HIKING TRAILS

I BACKGROUND

The visitor/interpretive center is proposed to be located near Kahala Tunnel, below Civil Defense. This area slopes gradually and is partially covered with vegetation and asphalt concrete pavement.

An existing hiking trail leads to the Leahi summit, located on the ocean side of the crater rim. New hiking trails are proposed to traverse the crater floor and crater rim.

II PROPOSED IMPROVEMENTS

Site preparation includes clearing and grubbing, excavation and embankment, hauling and disposal of excess material, and removal of existing roadways and parking lots.

Site work cost is estimated using preliminary visitor/interpretive center plans provided by PBR Hawaii. Approximately 2 acres are cleared for the Visitor Center, Figure 1. Extent of demolition work to existing pavement is based on topographic maps and conceptual plans provided by PBR Hawaii.

The proposed site improvements have an estimated cost of $1,998,000. See Appendix A for an itemized cost estimate.

Hiking trails are proposed on the crater floor and around the crater rim, Figure 1. Walkways, which comply with the Americans with Disabilities Act of 1990 (ADA), are proposed in the vicinity of the visitor/interpretive center and around the pond. About 7,800 lineal feet of 6-foot wide walkways are proposed. For cost estimating purposes, concrete walkways were assumed. During the design phase, alternative walkway material will be investigated. Approximately 15,000 lineal feet of non-ADA compliant hiking trails traverse the crater rim and provide access to various scenic points in the crater.

The proposed hiking trail improvements have an estimated cost of $650,000. See Appendix A for an itemized cost estimate

ELECTRICAL SYSTEM (prepared by Ronald N. S. Ho & Associates)

I BACKGROUND

Electrical, telephone and cable utility services are provided in the crater by Hawaiian Electric Company (HECO), Verizon and Oceanic.

II EXISTING SYSTEM

The HECO 12.27KV overhead line along with telephone and cable TV, enters the park from Diamond Head Road at the intersection with Makapuu Avenue and goes up the slope to the Kapahulu Tunnel. After passing through the tunnel underground to enter the crater, the lines become overhead again for distribution within the crater. The electrical service for each building is metered by HECO.

II PROPOSED DEMAND

HECO will determine the demand on the 12.47KV distribution system and will upgrade the system if necessary. Similarly, the demand for telephone and cable TV service will be determined by Verizon and Oceanic.

IV PROPOSED SYSTEM ADDITIONS

Electrical, telephone and cable TV services for the proposed facilities in the crater are provided by the extension of the existing overhead utility distribution system, Figure 6.

For the Visitor Center, the overhead line is extended to the proposed site where the 12.47KV primary line goes underground to a pad mounted transformer for the 120/208V secondary service for the building. Telephone and cable TV share the same poles and also go underground from the building from the last pole.

The overhead line is extended for one of the comfort stations and for the Caretaker's Residence. The line for each terminates with a pole mounted transformer. The other comfort station is close to an existing overhead line so a transformer can be mounted to the nearest existing pole. The electrical load of a comfort station and of the Caretaker's Residence is small enough for a secondary service of 120/208V single phase for each. For the Caretaker's Residence, telephone and cable TV are included in the overhead line.

For the sewage pump station and the drainage pump station in isolated locations, the overhead line is extended to each site for electrical and telephone service. Telephone lines are for the SCADA system for the pumps.

Utility service for the People Mover Station outside the crater at the site of the former Cannon Club consists of electrical and telephone from Wanke Street where HECO and Verizon have lines serving the residences. The utility service is underground from the street to the facility site.

Extension of the 12.47KV primary overhead line and the transformers are provided by HECO. Where the primary service is underground, the State must provide the ducts and the concrete pad for the HECO cables and transformers.

HECO assesses no cost for overhead service but does for underground service. Therefore, the utility service costs are only for the proposed Visitor Center and the People Mover Station where the service is underground.

Estimated site electrical distribution cost:

Visitor Center	$ 30,000
People Mover Station	$ 30,000

Estimated building electrical cost:

Visitor Center	$ 200,000
People Mover Station	$ 10,000
Comfort Stations (2)	$ 100,000 ($50,000 each)
Sewage Pump Station	$ 20,000
Drainage Pump Station	$ 30,000
Caretaker's Residence	$ 12,000
Total estimated electrical cost	$ 432,000

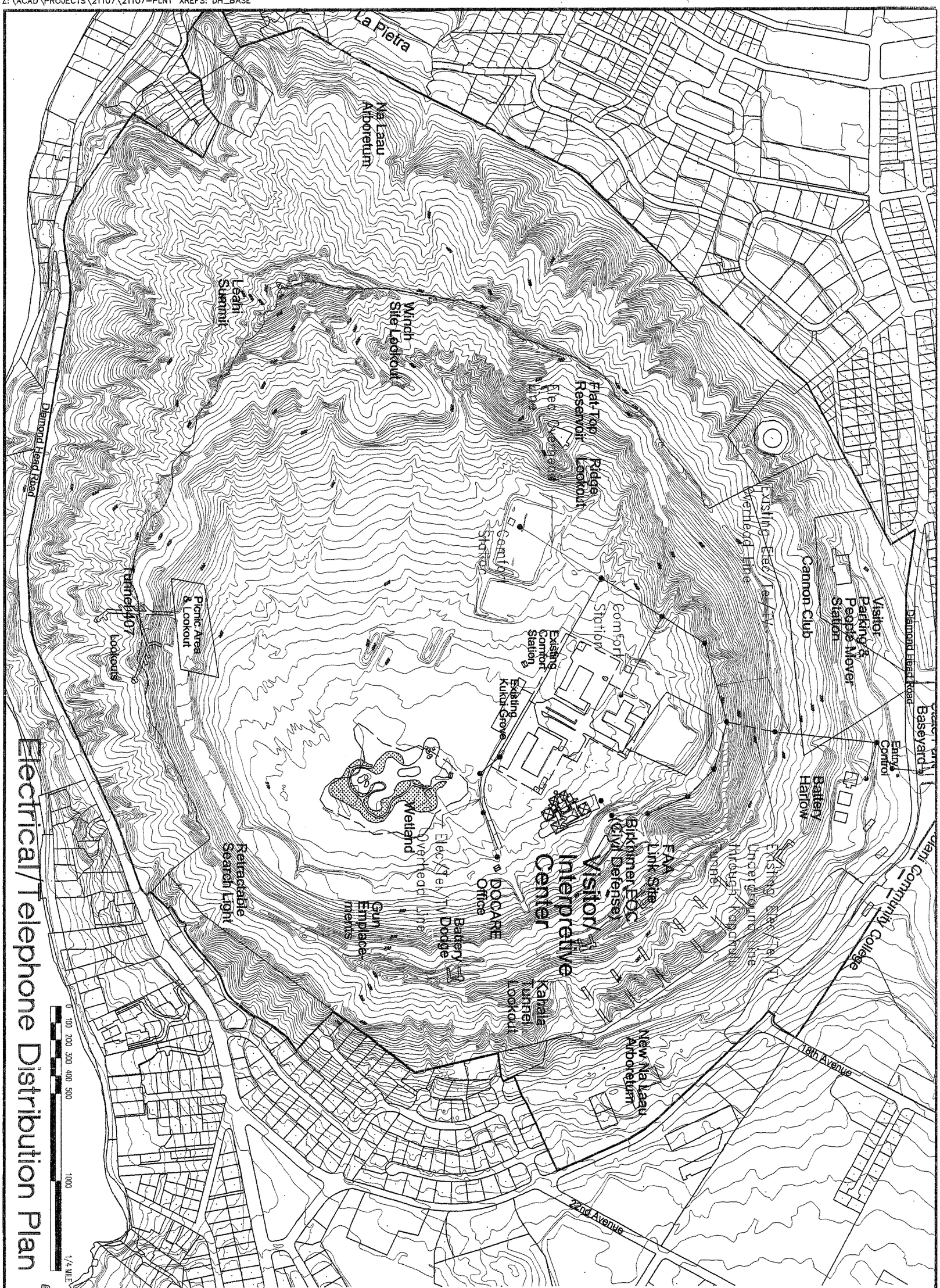


Figure 6

DIAMOND HEAD STATE MONUMENT
VISITOR/INTERPRETIVE CENTER

Appendix A

Cost Estimates

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

PROJECT Diamond Head State Monument
Cost Summary

PREPARED BY: MITSUNAGA AND ASSOCIATES, INC
DATE: SEPTEMBER 2001

PROJECT NO.:

SUBMITTAL: SCHEMATIC

ITEM NO.	ITEM	AMOUNT
1	Crater Exterior Improvements	$1,011,000
2	Crater Interior Improvements	$6,561,000
3	Trolley Road In Crater	$2,192,000
4	Intersection Improvements	$712,000
	TOTAL ESTIMATED COST	**$10,476,000**

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

PROJECT Diamond Head State Monument
Intersection Improvements at Diamond Head Road and Makapuu Ave.

PREPARED BY: MITSUNAGA AND ASSOCIATES, INC
DATE: SEPTEMBER 2001

PROJECT NO.:

SUBMITTAL: SCHEMATIC

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
	SITE IMPROVEMENTS				
1	Clearing and Grubbing	0.50	ACRE	$2,500.00	$1,250
2	Excavation	1100.00	CU YD	$25.00	$27,500
3	CRM Retaining Wall	500.00	CU YD	$400.00	$200,000
4	6" Aggregate Base Course	200	CU YD	$42.00	$8,400
5	2" Asphalt Concrete Pavement Mix No. IV	1,200	SQ YD	$13.00	$15,600
6	Curb and Gutter	900	LF	$30.00	$27,000
7	Striping	1,800	LF	$1.00	$1,800
8	Concrete Pad For Bus Lane	1,200	SQ FT	$10.00	$12,000
9	Traffic Signals For Four Way Intersection	1	LS	$250,000.00	$250,000
10	Fire Hydrants	3	Each	$2,000.00	$6,000
11	Temporary Project Water Pollution Control	1	LS	$10,000.00	$10,000
	SUBTOTAL				$559,550
	Mobilization (not to exceed 6 percent of the sum of all items excluding this item)	1	LS	$33,573.00	$33,573
	Subtotal				$593,123
	Contingency (20%)				$118,625
	TOTAL ESTIMATED COST				**$712,000**

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

PROJECT Diamond Head State Monument
Trolley Roadway/Parking/Bikeway/Emergency Access Outside of Crater

PREPARED BY: MITSUNAGA AND ASSOCIATES, INC
DATE: SEPTEMBER 2001

PROJECT NO.:

SUBMITTAL: SCHEMATIC

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
	SITE IMPROVEMENTS				
1	Clearing and Grubbing	3.00	ACRE	$2,500.00	$7,500
2	Rock Excavation (Trolley Turn Around)	450	CU YD	$100.00	$45,000
3	Embankment	2,800	CU YD	$35.00	$98,000
4	6" Aggregate Base Course	2,200	CU YD	$42.00	$92,400
5	2" Asphalt Concrete Pavement Mix No. IV	42,000	SQ YD	$13.00	$546,000
6	Curb and Gutter	200	LF	$30.00	$6,000
	SUBTOTAL				$794,900
7	Mobilization (not to exceed 6 percent of the sum of all items excluding this item)	1	LS	$47,694.00	$47,694
	Subtotal				$842,594
	Contingency (20%)				$168,519
	TOTAL ESTIMATED COST				**$1,011,000**

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

PROJECT: Diamond Head State Monument
Trolley Roadway With In Crater

PREPARED BY: MITSUNAGA AND ASSOCIATES, INC
DATE: SEPTEMBER 2001

PROJECT NO.:

SUBMITTAL: SCHEMATIC

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
	TROLLEY ROADWAY W/IN CRATER				
	SITE IMPROVEMENTS				
1	Clearing and Grubbing	20	ACRE	$2,500.00	$50,000
2	Excavation	1,750	CU YD	$40.00	$70,000
3	Embankment	19,600	CU YD	$35.00	$686,000
4	6" Aggregate Base Course	1,950	CU YD	$42.00	$81,900
5	2" Asphalt Concrete Pavement Mix No. IV	11,500	SQ YD	$13.00	$149,500
6	Grassing	215,000	SQ FT	$2.00	$430,000
7	Guardrail	8,000	LIN FT	$32.00	$256,000
	SUBTOTAL				$1,723,400
8	Mobilization (not to exceed 6 percent of the sum of all items excluding this item)	1	LS	$103,404.00	$103,404
	Subtotal				$1,826,804
	Contingency (20%)				$365,361
	TOTAL ESTIMATED COST				**$2,192,000**

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

PROJECT Diamond Head State Monument
Crater Interior Improvements

PREPARED BY: MITSUNAGA AND ASSOCIATES, INC
DATE: September 2001

PROJECT NO.:

SUBMITTAL: SCHEMATIC

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
	SITE IMPROVEMENTS FOR VISITOR CENTER				
1	Clearing and Grubbing	1.90	ACRE	$2,500	$4,750
2	Excavation	16,120	CU YD	$40	$644,800
3	Haul and Disposal	16,120	CU YD	$10	$161,200
4	Demolish and Remove Existing A/C Pavement	37,500	SQ YD	$20	$750,000
5	Erosion Control	1	LS	$10,000	$10,000
	Subtotal				$1,570,750
	Mobilization 6%				$94,245
	Subtotal				$1,664,995
	Contingency 20%				$332,999
	TOTAL				$1,998,000
	WATER SYSTEM				
6	Furnishing and Installing 16-inch Pipe, Valves and all Appurtenances,	3,400	LIN FT	$100	$340,000
7	Furnishing and Installing 12-inch Pipe, Valves and all Appurtenances,	1,200	LIN FT	$75	$90,000
8	Furnishing and Installing 8-inch Pipe, Valves and all Appurtenances,	1,100	LIN FT	$50	$55,000
9	Furnishing and Installing 6-inch Pipe, Valves and all Appurtenances,	250	LIN FT	$40	$10,000
10	Furnishing and Installing 4-inch Pipe, Valves and all Appurtenances,	700	LIN FT	$35	$24,500
11	Furnishing and Installing 2-inch Pipe, Valves and all Appurtenances,	2,200	LIN FT	$25	$55,000
12	Install 6" Water Meter, in place complete	1	EACH	$7,000	$7,000
	Chlorination and Testing	1	LS	$5,000	$5,000
	Subtotal				$586,500
	Mobilization 6%				$35,190
	Subtotal				$621,690
	Contingency 20%				$124,338
	TOTAL				$746,000
	SEWER SYSTEM				
13	Furnishing and Installing 6-inch sewer pipe, in place complete	5,580	LIN FT	$35	$195,300
14	Furnishing and Installing 8-inch sewer pipe, in place complete	2,250	LIN FT	$40	$90,000
15	Furnishing and Installing 6-inch sewer force main, in place complete	1,200	LIN FT	$40	$48,000
16	Sewer Manhole	33	EACH	$5,000	$165,000
17	Package Sewer Lift Station	1	EACH	$100,000	$100,000

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

PROJECT Diamond Head State Monument
Crater Interior Improvements

PREPARED BY: MITSUNAGA AND ASSOCIATES, INC
DATE: September 2001

PROJECT NO.:

SUBMITTAL: SCHEMATIC

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
	Subtotal				$598,300
	Mobilization 6%				$35,898
	Subtotal				$634,198
	Contingency 20%				$126,840
	TOTAL				$761,000

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

PROJECT Diamond Head State Monument
Crater Interior Improvements

PREPARED BY: MITSUNAGA AND ASSOCIATES, INC
DATE: September 2001

PROJECT NO.:

SUBMITTAL: SCHEMATIC

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
	DRAINAGE SYSTEM				
18	Furnishing and Installing 24-inch culvert drain pipe, in place complete	510	LIN FT	$150	$76,500
19	Furnishing and Installing 12-inch drain force main, in place complete	800	LIN FT	$75	$60,000
20	Furnishing and Installing 18-inch drain pipe, in place complete	1,350	LIN FT	$100	$135,000
21	Culvert Headwall	22	EACH	$5,000	$110,000
22	Manhole	4	EACH	$5,000	$20,000
23	Lift station	1	EACH	$200,000	$200,000
	Subtotal				$601,500
	Mobilization 6%				$36,090
	Subtotal				$637,590
	Contingency 20%				$127,518
	TOTAL				$765,000
	TRAIL IMPROVEMENTS				
24	4" Thick Conc. Walkway (ADA Comp.) w/ agg. base course - 6'-0" wide	7,800	LIN FT	$55	$429,000
25	Hiking Trails (non-ADA Comp.) - 5'-0" wide	14,900	LIN FT	$20	$298,000
26	Trail Hand Railings	7,100	LIN FT	$30	$213,000
	Subtotal				$511,000
	Mobilization 6%				$30,660
	Subtotal				$541,660
	Contingency 20%				$108,332
	TOTAL				$650,000
	WETLAND IMPROVEMENTS				
27	Wetland Pond Clearing and Grubbing	5	ACRE	$2,500	$11,500
28	Wetland Pond Excavation	21,000	CU YD	$40	$840,000
29	Pond Liner	80,000	SQ FT	$3	$240,000
30	Embankment Over Rubber Liner - 12" thick	3,000	CU YD	$10	$30,000
31	Furnish and Install 12" irrigation pipe from pond to pump	50	LIN FT	$75	$3,750
32	Irrigation Well and pump	2	EACH	$250,000	$500,000
33	Furnish and Install 6" irrigation pipe from wells to wetland	5,000	LIN FT	$40	$200,000
34	1 1/2" Asphalt Concrete Overlay on exist. roads in crater	5,100	SQ YD	$10	$51,000
	Subtotal				$1,876,250

Appendix B

Calculations

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

PROJECT Diamond Head State Monument
Crater Interior Improvements

PREPARED BY: MITSUNAGA AND ASSOCIATES, INC
DATE: September 2001

PROJECT NO.:

SUBMITTAL: SCHEMATIC

ITEM NO.	ITEM	APPROX. QUANTITY	UNIT	UNIT PRICE	AMOUNT
	Mobilization 6%				$112,575
	Subtotal				$1,988,825
	Contingency 20%				$397,765
	TOTAL				$2,387,000
	TOTAL				**$6,561,000**

Irrigation (Potable Water

Area around visitor center to be irrigated with potable water = 1 acre

Irrigation rate = 0.25 inches/day

Irrigation flow = 1 acre x 43,560 sf/acre x 0.25 inches/day x 1/12 =

= 907.5 cf/day = 6,788 call 6800 gpd.

Irrigation (Non-Potable Water)

Area to be irrigated = 31 acres

Irrigation rate = 0.25 inches/day

Irrigation flow = 31 acres x 43,560 sf/acre x 0.25 inches/day x 1/12 =

= 28,133 cf/day = 210,431 gpd

Pond evaporation:

Size of pond = 1.2 acres

Evaporation rate = 0.25 inches/day

Evaporation = 1.2 acre x 43,560 sf/acre x 0.25 inches/day x 1/12 =

= 1,089 cf/day = 8,146 gpd

Total non-potable water demand = irrigation + evaporation =

= 210,431 + 8,146 =

= 218,576 call 219,000 gpd

Non-potable Wells - Kaimuki Middle School

Two well drilled at Kaimuki Middle School.

Per Eric Yuasa, DLNR, wells can produce

Two wells pumping continuously = 350 gpm

= 350 gpm x 24 hrs x 60 min/hr = 504,000 gpd

Two wells pumping 8 - 10 hours = 600 gpm

= 600 gpm x 8 hrs x 60 min/hr = 288,000 gpd

= 600 gpm x 9 hrs x 60 min/hr = 324,000 gpd

= 600 gpm x 10 hrs = 360,000 gpd

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

Wells

2. each

Pumping volume = 219,000 gpd

pumping rate = 600 gpm for 6 hours

pipe size = 6" ϕ

length of pipe wells to pond = 4900 ft

8.9"

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

946-2563

From: "Allan Schildknecht" <irrighi@hawaii.rr.com>
To: "Russell Chung" <rchung@pbrhawaii.com>
Date: 9/24/01 9:43AM
Subject: RE: Evaporation Rates

Russell,

There is no specific data available for the Crater, but I would guess it would range from .21" to .25" per day.

The two nearest Stations indicate 78.5" per year (0.2137"/day) and 84.0" per year (0.2301"/day), but both are Mauka of it's Diamond Head. I would expect wind factor would be less, but the solar radiation may be higher.

Hope that helps!

Allan

-----Original Message-----
From: Russell Chung [mailto:rchung@pbrhawaii.com]
Sent: Monday, September 24, 2001 9:18 AM
To: irrighi@hawaii.rr.com
Subject: Evaporation Rates

Allan,

Can you tell me if you know what kind of evaporation loss/factor we would have for a holding pond in Diamond Head Creater?

Thanks

PBR HAWAII
1001 Bishop Street
Pacific Tower Suite 650
Honolulu, Hawaii 96813-3429
TEL: (808) 521-5631
FAX: (808) 523-1402
WEB: www.pbrhawaii.com
Office Email: sysadmin@pbrhawaii.com

Post-it® Fax Note 7671	Date	# of pages ▶ 1
To ED IIDA	From VINCENT	
Co./Dept. MITSUNAGA	Co. PBR	
Phone #	Phone #	
Fax # 946-2563	Fax #	

TNWRE
Tom Nance Water
Resource Engineering

# of pages: 4

Original ☑ will ☐ will not be mailed to you.

July 19, 2001
01/404 (01-44)
SD.039.163

MEMORANDUM

FAXED
JUL 19 2001

TO: Larry Kitamura and Dickie Lee - DLNR

FROM: Tom Nance

SUBJECT: Status of the Kaimuki Exploratory Well as Drilled to 400 Feet Below Sea Level (Job No. 17-OW-L1) (Well 'A') (#1647-04)

The well was sounded and a salinity profile made on the morning of July 19th. The well was found to be about 37 feet short of the intended depth of 400 feet below sea level, apparently due to a cave-in of the softer stratum at the bottom of the hole after drilling had been completed. Other aspects to note are:

- There has been no change in water level. It still stands about one foot above sea level with significant tidal variation.
- There has been no return of cuttings, the same condition that has prevailed from above the water table all the way down to the present depth.
- Based on a small sample of drill cuttings retrieved from the bottom of the drill bit, there was a formation change somewhere in the last 100 feet. The change was from dark brown alluvium to a soft coralline material (identified visually and by acid treatment as calcium carbonate). This soft calcareous layer is likely to be responsible for the cave-in.
- As the attached salinity and temperature profiles indicate, there has been essentially no change. From about 65 feet into water to the bottom of the hole, the salinity is essentially that of seawater.

From a practical perspective, drilling deeper to get into the Koolau basalt does not appear to be warranted. Upgradient wells 1747-01, 02, and 04, all of which tap the Koolau basalt, have heads of about 10 feet. This puts the midpoint of their transition zones about 400 feet below sea level. At the more makai location of the Kaimuku Exploratory Well, the lens is likely to be somewhat thinner. In other words, when the Koolau basalt is finally reached at this site, its water is virtually certain to be too salty for use.

Grout-filling the borehole back to a depth which leaves 10 to 12 feet of water in the hole and then running a pump test, as we discussed at the July 17th meeting in your office, seems to be the next appropriate step.

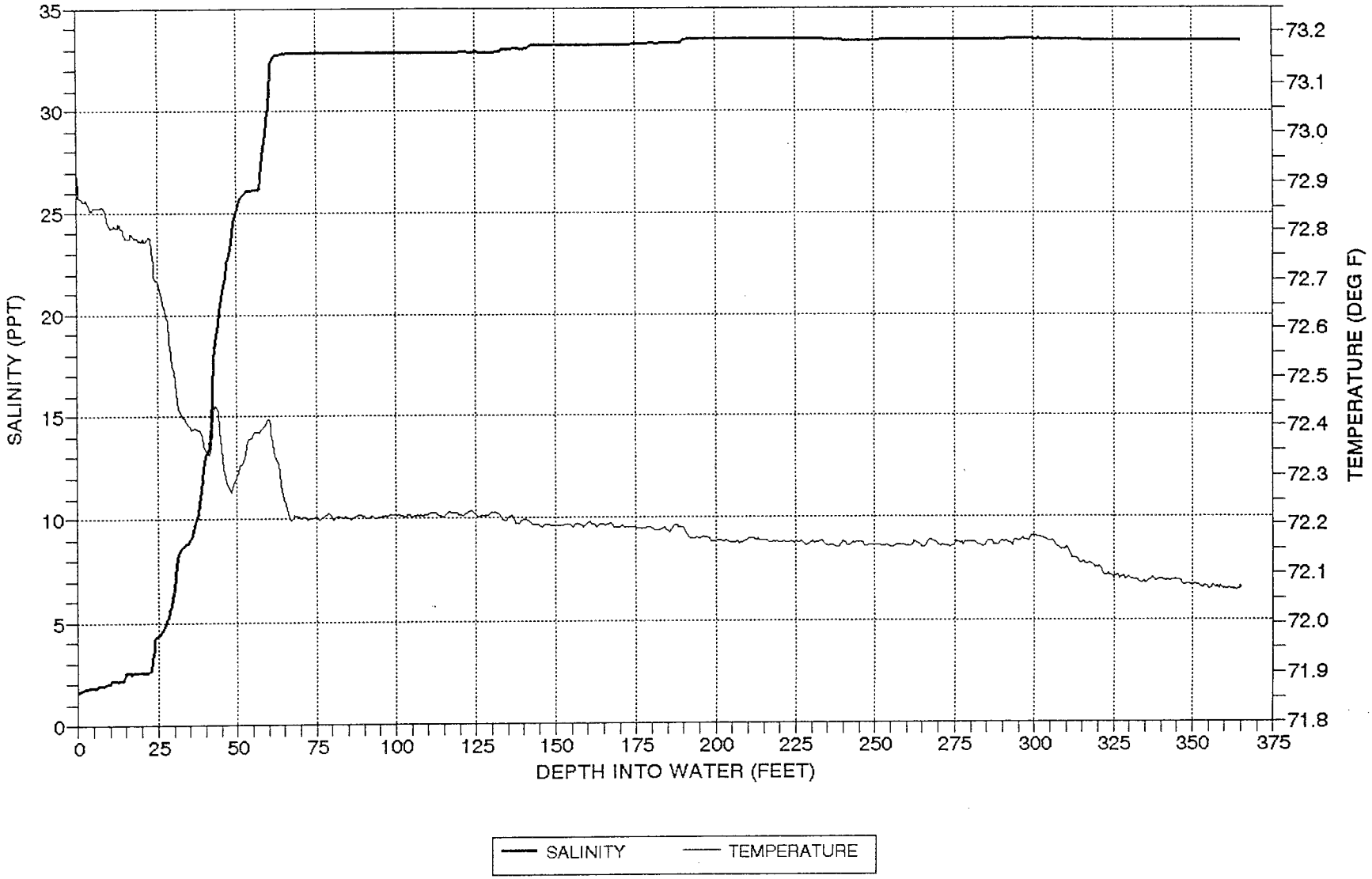
cc: Andrew Keane - Marc M. Siah & Associates [Fax only]

Attachments

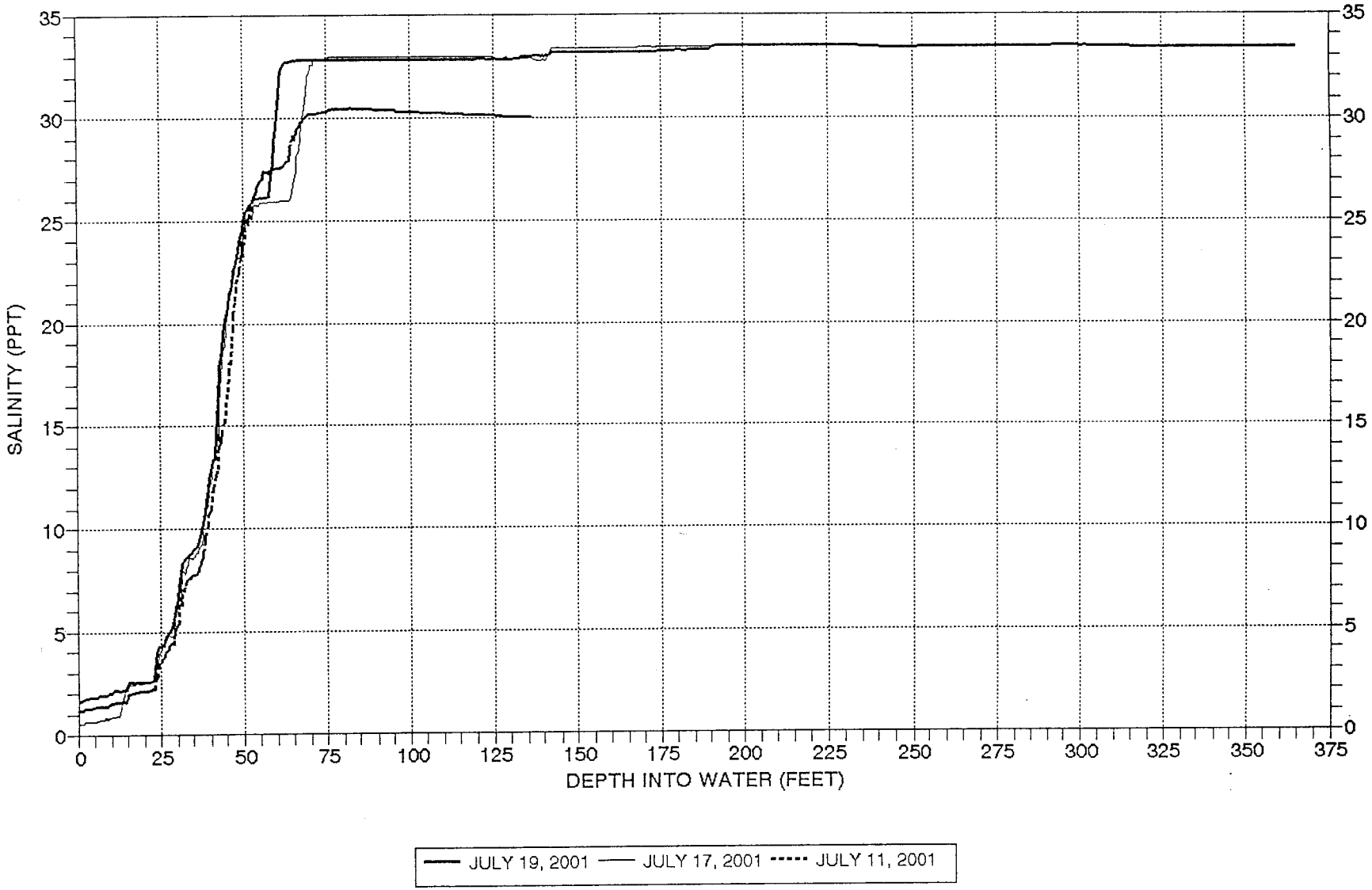
JUL 20 2001 10:02 COMMISSION ON WATER LAND

680 Ala Moana Boulevard, Suite 406 • Honolulu, Hawaii 96813-5411 • Phone: (808) 537-1141 • Fax: (808) 538-7757 • E-mail: tnwre@flex.com

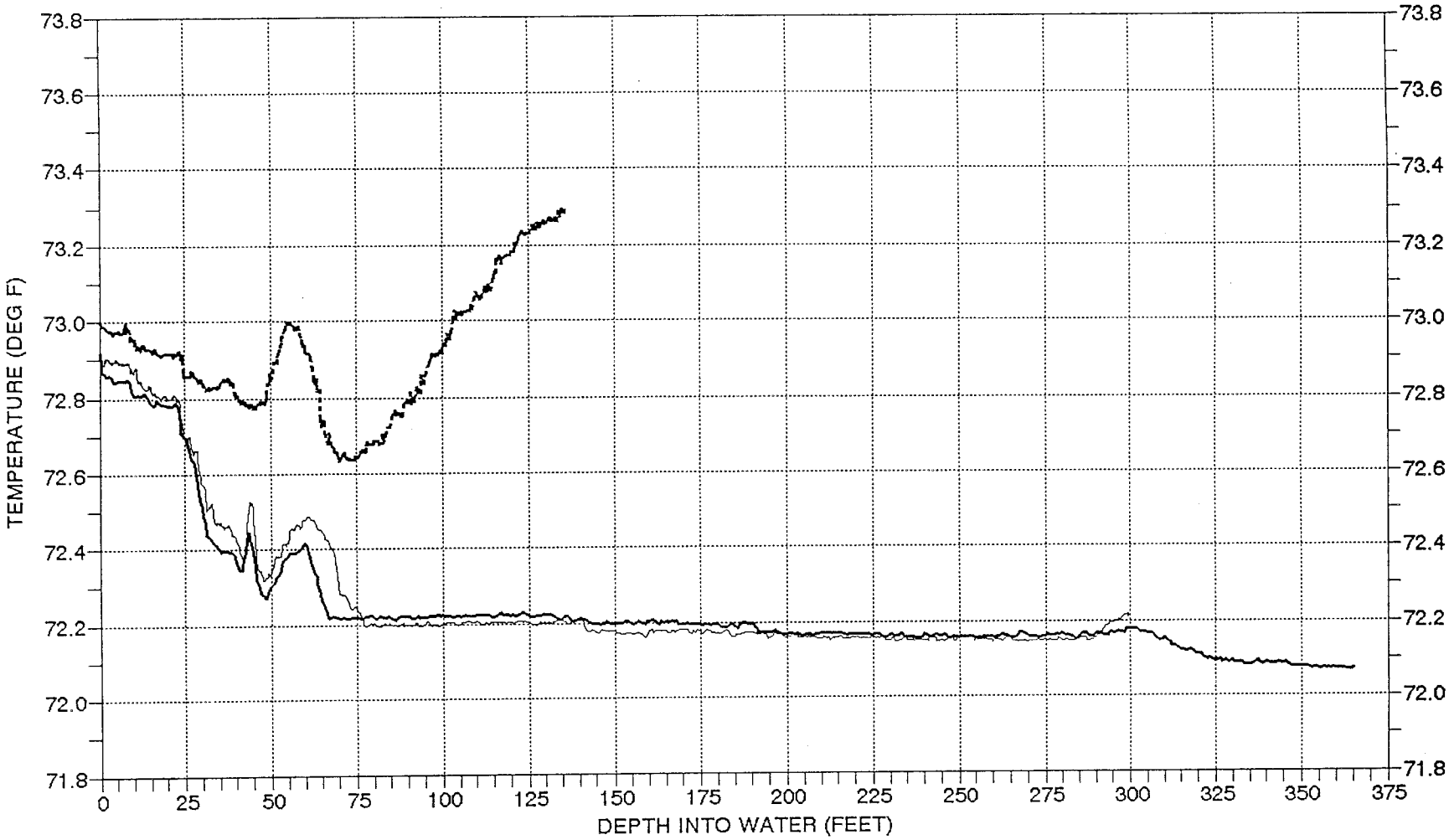
DLNR'S KAIMUKI EXPLORATORY WELL (Well 'A') (#1647-04)
JULY 19, 2001



DLNR'S KAIMUKI EXPLORATORY WELL (well A') (#1647-04)
SALINITY ON JULY 11, 17, AND 19, 2001



DLNR'S KAIMUKI EXPLORATORY WELL (Well 'A') (#1647-04)
TEMPERATURE - JULY 11, 17, AND 19, 2001



TNWRE
Tom Nance Water
Resource Engineering

# of pages: 4

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July 31, 2001
01/424 (01-44)
SD.039.163

MEMORANDUM

RUSH

TO: Larry Kitamura and Dickie Lee

FROM: Tom Nance

SUBJECT: July 30th Open Hole Pump Test of the Kaimuki Exploratory Well, DLNR Job No. 17-OW-L1 (Well 'A') (# 1647-04)

Recorded water level and step-drawdown performance during the open hole pump test of July 30th are illustrated on Figures 1, 2, and 3. The most significant results are:

- The water quality was stable at a salinity level which can be used to irrigate salt-tolerant grasses and plants. The initial sample had chlorides of 710 MG/L and conductivity of 2600 µS/cm. The end of test sample chlorides were 670 MG/L and the conductivity was 2460 µS/cm. The salinity steadily decreased throughout the test.

- The hydraulics of the well are excellent. Drawdown at 350 GPM, for example, would be less than 0.5 feet.

- There was a time-dependent component of drawdown and recovery, albeit of less than 0.1 feet in magnitude (refer to Figure 2).

It would be worthwhile to complete the well for irrigation supply to salt-tolerant landscaping. I would install louvered casing from the bottom of the borehole to two feet above water (ie. 14 feet of louvered casing), a cement basket five feet above the top of the louvered casing, and grout the annulus from there to the ground surface.

cc: Andrew Keane - Marc M. Siah & Associates

Attachments

680 Ala Moana Boulevard, Suite 406 • Honolulu, Hawaii 96813-5411 • Phone: (808) 537-1141 • Fax: (808) 538-7757 • E-mail: tnwre@flex.com

FIGURE 1. RECORDED WATER LEVEL, JULY 27 TO 30, 2001 (Well 'A') (#1647-04)

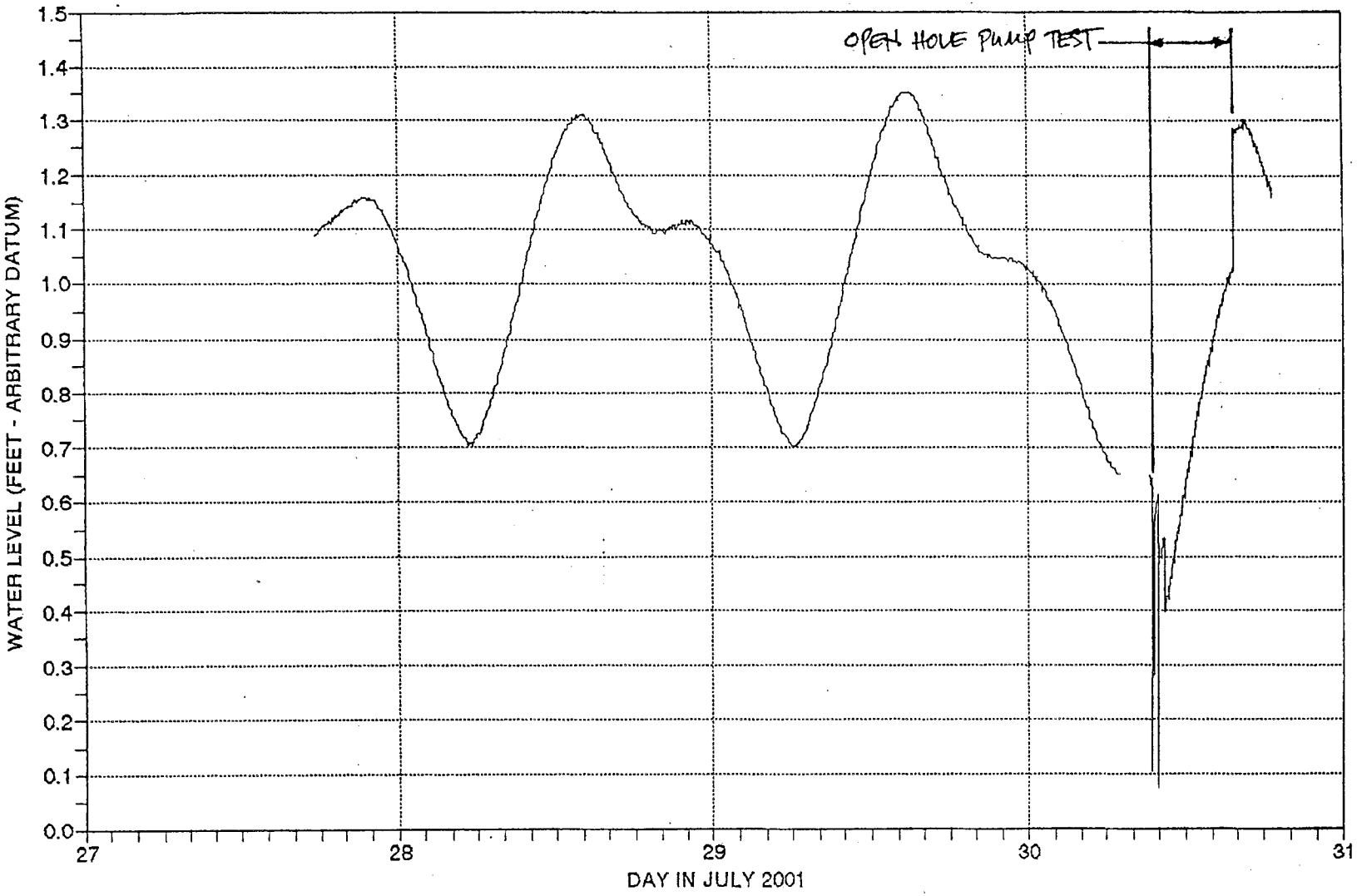


FIGURE 2. RECORDED WATER LEVEL DURING THE OPEN HOLE PUMP TEST (Well "A") (#1647-04)

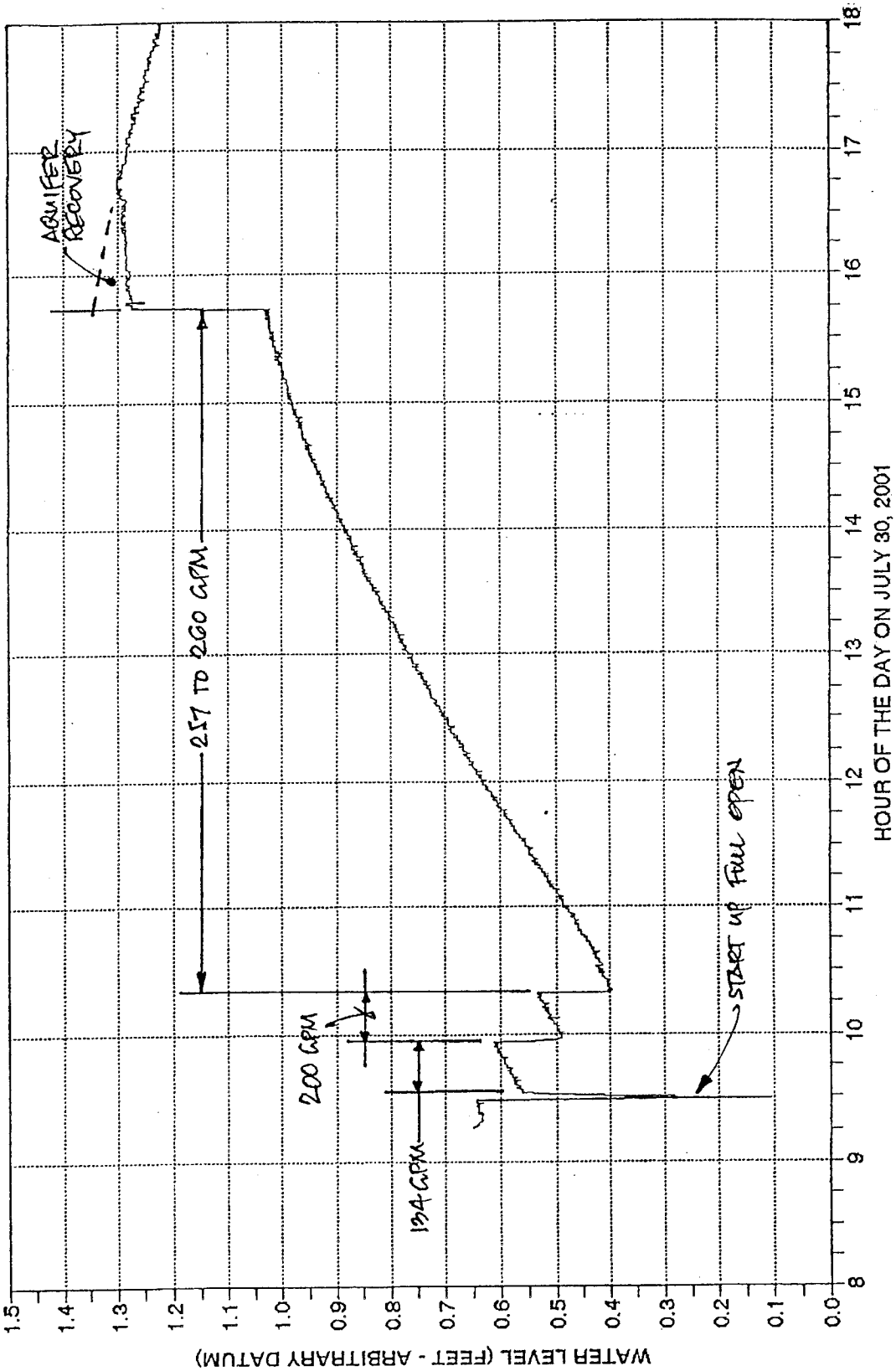
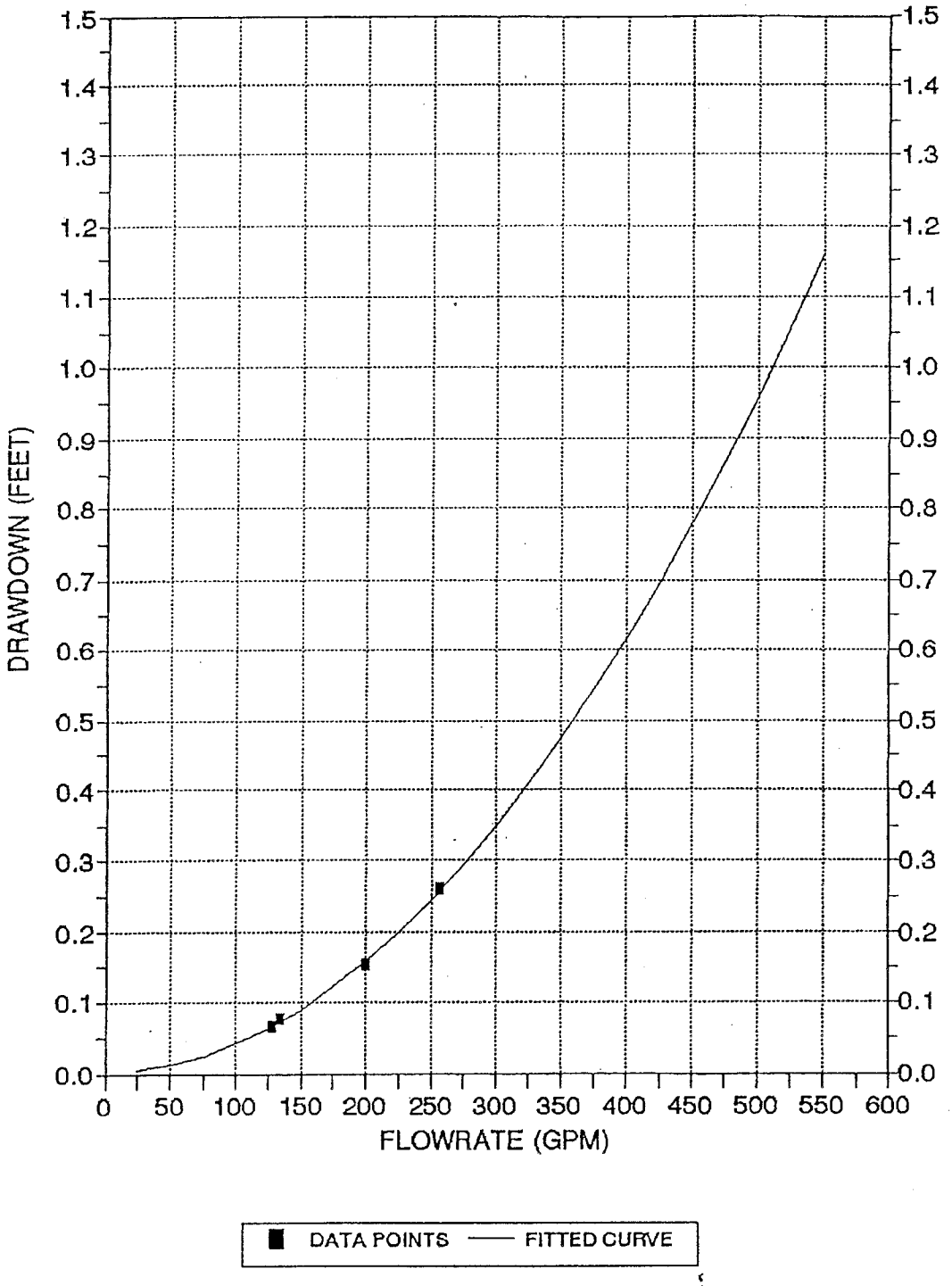


FIGURE 3. STEP-DRAWDOWN PERFORMANCE (Well 'A') (#1647-04)
JULY 30, 2001



# of pages: 8

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TNWRE
Tom Nance Water
Resource Engineering

September 10, 2001
01/505 (01-44)
SD.039.163.100b

MEMORANDUM

TO: Larry Kitamura and Dickie Lee - DLNR

FROM: Tom Nance

SUBJECT: Results of Pump Testing of Kaimuki Well B ('Well 'B') (#1647-05)

This memo and its attachments summarize results of the step-drawdown and constant rate pump tests of Kaimuki Well B. Testing was conducted from September 7 through 9, 2001.

Step-Drawdown Test

Four different rates from 452 to 693 GPM were run for 30 minutes each. Drawdown at each rate was essentially instantaneous and then constant for the remaining 30 minutes at each rate. The recorded water level through the step test is shown on Figure 1. Measured and tidally-corrected drawdown are shown in the tally below. The performance curve of these data points is shown on Figure 2. The hydraulic performance of well is excellent. Drawdown at 693 GPM is less than 1.7 feet.

Step-Drawdown Performance Points

Flowrate (GPM)	Drawdown (Feet)	
	As Measured	With Tidal Correction
452	0.73	0.73
543	1.02	0.99
616	1.32	1.28
693	1.67	1.59

Constant Rate Test

After allowing a little over two hours for complete recovery from the step test (actually, full recovery occurred in less than two minutes), the constant rate test was run for 53 hours at an average of 690 GPM (0.99 MGD). The water levels in Well B and in Well A as the observation well are shown on Figure 3. Drawdown and recovery were essentially instantaneous and the water level varied with the ocean tide before, during, and following the pump test. No water level response in Well A as a result of pumping Well B was evident.

Samples were collected hourly throughout the test. The conductivity varied from a low of 2230 µS/cm 13 hours into the test to a high of 2360 µS/cm after 46 hours (refer to Table 1). These conductivities are equivalent to chlorides of 580 and 615 MG/L, respectively. A rather unusual aspect of the pumped water salinity is its almost perfect correlation with the tidal variation in the well (Figure 4).

Conclusions and Recommendations

In order to determine if there was an upward drift of salinity superimposed over the tidal variation depicted on Figure 4, a semi-log plot of these results on was created (Figure 5). Based on this and other tests for trends of salinity, it does not appear that an upward drift occurred. This result is actually quite remarkable, given the very low basal head (about 1.5 feet MSL on average), substantial tidal variation (up to 0.5 feet), and the apparently small contributing watershed.

All of these factors, plus the potential interference if both Wells A and B are pumped concurrently), suggest that some moderation in the selection of the capacity for the permanent pump is appropriate. If the expected use will be essentially continuous, 350 GPM is the recommended capacity. If the use will be intermittent (up to 16-hour pumping days), 550 GPM is the recommended capacity. I do not recommend installing a larger capacity pump based on the relatively short constant rate pump test results.

cc: Andrew Keane - Marc M. Siah & Associates

Attachments

Table 1

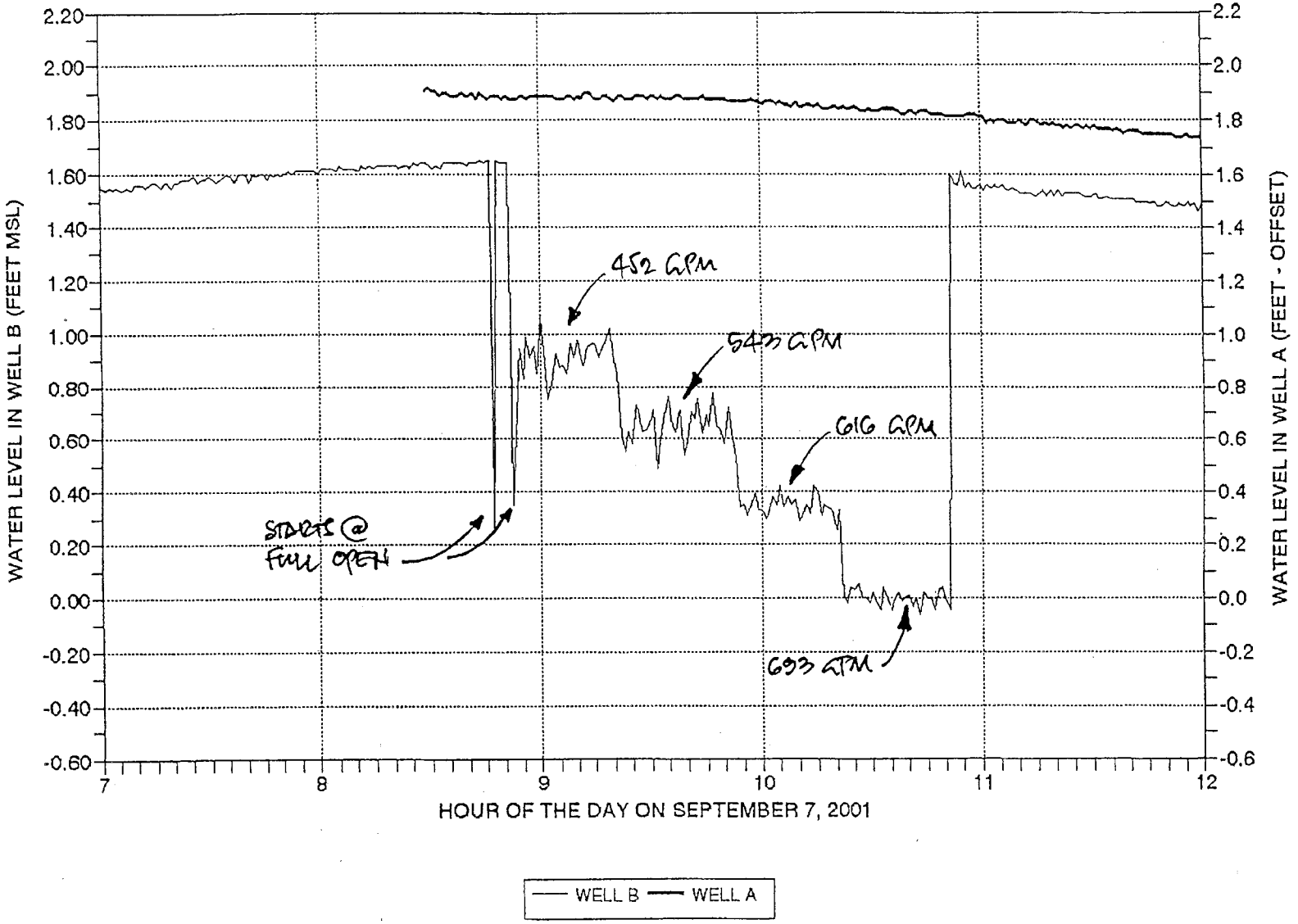
Conductivity of Hourly Samples Taken Through the Constant Rate Pump Test (Well '13') (#1647-05)

Day	Time	Conductivity (µS/cm)
Sept. 7	13:10	2240
	14:10	2240
	15:10	2240
	16:10	2250
	17:10	2260
	18:10	2270
	19:10	2280
	20:10	2290
	21:10	2280
	22:10	2270
	23:10	2250
Sept. 8	00:10	2250
	01:10	2240
	02:10	2230
	03:10	2240
	04:10	2260
	05:10	2270
	06:10	2290

Day	Time	Conductivity (µS/cm)
	07:10	2300
	08:10	2310
	09:10	2320
	10:10	2330
	11:10	2330
	12:10	2310
	13:10	2300
	14:10	2290
	15:10	2290
	16:10	2280
	17:10	2280
	18:10	2290
	19:10	2300
	20:10	2300
	21:10	2300
	22:10	2290
	23:10	2270
Sept. 9	00:10	2270

Day	Time	Conductivity (µS/cm)
	01:10	2260
	02:10	2250
	03:10	2250
	04:10	2260
	05:10	2280
	06:10	2285
	07:10	2290
	08:10	2310
	09:10	2320
	10:10	2350
	11:10	2360
	12:10	2350
	13:10	2340
	14:10	2330
	15:10	2320
	16:10	2310
	17:10	2300
	18:00	2290

FIGURE 1. WATER LEVELS IN WELLS B AND A DURING THE STEP-DRAWDOWN PUMP TEST (Well 'B') (#1647-05)



9-10-01;11:37AM; ULNR-Land Division;538 7 57 # 4/ 8

FIGURE 2. STEP-DRAWDOWN PERFORMANCE OF KAIMUKI WELL B, SEPTEMBER 7, 2001 (Well 'B') (#1647-05)

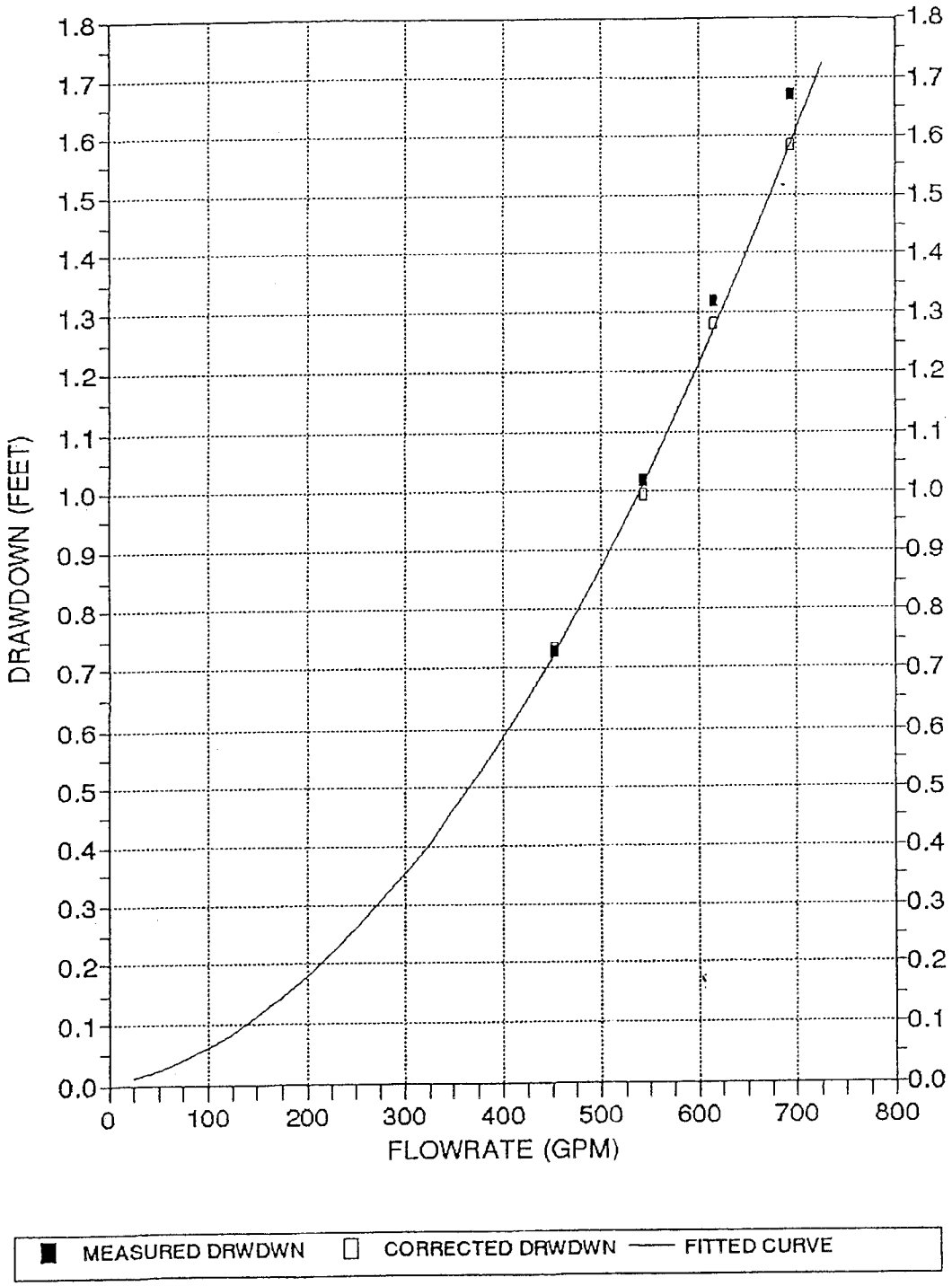


FIGURE 3. WATER LEVELS IN WELLS B AND A DURING THE CONSTANT RATE PUMP TEST (Well 'B') (#1647-05)

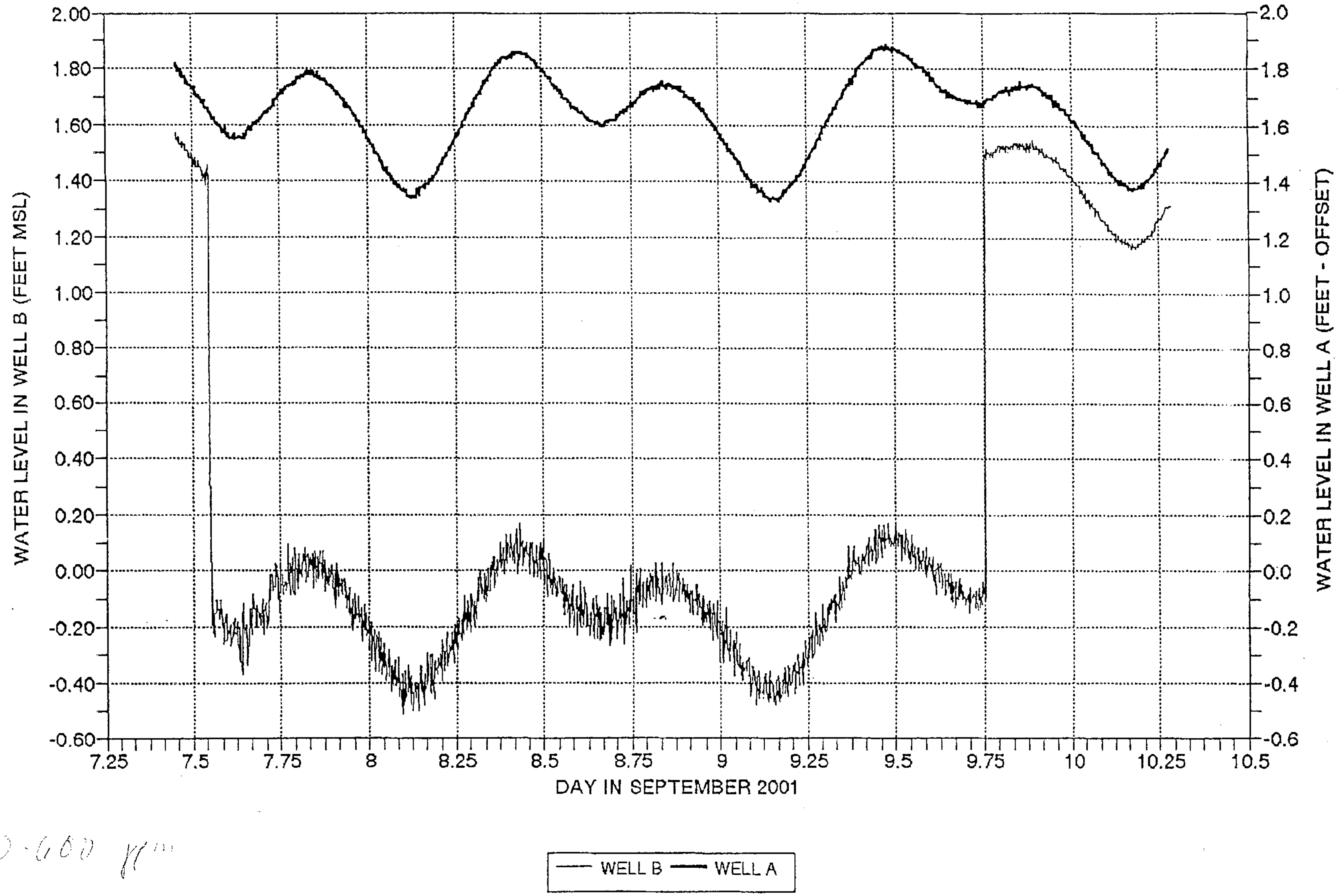
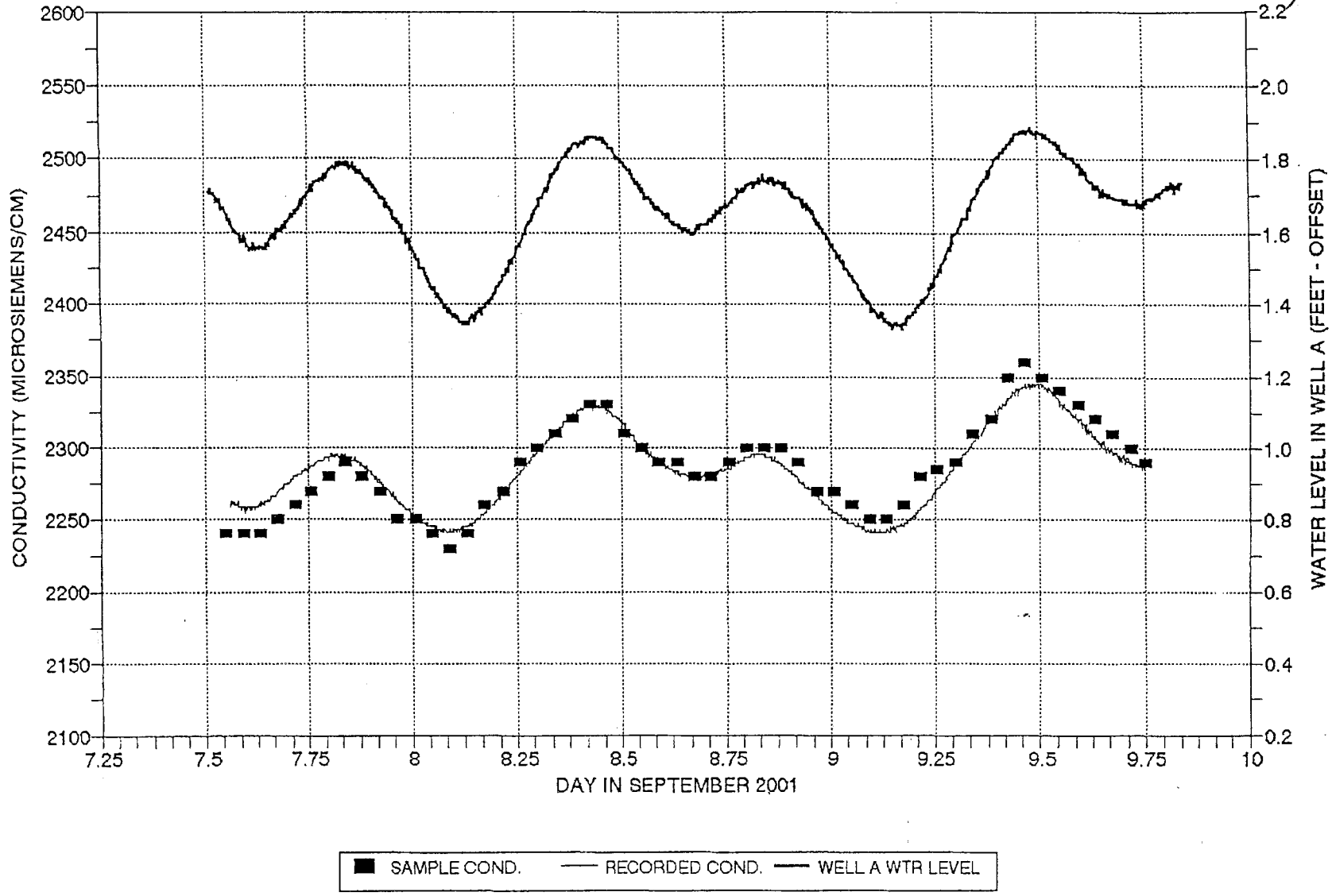


FIGURE 4. CORRELATION OF PUMPED WATER CONDUCTIVITY WITH TIDAL LEVEL (Well 'B') (#1647-05)



'9-10-01;11:37AM;
ULNR-Land Division;
8

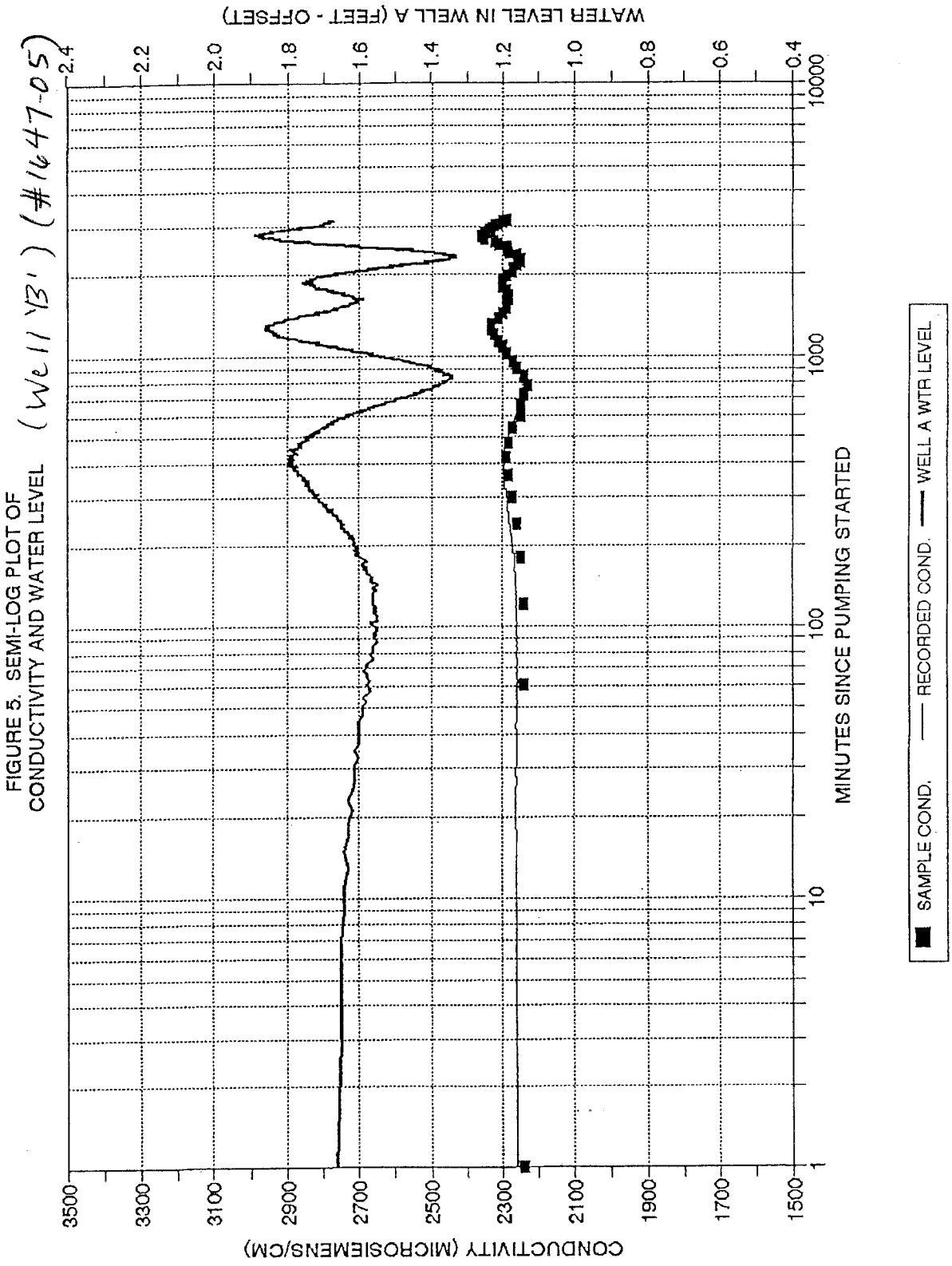
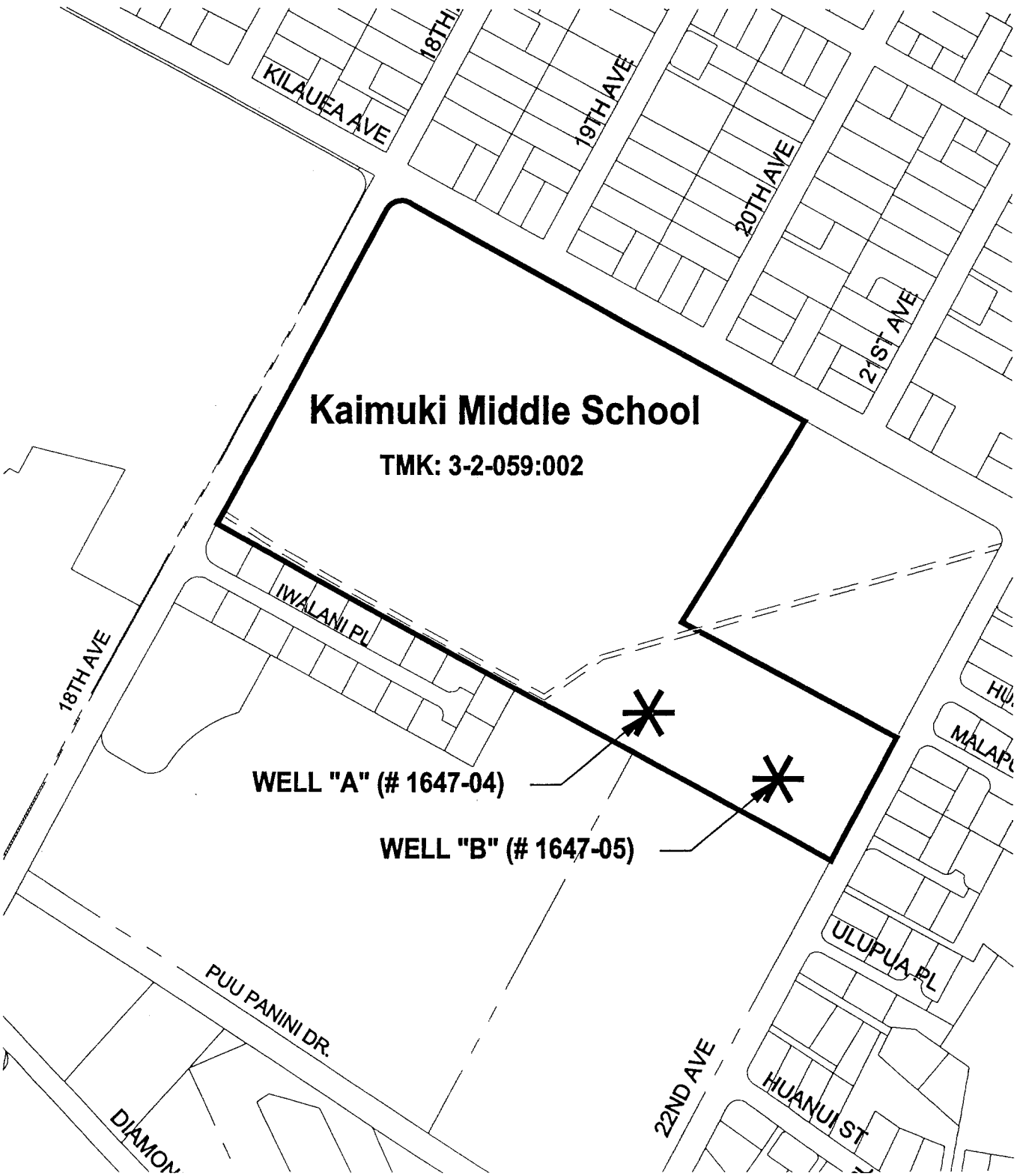


FIGURE 5. SEMI-LOG PLOT OF CONDUCTIVITY AND WATER LEVEL (Well 13') (#1647-05)

Parcel Map of the Kaimuki Exploratory Wells



Water Supply

Visitors/year = 1,000,000

Visitors/day = 1,000,000/365 = 2740 visitors/day use 3,000

Employees = 25/day

Water usage:

Source: Wastewater Engineering, Third Edition, Metcalf & Eddy,

Visitor center: 4-8 gal/visitor, use 7gal/day/visitor

Office: 8-20 gall/day/employee, use 20gal/day/employee

Average daily demand:

Visitor: 7gall/day/visitor x 3,000 visitors/day =	21,000 gpd
Office workers: 20 gpd/employee x 25employees =	500 gpd
Battery Br-Kheimer =	2,000 gpd
Irrigation around visitor center	6,900 gpd
	30,400 gpd
	21.1 gpm
call	22 gpm

* Maximum Daily Demand = 1.5 x Ave. Daily Demand
= 22 gpm x 1.5 = 33. gpm.

* Peak Flow = 3.0 x Ave Daily Demand
= 22 gpm x 3 = 66 gpm.

* Fire Flow = 2,000 gpm / 2 hours / 250' fire hydrant spacing

* Design Flow = max. daily demand + fire flow with 20 psi residual pressure
= 33 gpm + 2000 gpm = 2033 gpm.

* Source: Water System Standards, Board of Water Supply, City and County of Honolulu. Vol. 1, 1985

DESCRIPTION	Mitsunaga & Associates, Inc.	BY: EI	CHECKED
	PROJECT: Diamond Head State Monument	JOB NO.	SHEET OF
		DATE	

WATER READING DIAMOND HEAD
SERVICE LOCATION: 18th Ave 510, 18th Ave. 510s

Period		Thousands of Gallons
From	To	
7/6/94	8/3/94	1201
8/3/94	9/6/94	1487
9/6/94	10/5/94	3249
10/5/94	11/3/94	1246
11/3/94	12/7/94	1298
12/7/94	1/9/95	816
	Total	9297
	days	187
	gpd	49.717
1/9/95	2/7/95	769
2/7/95	3/9/95	463
3/9/95	4/7/95	618
4/7/95	5/8/95	932
6/6/95	7/6/95	1617
7/6/95	8/4/95	1889
8/4/95	9/6/95	1919
9/6/95	10/5/95	1063
10/5/95	11/2/95	1046
11/2/95	12/5/95	763
12/5/95	1/5/96	967
	Total	12046
	days	361
	gpd	33.368
1/5/96	2/5/96	557
2/5/96	3/5/96	494
3/5/96	4/4/96	683
4/4/96	5/3/96	1452
5/3/96	6/4/96	1451
6/4/96	7/3/96	1204
7/3/96	8/1/96	1645
8/1/96	9/3/96	1822
9/3/96	10/2/96	1633
10/2/96	10/31/96	1109
10/31/96	12/5/96	576
12/5/96	1/6/97	557
	Total	13183
	days	364
	gpd	36.217
1/6/97	2/5/97	387
2/5/97	3/7/97	585
3/7/97	4/8/97	385
4/8/97	5/6/97	332

5/6/97	6/4/97	794
6/4/97	7/7/97	858
7/7/97	8/4/97	726
9/3/97	10/2/97	747
10/2/97	10/31/97	352
10/31/97	11/28/97	349
11/28/97	1/2/98	579
	Total	6094
	days	362
	gpd	16.834

2/4/98	3/9/98	843
3/9/98	4/14/98	1039
4/14/98	5/11/98	825
5/11/98	6/9/98	860
6/9/98	7/13/98	1355
7/13/98	8/10/98	1088
8/10/98	9/8/98	1334
9/8/98	10/6/98	1132
10/6/98	11/5/98	0
11/5/98	12/9/98	777
12/9/98	1/12/99	759
	Total	10012
	days	375
	gpd	26.699

1/12/99	2/10/99	565
5/6/99	6/7/99	622
6/7/99	7/7/99	870
7/7/99	8/4/99	1055
8/4/99	9/3/99	1364
9/3/99	10/4/99	995
10/4/99	11/1/99	620
11/1/99	12/2/99	744
12/2/99	1/11/00	885
	Total	7720
	days	365
	gpd	21.151

1/11/00	2/7/00	681
2/7/00	3/9/00	782
3/9/00	4/7/00	598
4/7/00	5/10/00	810
5/10/00	6/7/00	984
6/7/00	7/7/00	813
7/7/00	8/4/00	834
8/4/00	9/13/00	1276
9/13/00	10/9/00	744
10/9/00	11/3/00	693
11/3/00	12/2/00	852
12/2/00	1/12/01	1179

	Total	10246
	days	367
	gpd	27.918
1/12/01	2/8/01	879
2/8/01	3/12/01	1037
3/12/01	4/12/01	1171
4/12/01	5/16/01	1657
5/16/01	6/15/01	1659
	Total	6403
	days	186
	gpd	34.425
	Total	75001
	days	2567
	gpd	29.217

WATER BILLING - SELECTED OAHU DISTRICT PARKS

Park	Service Location	From	To	Current Reading	Thousand of Gallons	Total (1,000) Gal/Month	Total Cost
Diamond Hd	18th Av 510	7/20/01	8/21/01	19,561			26.05
Diamond Hd	18th Av 510S	7/20/01	8/21/01	19,435			5,680.60
			7/01 - 6/02			TOTAL DIAMOND HEAD	5,706.65
Diamond Hd	18th Av 510	6/15/01	7/20/01	19,561			26.05
Diamond Hd	18th Av 510S	6/15/01	7/20/01	19,108			6,713.17
Diamond Hd	18th Av 510	5/16/01	6/15/01	19,561			26.05
Diamond Hd	18th Av 510S	5/16/01	6/15/01	18,557	1,659		7,419.43
Diamond Hd	18th Av 510						
Diamond Hd	18th Av 510S	4/12/01	5/16/01	18,230	1,657		7,310.49
Diamond Hd	18th Av 510	3/12/01	4/12/01	19,561			26.05
Diamond Hd	18th Av 510S	3/12/01	4/12/01	17,737	1,171		5,238.07
Diamond Hd	18th Av 510	2/8/01	3/12/01	19,561			26.05
Diamond Hd	18th Av 510S	2/8/01	3/12/01	17,452	1,037		4,639.09
Diamond Hd	18th Av 510						
Diamond Hd	18th Av 510S	1/12/01	2/8/01	17,318	879		3,932.83
Diamond Hd	18th Av 510	12/2/00	1/9/01	19,561			26.05
Diamond Hd	18th Av 510S	12/2/00	1/12/01	17,105	1,179		5,273.83
Diamond Hd	18th Av 510	11/3/00	12/2/00	19,561			26.05
Diamond Hd	18th Av 510S	11/3/00	12/2/00	16,982	852		3,811.14
Diamond Hd	18th Av 510	10/5/00	11/3/00				26.05
Diamond Hd	18th Av 510S	10/9/00	11/3/00	16,906	693		3,101.41

08/30/2001 15:41 FAX 8085870283 STATE HAWAII DLNR 002/010

WATER BILLING - SELECTED OAHU DISTRICT PARKS

Park	Service Location	From	To	Current Reading	Thousand of Gallons	Total (1,000) Gal/Month	Total Cost
Diamond Hd	18th Av 510	9/7/00	10/5/00	19,561			26.05
Diamond Hd	18th Av 510S	9/13/00	10/9/00	16,840	744		3,329.38
Diamond Hd	18th Av 510	8/4/00	9/7/00	19,561			26.05
Diamond Hd	18th Av 510S	8/4/00	9/13/00	16,756	1,276		5,707.42
Diamond Hd	18th Av 510	7/11/00	8/4/00	19,561			26.05
Diamond Hd	18th Av 510S	7/7/00	8/4/00	16,515	834		3,284.68
			7/00 - 7/01		TOTAL DIAMOND HEAD		71,434.74
Diamond Hd	18th Av 510	6/9/99	7/11/00	19,561			26.05
Diamond Hd	18th Av 510S	6/7/99	7/7/00	16,459	813		3,637.81
Diamond Hd	18th Av 510	5/10/00	6/9/00	19,561	253		1,134.61
Diamond Hd	18th Av 510S	5/10/00	6/7/00	16,346	731		3,271.27
Diamond Hd	18th Av 510	4/7/00	5/10/00	19,345			26.05
Diamond Hd	18th Av 510S	4/7/00	5/10/00	16,277	810		3,624.40
Diamond Hd	18th Av 510	3/9/00	4/7/00	19,345			26.05
Diamond Hd	18th Av 510S	3/9/00	4/7/00	16,243	598		2,676.76
Diamond Hd	18th Av 510	2/7/00	3/9/00	19,345			26.05
Diamond Hd	18th Av 510S	2/7/00	3/9/00	16,206	782		3,499.24
Diamond Hd	18th Av 510	1/11/00	2/7/00	19,345			26.05
Diamond Hd	18th Av 510S	1/11/00	2/7/00	16,167	681		3,047.77
Diamond Hd	18th Av 510	12/2/99	1/11/00	19,345			26.05
Diamond Hd	18th Av 510S	12/2/99	1/11/00	16,102	885		3,959.65

WATER BILLING - SELECTED OAHU DISTRICT PARKS

Park	Service Location	From	To	Current Reading	Thousand of Gallons	Total (1,000) Gal/Month	Total Cost
Diamond Hd	18th Av 510	11/1/99	12/2/99	19,345			26.05
Diamond Hd	18th Av 510S	11/1/99	12/2/99	16,051	744		3,329.38
Diamond Hd	18th Av 510	10/6/99	11/1/99	19,345			26.05
Diamond Hd	18th Av 510S	10/4/99	11/1/99	16,051	620		2,775.10
Diamond Hd	18th Av 510	9/3/99	10/6/99	19.345			26.05
Diamond Hd	18th Av 510S	9/3/99	10/4/99	16,000	995		4,451.35
Diamond Hd	18th Av 510	8/4/99	9/3/99	19,345			26.05
Diamond Hd	18th Av 510S	8/4/99	9/3/99	15,891	1,364		6,100.78
Diamond Hd	18th Av 510	7/7/99	8/4/99	19,345	20		93.1
Diamond Hd	18th Av 510S	7/7/99	8/4/99	15,680	1,035		4,630.15
			7/99 - 7/00			TOTAL DIAMOND HEAD	189,361.35
Diamond Hd	18th Av 510	6/7/99	7/7/99	19,345			26.05
Diamond Hd	18th Av 510S	6/7/99	7/7/99	15,535	870		3,892.60
Diamond Hd	18th Av 510	5/7/99	6/7/99	19,345			26.05
Diamond Hd	18th Av 510S	5/7/99	6/7/99	15,335	922		4,125.04
Diamond Hd	18th Av 510	1/12/99	2/10/99	19,345	1		28.16
Diamond Hd	18th Av 510S	1/12/99	2/10/99	12,129	565		2,529.25
Diamond Hd	18th Av 510	12/9/98	1/12/99	26,390			26.05
Diamond Hd	18th Av 510S	12/9/98	1/12/99	15,065	759		3,396.43
Diamond Hd	18th Av 510	11/5/98	12/9/98	26,390			26.05
Diamond Hd	18th Av 510S	11/5/98	12/9/98	14,934	777		3,476.89

WATER BILLING - SELECTED OAHU DISTRICT PARKS

Park	Service Location	From	To	Current Reading	Thousand of Gallons	Total (1,000) Gal/Month	Total Cost
Diamond Hd	18th Av 510	10/6/98	11/5/98	26,390			
Diamond Hd	18th Av 510S						26.05
Diamond Hd	18th Av 510	9/8/98	10/6/98	26,390			
Diamond Hd	18th Av 510S	9/8/98	10/6/98	14,420	1,132		26.05 5,063.74
Diamond Hd	18th Av 510	8/10/98	9/8/98	26,390			
Diamond Hd	18th Av 510S	8/10/98	9/8/98	14,420	1,334		67.04 5,966.68
Diamond Hd	18th Av 510	7/13/98	8/10/98	26,390			
Diamond Hd	18th Av 510S	7/13/98	8/10/98	14,163	1,088		67.04 4,867.06
			7/98 - 7/99			TOTAL DIAMOND HEAD	412,358.93
Diamond Hd	18th Av 510	6/9/98	7/13/98	26,390			
Diamond Hd	18th Av 510S	6/9/98	7/13/98	13,972	1,355		26.05 6,060.95
Diamond Hd	18th Av 510	5/11/98	6/9/98	26,390			
Diamond Hd	18th Av 510S	5/11/98	6/9/98	13,741	860		26.05 3,847.90
Diamond Hd	18th Av 510	4/14/98	5/11/98	26,390			
Diamond Hd	18th Av 510S	4/14/98	5/11/98	13,573	825		26.05 3,691.45
Diamond Hd	18th Av 510	3/9/98	4/14/98	26,390			
Diamond Hd	18th Av 510S	3/9/98	4/14/98	13,411	1,039		30.15 4,648.03
Diamond Hd	18th Av 510	2/4/98	3/9/98	26,930			
Diamond Hd	18th Av 510S	2/4/98	3/9/98	13,247	843		27.95 3,771.91
Diamond Hd	18th Av 510	1/2/98	2/4/98	26,390			
Diamond Hd	18th Av 510S						27.95

WATER BILLING - SELECTED OAHU DISTRICT PARKS

Park	Service Location	From	To	Current Reading	Thousand of Gallons	Total (1,000) Gal/Month	Total Cost
Diamond Hd	18th Av 510	11/28/97	1/2/98	29,390			
Diamond Hd	18th Av 510S	11/28/97	1/2/98	13,030	579		2,591.83
Diamond Hd	18th Av 510	10/31/97	11/28/97	29,390			24.27
Diamond Hd	18th Av 510S	10/31/97	11/28/97	12,992	349		1,563.73
Diamond Hd	18th Av 510	10/2/97	10/31/97	45,734			26.05
Diamond Hd	18th Av 510S	10/2/97	10/31/97	58,759	352	352	1,577.14
Diamond Hd	18th Av 510	9/3/97	10/2/97	45,734	1	1	22.48
Diamond Hd	18th Av 510S	9/3/97	10/2/97	58,407	747	747	1,860.03
Diamond Hd	18th Av 510	7/7/97	8/4/97	45,733			26.05
Diamond Hd	18th Av 510S	7/7/97	8/4/97	57,108	726	726	3,248.92
			7/97 - 7/98		TOTAL DIAMOND HEAD		33,124.94
Diamond Hd	18th Av 510	6/4/97	7/7/97	45,733			26.05
Diamond Hd	18th Av 510S	6/4/97	7/7/97	56,382	858	858	3,838.96
Diamond Hd	18th Av 510	5/6/97	6/4/97	45,733			26.05
Diamond Hd	18th Av 510S	5/6/97	6/4/97	55,524	794	794	3,552.88
Diamond Hd	18th Av 510	4/8/97	5/6/97	45,733			26.05
Diamond Hd	18th Av 510S	4/8/97	5/6/97	54,730	332	332	1,487.74
Diamond Hd	18th Av 510	3/7/97	4/8/97	45,733			26.05
Diamond Hd	18th Av 510S	3/7/97	4/8/97	54,398	385	385	1,724.65
Diamond Hd	18th Av 510	2/5/97	3/7/97	45,733			26.05
Diamond Hd	18th Av 510S	2/5/97	3/7/97	54,013	585	585	2,618.65

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WATER BILLING - SELECTED OAHU DISTRICT PARKS

Park	Service Location	From	To	Current Reading	Thousand of Gallons	Total (1,000) Gal/Month	Total Cost
Diamond Hd	18th Av 510	1/6/97	2/5/97	45,733			26.05
Diamond Hd	18th Av 510S	1/6/97	2/5/97	53,428	387	387	1,733.59
Diamond Hd	18th Av 510	12/5/96	1/6/97	45,733			26.05
Diamond Hd	18th Av 510S	12/5/96	1/6/97	53,041	557	557	2,493.49
Diamond Hd	18th Av 510	10/31/96	12/5/96	45,733			26.05
Diamond Hd	18th Av 510S	10/31/96	12/5/96	52,484	576	557	2,578.42
Diamond Hd	18th Av 510	10/2/96	10/31/96	45,733			26.05
Diamond Hd	18th Av 510S	10/2/96	10/31/96	51,908	1,109	1,109	4,960.93
Diamond Hd	18th Av 510	9/3/96	10/2/96	45,733			26.05
Diamond Hd	18th Av 510S	9/3/96	10/2/96	50,799	1,633	1,633	7,303.21
Diamond Hd	18th Av 510	8/1/96	9/3/96	45,733			26.05
Diamond Hd	18th Av 510S	8/1/96	9/3/96	49,166	1,822	1,822	8,148.04
Diamond Hd	18th Av 510	7/3/96	8/1/96	45,733			26.05
Diamond Hd	18th Av 510S	7/3/96	8/1/96	47,344	1,645	1,645	7,356.85
			7/96 - 7/97		TOTAL DIAMOND HEAD		48,110.01
Diamond Hd	18th Av 510	6/4/96	7/3/96	45,733			26.05
Diamond Hd	18th Av 510S	6/4/96	7/3/96	45,699	1,204	1,204	5,385.58
Diamond Hd	18th Av 510	5/3/96	6/4/96	45,733			26.05
Diamond Hd	18th Av 510S	5/3/96	6/4/96	44,495	1,451	1,451	6,489.67
Diamond Hd	18th Av 510	4/4/96	5/3/96	45,733			26.05

WATER BILLING - SELECTED OAHU DISTRICT PARKS

Park	Service Location	From	To	Current Reading	Thousand of Gallons	Total (1,000) Gal/Month	Total Cost
Diamond Hd	18th Av 510S	4/4/96	5/3/96	43,044	1,452	1,452	6,494.14
Diamond Hd	18th Av 510	3/5/96	4/4/96	45,733			26.05
Diamond Hd	18th Av 510S	3/5/96	4/4/96	41,592	683	683	3,056.71
Diamond Hd	18th Av 510	2/5/96	3/5/96	45,733			26.05
Diamond Hd	18th Av 510S	2/5/96	3/5/96	40,909	494	494	2,211.88
Diamond Hd	18th Av 510	1/5/96	2/5/96	45,733	37		169.09
Diamond Hd	18th Av 510S	1/5/96	2/5/96	40,415	520	557	2,328.10
Diamond Hd	18th Av 510	12/5/95	1/5/96	45,696			26.05
Diamond Hd	18th Av 510S	12/5/95	1/5/96	39,895	967	967	4,326.19
Diamond Hd	18th Av 510	11/2/95	12/5/95	45,696	0	0	26.05
Diamond Hd	18th Av 510S	11/2/95	12/5/95	38,928	763	763	3,414.31
Diamond Hd	18th Av 510	10/5/95	11/2/95	45,696	0	0	26.05
Diamond Hd	18th Av 510S	10/5/95	11/2/95	38,165	1,046	1,046	4,679.32
Diamond Hd	18th Av 510	9/6/95	10/5/95	45,696	0		26.05
Diamond Hd	18th Av 510S	9/6/95	10/5/95	37,119	1,063	1,063	4,755.31
Diamond Hd	18th Av 510	8/4/95	9/6/95	45,696	0		26.05
Diamond Hd	18th Av 510S	8/4/95	9/6/95	36,056	1,919	1,919	8,581.63
Diamond Hd	18th Av 510	7/6/95	8/4/95	45,696	0		26.05
Diamond Hd	18th Av 510S	7/6/95	8/4/95	34,137	1,889	1,889	3,743.92
			7/95 - 7/96		TOTAL DIAMOND HEAD		55,922.40
Diamond Hd	18th Av 510	6/6/95	7/6/95	45,696	0		26.05

WATER BILLING - SELECTED OAHU DISTRICT PARKS

Park	Service Location	From	To	Current Reading	Thousand of Gallons	Total (1,000) Gal/Month	Total Cost
Diamond Hd	18th Av 510S	6/6/95	7/6/95	32,248	1,617	1,617	3,030.25
Diamond Hd	18th Av 510	4/7/95	5/8/95	45,696	0		26.05
Diamond Hd	18th Av 510S	4/7/95	5/8/95	29,468	932	932	1,727.90
Diamond Hd	18th Av 510	3/9/95	4/7/95	45,696	0		26.05
Diamond Hd	18th Av 510S	3/9/95	4/7/95	28,536	618	618	1,147.00
Diamond Hd	18th Av 510	2/7/95	3/9/95	45,696	0		26.05
Diamond Hd	18th Av 510S	2/7/95	3/9/95	27,918	463	463	860.25
Diamond Hd	18th Av 510	1/9/95	2/7/95	45,696	0		26.05
Diamond Hd	18th Av 510S	1/9/95	2/7/95	27,455	769	769	1,426.35
Diamond Hd	18th Av 510	12/7/94	1/9/95	45,696	0		26.05
Diamond Hd	18th Av 510S	12/7/94	1/9/95	26,686	816	816	1,513.30
Diamond Hd	18th Av 510	11/3/94	12/7/94	45,696	0		26.05
Diamond Hd	18th Av 510S	11/3/94	12/7/94	25,870	1,298	1,298	2,405.00
Diamond Hd	18th Av 510	10/5/94	11/3/94	45,696	0		26.05
Diamond Hd	18th Av 510S	10/5/94	11/3/94	25,520	1,246	1,246	2,308.80
Diamond Hd	18th Av 510	9/6/94	10/5/94	45,696	0		26.05
Diamond Hd	18th Av 510S	9/6/94	10/5/94	24,274	3,249	3,249	6,014.35
Diamond Hd	18th Av 510	8/3/94	9/6/94	45,696	0		26.05
Diamond Hd	18th Av 510S	8/3/94	9/6/94	21,025	1,487	1,487	2,754.65
Diamond Hd	18th Av 510	7/6/94	8/3/94	45,696	0		26.05
Diamond Hd	18th Av 510S	7/6/94	8/3/94	19,538	1,201	1,201	2,225.55

WATER BILLING - SELECTED OAHU DISTRICT PARKS

Park	Service Location	From	To	Current Reading	Thousand of Gallons	Total (1,000) Gal/Month	Total Cost
			7/94 - 7/95		TOTAL DIAMOND HEAD		25,699.95

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DIAMOND HEAD STATE MONUMENT
Water Meter Readings - June 1995 to August 2001

Month-Year	Meter Readings in Gallons Per Month									
	Bldg 301	Bldg 303	Bldg 304	Diamond Head Park	Battery Harlow	Birkhimer EOC	FAA	Battery 407	Cannon Club	Total gallons/month
Jun-95	365,540	99,875	27,873	537,536	17,314	139,938	36,915	4,629	618,185	1,847,805
Jul-95	391,779	94,581	32,315	343,557	17,491	179,016	36,258	5,908	584,612	1,685,517
Aug-95	318,567	100,110	33,998	473,064	22,111	122,738	43,084	5,789	549,948	1,669,409
Sep-95	342,519	100,080	36,436	48,654	14,523	127,641	38,321	1,954	268,358	978,486
Oct-95	274,782	54,360	23,288	401,759	13,746	148,481	38,553	6,158	235,323	1,196,450
Nov-95	131,749	47,585	18,964	240,985	5,128	39,767	35,506	6,474	187,488	713,646
Dec-95	290,411	44,115	30,722	369,784	27,752	90,266	36,386	2,227	148,826	1,040,489
subtotal	2,115,347	540,706	203,596	2,415,339	118,065	847,847	265,023	33,139	2,592,740	9,131,802
gpd	9,885	2,527	951	11,287	552	3,962	1,238	155	12,116	42,672
Jan-96	96,302	24,715	9,487	53,201	24,331	26,436	36,182	6,366	66,347	343,367
Feb-96	144,517	38,883	9,973	195,463	5,132	67,580	33,140	1,819	60,450	556,957
Mar-96	166,583	37,407	18,407	277,752	8,126	32,227	37,742	2,616	137,878	718,738
Apr-96	262,570	46,050	23,075	351,832	7,533	123,266	39,930	3,874	298,320	1,156,450
May-96	480,422	81,516	41,620	524,830	12,339	197,137	42,142	21,797	492,285	1,894,088
Jun-96	255,883	119,639	26,226	393,843	12,403	34,906	37,522	31,316	234,825	1,146,563
Jul-96	560,932	79,267	36,555	444,775	1,890	53,932	37,462	9,201	373,278	1,597,292
Aug-96	474,448	97,513	26,202	429,790	8,415	83,874	43,247	8,774	290,937	1,463,200
Sep-96	424,952	67,990	12,758	370,920	8,465	46,862	41,176	3,390	100,433	1,076,946
Oct-96	337,222	76,939	18,411	316,048	6,765	112,246	46,526	3,198	122,872	1,040,227
Nov-96	31,950	24,156	9,302	112,887	3,200	20,352	40,509	3,114	79,278	324,748
Dec-96	33,188	34,310	10,172	181,435	24,540	13,066	34,631	9,133	89,682	430,157
subtotal	3,268,969	728,385	242,188	3,652,776	123,139	811,884	470,209	104,598	2,346,585	11,748,733
gpd	8,956	1,996	664	10,008	337	2,224	1,288	287	6,429	32,188
Jan-97	49,365	23,512	7,666	93,645	4,598	10,112	35,159	8,265	64,780	297,102
Feb-97	37,005	23,106	10,140	204,540	4,512	9,386	33,470	5,777	105,645	433,581
Mar-97	35,040	30,722	8,273	212,755	12,000	14,307	31,019	1,112	81,145	426,373
Apr-97	54,230	37,258	9,107	103,028	117,830	43,770	38,585	3,379	91,462	498,649
May-97	151,958	185,127	12,615	151,887	6,067	9,561	40,591	3,214	137,935	698,955
Jun-97	453,322	70,035	22,049	136,559	2,149	36,099	46,321	2,612	296,525	1,065,671

Jul-97	426,330	126,987	32,580	238,196	5,144	41,534	55,982	10,013		936,766
Aug-97	258,485	62,280	30,648	153,171	4,460	39,305	154,666	4,468		707,483
Sep-97	333,125	69,383	28,362	168,898	12,740	59,486		2,795		674,789
Oct-97	155,350	24,175	24,145	111,031	1,292,956	41,945	52,040	3,030		1,704,672
Nov-97	25,395	18,033	15,092	84,453	1,981	21,300	37,625	2,074		205,953
Dec-97	165,477	24,274	12,838	136,372	291,153	31,583	46,618	2,050		710,365
subtotal	2,145,082	694,892	213,515	1,794,535	1,755,590	358,388	572,076	48,789	777,492	8,360,359
gpd	5,877	1,904	585	4,917	4,810	982	1,567	134	2,130	22,905
Jan-98	85,819	31,718	6,850	131,880	339	59,037	39,892	2,082		357,617
Feb-98	764,119	33,930	33,985	160,805	183	58,485	65,270	7,069		1,123,846
Mar-98	250,690	58,230	26,290	265,485	1,627	35,840	83,270	2,262		723,694
Apr-98	689,075	66,540	35,750	277,970	1,168	74,070	59,395	7,742		1,211,710
May-98	156,795	58,915	25,935	304,535	1,415	57,845	56,155	6,822		668,417
Jul-98	303,805	79,105	61,185	902,350	1,051	111,035	117,265	11,186		1,586,982
Aug-98	323,005	52,130	17,840	494,850	359	59,470	59,175	5,429		1,012,258
Sep-98	170,830	73,860	39,900	438,760	828	112,370	63,985	5,978		906,511
Oct-98	316,980	88,155	19,170	426,670	319	62,190	66,375	6,787		986,646
Nov-98	26,940	23,380	17,920	274,515	201		48,245	2,825		394,026
Dec-98	194,970	44,035	44,780	491,215	294	91,580	64,410	10,687		941,971
subtotal	3,283,028	609,998	329,605	4,169,035	7,784	721,922	723,437	68,869	0	9,913,678
gpd	8,995	1,671	903	11,422	21	1,978	1,982	189	0	27,161
Jan-99	17,850	19,930	7,710	250,560	133	18,375	49,510	6,514		370,582
Feb-99	26,940	31,545	9,155	255,600	268	44,306	41,505	6,987		416,306
Mar-99	219,735	34,015	9,865	276,785	754	61,539	49,705	11,173		663,571
Apr-99	67,105	24,880	15,865	259,260	147	52,670	51,715	6,644		478,286
May-99	179,000	39,460	10,060	246,385		204,635	46,115	5,003		730,658
Jun-99	341,065	47,560	9,340	280,805		52,730	56,775	5,558		793,833
Jul-99	414,345	64,050	114,425	270,905		100,770	64,355	8,475		1,037,325
Aug-99	250,600	47,395	161,780	454,065		137,570	63,025	10,086		1,124,521
Sep-99	248,960	65,715	28,795	334,615		59,737	69,345	6,092		813,259
Oct-99	78,370	40,380	15,735	331,940	1,244	43,923	59,495	5,206		576,293
Nov-99	36,840	34,180	14,440	342,410	296	45,180	49,635	7,789		530,770
Dec-99	132,150	18,690	18,795	305,620	5,986	36,955	44,030	10,730		572,956
subtotal	2,012,960	467,800	415,965	3,608,950	8,828	858,390	645,210	90,257	0	8,108,360
gpd	5,515	1,282	1,140	9,888	24	2,352	1,768	247	0	22,215

Jan-00	17,895	29,170	13,520	327,081	2,690	33,920	51,938	9,141		485,355
Feb-00	20,170	51,775	16,720	373,054	13,225	60,660	76,987	8,533		621,124
Apr-00	323,368	88,359	44,459	686,283	56,540	79,627	126,782	12,461		1,417,879
May-00	26,215	112,956	34,466	305,917	32,384	50,916	60,658	6,402		629,914
Jun-00	846,670	48,185	55,350	312,225	4,669	60,665	52,720	7,331		1,387,815
Jul-00	202,177	43,140	24,232	306,470	18,702	119,451	47,704	5,619		767,495
Aug-00	741,900	117,200	34,846	449,340	15,829	32,766	55,991	8,948		1,456,820
Sep-00	565,600	81,175	23,202	395,500	8,437	44,808	51,138	7,074		1,176,934
Oct-00	495,335	50,280	37,525	301,928	4,742	13,437	44,355	4,078	679	952,359
Nov-00	258,670	70,035	36,873	437,467	9,600	37,105	41,995	8,130	2,866	902,741
Dec-00	284,625	70,503	37,682	425,680	172,985	28,505	24,610	2,832	160	1,047,582
subtotal	3,782,625	762,778	358,875	4,320,945	339,803	561,860	634,878	80,549	3,705	10,846,018
gpd	10,363	2,090	983	11,838	931	1,539	1,739	221	40	29,715
Jan-01	1,411,153	55,842	33,821	250,995	73,170	63,075	14,042	10,662	2,105	1,914,865
Feb-01	1,000,180	52,140	27,367	237,890	188,027	93,788	6,898	4,416	1,625	1,612,331
Mar-01	1,596,502	72,160	46,812	333,650	142,824	42,032	118,252	3,980	4,800	2,361,012
Apr-01	1,847,945	57,220	35,950	225,120	35,496	15,042	196,055	11,928	12,290	2,437,046
May-01	1,426,421	106,815	38,764	344,320	36,779	43,498		-5,966	15,620	2,006,251
Jun-01	2,027,414	72,845	80,206	328,680	15,864	170,439		1,462	10	2,696,920
Jul-01	1,228,115	91,360	42,067	428,715	-828,285	73,671		3,265	0	1,038,908
Aug-01	2,658,025	171,130	26,651	451,430	10,062	41,750		7,935	0	3,366,983
subtotal	13,195,755	679,512	331,638	2,600,800	-326,063	543,295	335,247	37,682	36,450	17,434,316
gpd	54,304	2,796	1,365	10,703	-1,342	2,236	1,380	155	150	71,746
Total	29,803,766	4,484,071	2,095,382	22,562,380	2,027,146	4,703,586	3,646,080	463,883	5,756,972	75,543,266
gpd	13,060	1,965	918	9,887	888	2,061	1,598	203	2,523	33,104

Note: October 2000 to August 2001 consumption data is for Cannon Club (Harlow)

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
May-1995	Bldg 301	7029377	37,809,364	0	
May-1995	Bldg 303	94500633	849,809	0	
May-1995	Bldg 304	80428662	3,581,326	0	
May-1995	Diamond Hd Park	14087805	50,908,885	0	
May-1995	Battery Harlow	4402022	1,026,396	0	
May-1995	Birkhimer EOC	94500632	1,791,919	0	
May-1995	FAA	7180137	5,506,263	0	
May-1995	Battery 407	5064437	510,978	0	
May-1995	Cannon Club	14991355	44,959,275	0	
May-1995	Cannon Club (Harlow)	93737807	3,308,183	0	
Jun-1995	Bldg 301	7029377	38,174,904	365,540	
Jun-1995	Bldg 303	94500633	949,684	99,875	
Jun-1995	Bldg 304	80428662	3,609,199	27,873	
Jun-1995	Diamond Head Park	14087805	51,446,421	537,536	
Jun-1995	Battery Harlow	4402022	1,043,710	17,314	
Jun-1995	Birkhimer EOC	94500632	1,931,857	139,938	
Jun-1995	FAA	7180137	5,543,178	36,915	
Jun-1995	Battery 407	5064437	515,607	4,629	
Jun-1995	Cannon Club	14991355	45,577,460	618,185	1,847,805
Jun-1995	Cannon Club (Harlow)	93737807	3,925,168	616,985	
Jul-1995	Bldg 301	7029377	38,566,683	391,779	
Jul-1995	Bldg 303	94500633	1,044,265	94,581	
Jul-1995	Bldg 304	80428662	3,641,514	32,315	
Jul-1995	Diamond Head Park	14087805	51,789,978	343,557	
Jul-1995	Battery Harlow	4402022	1,061,201	17,491	
Jul-1995	Birkhimer EOC	94500632	2,110,873	179,016	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Jul-1995	FAA	7180137	5,579,436	36,258	
Jul-1995	Battery 407	5064437	521,515	5,908	
Jul-1995	Cannon Club	14991355	46,162,072	584,612	1,685,517
Jul-1995	Cannon Club (Harlow)	93737807	4,507,165	581,997	
Aug-1995	Bldg 301	7029377	38,885,250	318,567	
Aug-1995	Bldg 303	94500633	1,144,375	100,110	
Aug-1995	Bldg 304	80428662	3,675,512	33,998	
Aug-1995	Diamond Head Park	14087805	52,263,042	473,064	
Aug-1995	Battery Harlow	4402022	1,083,312	22,111	
Aug-1995	Birkhimer EOC	94500632	2,233,611	122,738	
Aug-1995	FAA	7180137	5,622,520	43,084	
Aug-1995	Battery 407	5064437	527,304	5,789	
Aug-1995	Cannon Club	14991355	46,712,020	549,948	1,669,409
Aug-1995	Cannon Club (Harlow)	93737807	5,054,384	547,219	
Sep-1995	Bldg 301	7029377	39,227,769	342,519	
Sep-1995	Bldg 303	94500633	1,244,455	100,080	
Sep-1995	Bldg 304	80428662	3,711,948	36,436	
Sep-1995	Diamond Head Park	14087805	52,311,696	48,654	
Sep-1995	Battery Harlow	4402022	1,097,835	14,523	
Sep-1995	Birkhimer EOC	94500632	2,361,252	127,641	
Sep-1995	FAA	7180137	5,660,841	38,321	
Sep-1995	Battery 407	5064437	529,258	1,954	
Sep-1995	Cannon Club	14991355	46,980,378	268,358	978,486
Sep-1995	Cannon Club (Harlow)	93737807	5,321,713	267,329	
Oct-1995	Bldg 301	7029377	39,502,551	274,782	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Oct-1995	Bldg 303	94500633	1,298,815	54,360	
Oct-1995	Bldg 304	80428662	3,735,236	23,288	
Oct-1995	Diamond Head Park	14087805	52,713,455	401,759	
Oct-1995	Battery Harlow	4402022	1,111,581	13,746	
Oct-1995	Birkhimer EOC	94500632	2,509,733	148,481	
Oct-1995	FAA	7180137	5,699,394	38,553	
Oct-1995	Battery 407	5064437	535,416	6,158	
Oct-1995	Cannon Club	14991355	47,215,701	235,323	1,196,450
Oct-1995	Cannon Club (Harlow)	93737807	5,699,394	377,681	
Nov-1995	Bldg 301	7029377	39,634,300	131,749	
Nov-1995	Bldg 303	94500633	1,346,400	47,585	
Nov-1995	Bldg 304	80428662	3,754,200	18,964	
Nov-1995	Diamond Head Park	14087805	52,954,440	240,985	
Nov-1995	Battery Harlow	4402022	1,116,709	5,128	
Nov-1995	Birkhimer EOC	94500632	2,549,500	39,767	
Nov-1995	FAA	7180137	5,734,900	35,506	
Nov-1995	Battery 407	5064437	541,890	6,474	
Nov-1995	Cannon Club	14991355	47,403,189	187,488	713,646
Nov-1995	Cannon Club (Harlow)	93737807	5,744,311	44,917	
Dec-1995	Bldg 301	7029377	39,924,711	290,411	
Dec-1995	Bldg 303	94500633	1,390,515	44,115	
Dec-1995	Bldg 304	80428662	3,784,922	30,722	
Dec-1995	Diamond Head Park	14087805	53,324,224	369,784	
Dec-1995	Battery Harlow	4402022	1,144,461	27,752	
Dec-1995	Birkhimer EOC	94500632	2,639,766	90,266	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Dec-1995	FAA	7180137	5,771,286	36,386	
Dec-1995	Battery 407	5064437	544,117	2,227	
Dec-1995	Cannon Club	14991355	47,552,015	148,826	1,040,489
Dec-1995	Cannon Club (Harlow)	93737807	5,893,457	149,146	
Jan-1996	Bldg 301	7029377	40,021,013	96,302	
Jan-1996	Bldg 303	94500633	1,415,230	24,715	
Jan-1996	Bldg 304	80428662	3,794,409	9,487	
Jan-1996	Diamond Head Park	14087805	53,377,425	53,201	
Jan-1996	Battery Harlow	4402022	1,168,792	24,331	
Jan-1996	Birkhimer EOC	94500632	2,666,202	26,436	
Jan-1996	FAA	7180137	5,807,468	36,182	
Jan-1996	Battery 407	5064437	550,483	6,366	
Jan-1996	Cannon Club	14991355	47,618,362	66,347	343,367
Jan-1996	Cannon Club (Harlow)	93737807	5,961,542	68,085	
Feb-1996	Bldg 301	7029377	40,165,530	144,517	
Feb-1996	Bldg 303	94500633	1,454,113	38,883	
Feb-1996	Bldg 304	80428662	3,804,382	9,973	
Feb-1996	Diamond Head Park	14087805	53,572,888	195,463	
Feb-1996	Battery Harlow	4402022	1,173,924	5,132	
Feb-1996	Birkhimer EOC	94500632	2,733,782	67,580	
Feb-1996	FAA	7180137	5,840,608	33,140	
Feb-1996	Battery 407	5064437	552,302	1,819	
Feb-1996	Cannon Club	14991355	47,678,812	60,450	556,957
Feb-1996	Cannon Club (Harlow)	93737807	6,023,412	61,870	
Mar-1996	Bldg 301	7029377	40,332,113	166,583	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Mar-1996	Bldg 303	94500633	1,491,520	37,407	
Mar-1996	Bldg 304	80428662	3,822,789	18,407	
Mar-1996	Diamond Head Park	14087805	53,850,640	277,752	
Mar-1996	Battery Harlow	4402022	1,182,050	8,126	
Mar-1996	Birkhimer EOC	94500632	2,766,009	32,227	
Mar-1996	FAA	7180137	5,878,350	37,742	
Mar-1996	Battery 407	5064437	554,918	2,616	
Mar-1996	Cannon Club	14991355	47,816,690	137,878	718,738
Mar-1996	Cannon Club (Harlow)	93737807	6,161,745	138,333	
Apr-1996	Bldg 301	7029377	40,594,683	262,570	
Apr-1996	Bldg 303	94500633	1,537,570	46,050	
Apr-1996	Bldg 304	80428662	3,845,864	23,075	
Apr-1996	Diamond Head Park	14087805	54,202,472	351,832	
Apr-1996	Battery Harlow	4402022	1,189,583	7,533	
Apr-1996	Birkhimer EOC	94500632	2,889,275	123,266	
Apr-1996	FAA	7180137	5,918,280	39,930	
Apr-1996	Battery 407	5064437	558,792	3,874	
Apr-1996	Cannon Club	14991355	48,115,010	298,320	1,156,450
Apr-1996	Cannon Club (Harlow)	93737807	6,460,740	298,995	
May-1996	Bldg 301	7029377	41,075,105	480,422	
May-1996	Bldg 303	94500633	1,619,086	81,516	
May-1996	Bldg 304	80428662	3,887,484	41,620	
May-1996	Diamond Head Park	14087805	54,727,302	524,830	
May-1996	Battery Harlow	4402022	1,201,922	12,339	
May-1996	Birkhimer EOC	94500632	3,086,412	197,137	
May-1996	FAA	7180137	5,960,422	42,142	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
May-1996	Battery 407	5064437	580,589	21,797	
May-1996	Cannon Club	14991355	48,607,295	492,285	1,894,088
May-1996	Cannon Club (Harlow)	93737807	6,951,580	490,840	
Jun-1996	Bldg 301	7029377	41,330,988	255,883	
Jun-1996	Bldg 303	94500633	1,738,725	119,639	
Jun-1996	Bldg 304	80428662	3,913,710	26,226	
Jun-1996	Diamond Head Park	14087805	55,121,145	393,843	
Jun-1996	Battery Harlow	4402022	1,214,325	12,403	
Jun-1996	Birkhimer EOC	94500632	3,121,318	34,906	
Jun-1996	FAA	7180137	5,997,944	37,522	
Jun-1996	Battery 407	5064437	611,905	31,316	
Jun-1996	Cannon Club	14991355	48,842,120	234,825	1,146,563
Jun-1996	Cannon Club (Harlow)	93737807	7,190,945	239,365	
Jul-1996	Bldg 301	7029377	41,891,920	560,932	
Jul-1996	Bldg 303	94500633	1,817,992	79,267	
Jul-1996	Bldg 304	80428662	3,950,265	36,555	
Jul-1996	Diamond Head Park	14087805	55,565,920	444,775	
Jul-1996	Battery Harlow	4402022	1,216,215	1,890	
Jul-1996	Birkhimer EOC	94500632	3,175,250	53,932	
Jul-1996	FAA	7180137	6,035,406	37,462	
Jul-1996	Battery 407	5064437	621,106	9,201	
Jul-1996	Cannon Club	14991355	49,215,398	373,278	1,597,292
Jul-1996	Cannon Club (Harlow)	93737807	7,566,235	375,290	
Aug-1996	Bldg 301	7029377	42,366,368	474,448	
Aug-1996	Bldg 303	94500633	1,915,505	97,513	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Aug-1996	Bldg 304	80428662	3,976,467	26,202	
Aug-1996	Diamond Head Park	14087805	55,995,710	429,790	
Aug-1996	Battery Harlow	4402022	1,224,630	8,415	
Aug-1996	Birkhimer EOC	94500632	3,259,124	83,874	
Aug-1996	FAA	7180137	6,078,653	43,247	
Aug-1996	Battery 407	5064437	629,880	8,774	
Aug-1996	Cannon Club	14991355	49,506,335	290,937	1,463,200
Aug-1996	Cannon Club (Harlow)	93737807	7,885,383	319,148	
Sep-1996	Bldg 301	7029377	42,791,320	424,952	
Sep-1996	Bldg 303	94500633	1,983,495	67,990	
Sep-1996	Bldg 304	80428662	3,989,225	12,758	
Sep-1996	Diamond Head Park	14087805	56,366,630	370,920	
Sep-1996	Battery Harlow	4402022	1,233,095	8,465	
Sep-1996	Birkhimer EOC	94500632	3,305,986	46,862	
Sep-1996	FAA	7180137	6,119,829	41,176	
Sep-1996	Battery 407	5064437	633,270	3,390	
Sep-1996	Cannon Club	14991355	49,606,768	100,433	1,076,946
Sep-1996	Cannon Club (Harlow)	93737807	8,010,245	124,862	
Oct-1996	Bldg 301	7029377	43,128,542	337,222	
Oct-1996	Bldg 303	94500633	2,060,434	76,939	
Oct-1996	Bldg 304	80428662	4,007,636	18,411	
Oct-1996	Diamond Head Park	14087805	56,682,678	316,048	
Oct-1996	Battery Harlow	4402022	1,239,860	6,765	
Oct-1996	Birkhimer EOC	94500632	3,418,232	112,246	
Oct-1996	FAA	7180137	6,166,355	46,526	
Oct-1996	Battery 407	5064437	636,468	3,198	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Oct-1996	Cannon Club	14991355	49,729,640	122,872	1,040,227
Oct-1996	Cannon Club (Harlow)	93737807	8,136,190	125,945	
Nov-1996	Bldg 301	7029377	43,160,492	31,950	
Nov-1996	Bldg 303	94500633	2,084,590	24,156	
Nov-1996	Bldg 304	80428662	4,016,938	9,302	
Nov-1996	Diamond Head Park	14087805	56,795,565	112,887	
Nov-1996	Battery Harlow	4402022	1,243,060	3,200	
Nov-1996	Birkhimer EOC	94500632	3,438,584	20,352	
Nov-1996	FAA	7180137	6,206,864	40,509	
Nov-1996	Battery 407	5064437	639,582	3,114	
Nov-1996	Cannon Club	14991355	49,808,918	79,278	324,748
Nov-1996	Cannon Club (Harlow)	93737807	8,219,036	82,846	
Dec-1996	Bldg 301	7029377	43,193,680	33,188	
Dec-1996	Bldg 303	94500633	2,118,900	34,310	
Dec-1996	Bldg 304	80428662	4,027,110	10,172	
Dec-1996	Diamond Head Park	14087805	56,977,000	181,435	
Dec-1996	Battery Harlow	4402022	1,267,600	24,540	
Dec-1996	Birkhimer EOC	94500632	3,451,650	13,066	
Dec-1996	FAA	7180137	6,241,495	34,631	
Dec-1996	Battery 407	5064437	648,715	9,133	
Dec-1996	Cannon Club	14991355	49,898,600	89,682	430,157
Dec-1996	Cannon Club (Harlow)	93737807	8,313,000	93,964	
Jan-1997	Bldg 301	7029377	43,243,045	49,365	
Jan-1997	Bldg 303	94500633	2,142,412	23,512	
Jan-1997	Bldg 304	80428662	4,034,776	7,666	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Jan-1997	Diamond Head Park	14087805	57,070,645	93,645	
Jan-1997	Battery Harlow	4402022	1,272,198	4,598	
Jan-1997	Birkhimer EOC	94500632	3,461,762	10,112	
Jan-1997	FAA	7180137	6,276,654	35,159	
Jan-1997	Battery 407	5064437	656,980	8,265	
Jan-1997	Cannon Club	14991355	49,963,380	64,780	297,102
Jan-1997	Cannon Club (Harlow)	93737807	8,381,275	68,275	
Feb-1997	Bldg 301	7029377	43,280,050	37,005	
Feb-1997	Bldg 303	94500633	2,165,518	23,106	
Feb-1997	Bldg 304	80428662	4,044,916	10,140	
Feb-1997	Diamond Head Park	14087805	57,275,185	204,540	
Feb-1997	Battery Harlow	4402022	1,276,710	4,512	
Feb-1997	Birkhimer EOC	94500632	3,471,148	9,386	
Feb-1997	FAA	7180137	6,310,124	33,470	
Feb-1997	Battery 407	5064437	662,757	5,777	
Feb-1997	Cannon Club	14991355	50,069,025	105,645	433,581
Feb-1997	Cannon Club (Harlow)	93737807	8,489,218	107,943	
Mar-1997	Bldg 301	7029377	43,315,090	35,040	
Mar-1997	Bldg 303	94500633	2,196,240	30,722	
Mar-1997	Bldg 304	80428662	4,053,189	8,273	
Mar-1997	Diamond Head Park	14087805	57,487,940	212,755	
Mar-1997	Battery Harlow	4402022	1,288,710	12,000	
Mar-1997	Birkhimer EOC	94500632	3,485,455	14,307	
Mar-1997	FAA	7180137	6,341,143	31,019	
Mar-1997	Battery 407	5064437	663,869	1,112	
Mar-1997	Cannon Club	14991355	50,150,170	81,145	426,373

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Mar-1997	Cannon Club (Harlow)	93737807	8,573,984	84,766	
Apr-1997	Bldg 301	7029377	43,369,320	54,230	
Apr-1997	Bldg 303	94500633	2,233,498	37,258	
Apr-1997	Bldg 304	80428662	4,062,296	9,107	
Apr-1997	Diamond Head Park	14087805	57,590,968	103,028	
Apr-1997	Battery Harlow	4402022	1,406,540	117,830	
Apr-1997	Birkhimer EOC	94500632	3,529,225	43,770	
Apr-1997	FAA	7180137	6,379,728	38,585	
Apr-1997	Battery 407	5064437	667,248	3,379	
Apr-1997	Cannon Club	14991355	50,241,632	91,462	498,649
Apr-1997	Cannon Club (Harlow)	93737807	8,668,678	94,694	
May-1997	Bldg 301	7029377	43,521,278	151,958	
May-1997	Bldg 303	94500633	2,418,625	185,127	
May-1997	Bldg 304	80428662	4,074,911	12,615	
May-1997	Diamond Head Park	14087805	57,742,855	151,887	
May-1997	Battery Harlow	4402022	1,412,607	6,067	
May-1997	Birkhimer EOC	94500632	3,538,786	9,561	
May-1997	FAA	7180137	6,420,319	40,591	
May-1997	Battery 407	5064437	670,462	3,214	
May-1997	Cannon Club	14991355	50,379,567	137,935	698,955
May-1997	Cannon Club (Harlow)	93737807	8,808,880	140,202	
Jun-1997	Bldg 301	7029377	43,974,600	453,322	
Jun-1997	Bldg 303	94500633	2,488,660	70,035	
Jun-1997	Bldg 304	80428662	4,096,960	22,049	
Jun-1997	Diamond Head Park	14087805	57,879,414	136,559	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Jun-1997	Battery Harlow	4402022	1,414,756	2,149	
Jun-1997	Birkhimer EOC	94500632	3,574,885	36,099	
Jun-1997	FAA	7180137	6,466,640	46,321	
Jun-1997	Battery 407	5064437	673,074	2,612	
Jun-1997	Cannon Club	14991355	50,676,092	296,525	1,065,671
Jun-1997	Cannon Club (Harlow)	93737807	9,102,085	293,205	
Jul-1997	Bldg 301	7029377	44,400,930	426,330	
Jul-1997	Bldg 303	94500633	2,615,647	126,987	
Jul-1997	Bldg 304	80428662	4,129,540	32,580	
Jul-1997	Diamond Head Park	14087805	58,117,610	238,196	
Jul-1997	Battery Harlow	4402022	1,419,900	5,144	
Jul-1997	Birkhimer EOC	94500632	3,616,419	41,534	
Jul-1997	FAA	7180137	6,522,622	55,982	
Jul-1997	Battery 407	5064437	683,087	10,013	
Jul-1997	Cannon Club	14991355			
Jul-1997	Cannon Club (Harlow)	93737807	9,141,610	39,525	
Aug-1997	Bldg 301	7029377	44,659,415	258,485	
Aug-1997	Bldg 303	94500633	2,677,927	62,280	
Aug-1997	Bldg 304	80428662	4,160,188	30,648	
Aug-1997	Diamond Head Park	14087805	58,270,781	153,171	
Aug-1997	Battery Harlow	4402022	1,424,360	4,460	
Aug-1997	Birkhimer EOC	94500632	3,655,724	39,305	
Aug-1997	FAA	7180137	6,677,288	154,666	???
Aug-1997	Battery 407	5064437	687,555	4,468	
Aug-1997	Cannon Club	14991355			
Aug-1997	Cannon Club (Harlow)	93737807	9,253,364	111,754	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Sep-1997	Bldg 301	7029377	44,992,540	333,125	
Sep-1997	Bldg 303	94500633	2,747,310	69,383	
Sep-1997	Bldg 304	80428662	4,188,550	28,362	
Sep-1997	Diamond Head Park	14087805	58,439,679	168,898	
Sep-1997	Battery Harlow	4402022	1,437,100	12,740	
Sep-1997	Birkhimer EOC	94500632	3,715,210	59,486	
Sep-1997	FAA	7180137	6,633,500	-43,788	????
Sep-1997	Battery 407	5064437	690,350	2,795	
Sep-1997	Cannon Club	14991355			
Sep-1997	Cannon Club (Harlow)	93737807	9,380,880	127,516	
Oct-1997	Bldg 301	7029377	45,147,890	155,350	
Oct-1997	Bldg 303	94500633	2,771,485	24,175	
Oct-1997	Bldg 304	80428662	4,212,695	24,145	
Oct-1997	Diamond Head Park	14087805	58,550,710	111,031	
Oct-1997	Battery Harlow	4402022	144,144	1,292,956	✓
Oct-1997	Birkhimer EOC	94500632	3,757,155	41,945	
Oct-1997	FAA	7180137	6,685,540	52,040	
Oct-1997	Battery 407	5064437	693,380	3,030	
Oct-1997	Cannon Club	14991355			
Oct-1997	Cannon Club (Harlow)	93737807	9,393,020	12,140	
Nov-1997	Bldg 301	7029377	45,173,285	25,395	
Nov-1997	Bldg 303	94500633	2,789,518	18,033	
Nov-1997	Bldg 304	80428662	4,227,787	15,092	
Nov-1997	Diamond Head Park	14087805	58,635,163	84,453	
Nov-1997	Battery Harlow	4402022	146,125	1,981	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Nov-1997	Birkhimer EOC	94500632	3,778,455	21,300	
Nov-1997	FAA	7180137	6,723,165	37,625	
Nov-1997	Battery 407	5064437	695,454	2,074	
Nov-1997	Cannon Club	14991355			
Nov-1997	Cannon Club (Harlow)	93737807	9,407,440	14,420	
Dec-1997	Bldg 301	7029377	45,338,762	165,477	
Dec-1997	Bldg 303	94500633	2,813,792	24,274	
Dec-1997	Bldg 304	80428662	4,240,625	12,838	
Dec-1997	Diamond Head Park	14087805	58,771,535	136,372	
Dec-1997	Battery Harlow	4402022	145,028	291,153	
Dec-1997	Birkhimer EOC	94500632	3,810,038	31,583	
Dec-1997	FAA	7180137	6,769,783	46,618	
Dec-1997	Battery 407	5064437	697,504	2,050	
Dec-1997	Cannon Club	14991355			
Dec-1997	Cannon Club (Harlow)	93737807	9,645,895	238,455	
Jan-1998	Bldg 301	7029377	45,424,581	85,819	
Jan-1998	Bldg 303	94500633	2,845,510	31,718	
Jan-1998	Bldg 304	80428662	4,247,475	6,850	
Jan-1998	Diamond Head Park	14087805	58,903,415	131,880	
Jan-1998	Battery Harlow	4402022	145,367	339	
Jan-1998	Birkhimer EOC	94500632	3,869,075	59,037	
Jan-1998	FAA	7180137	6,809,675	39,892	
Jan-1998	Battery 407	5064437	699,586	2,082	
Jan-1998	Cannon Club	14991355			
Jan-1998	Cannon Club (Harlow)	93737807	9,841,715	195,820	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Feb-1998	Bldg 301	7029377	46,188,700	764,119	
Feb-1998	Bldg 303	94500633	2,879,440	33,930	
Feb-1998	Bldg 304	80428662	4,281,460	33,985	
Feb-1998	Diamond Head Park	14087805	59,064,220	160,805	
Feb-1998	Battery Harlow	4402022	145,550	183	
Feb-1998	Birkhimer EOC	94500632	3,927,560	58,485	
Feb-1998	FAA	7180137	6,874,945	65,270	
Feb-1998	Battery 407	5064437	706,655	7,069	
Feb-1998	Cannon Club	14991355			
Feb-1998	Cannon Club (Harlow)	93737807	10,027,000	185,285	
Mar-1998	Bldg 301	7029377	46,439,390	250,690	
Mar-1998	Bldg 303	94500633	2,937,670	58,230	
Mar-1998	Bldg 304	80428662	4,307,750	26,290	
Mar-1998	Diamond Head Park	14087805	59,329,705	265,485	
Mar-1998	Battery Harlow	4402022	147,177	1,627	
Mar-1998	Birkhimer EOC	94500632	3,963,400	35,840	
Mar-1998	FAA	7180137	6,958,215	83,270	
Mar-1998	Battery 407	5064437	708,917	2,262	
Mar-1998	Cannon Club	14991355			
Mar-1998	Cannon Club (Harlow)	93737807	10,271,580	244,580	
Apr-1998	Bldg 301	7029377	47,128,465	689,075	
Apr-1998	Bldg 303	94500633	3,004,210	66,540	
Apr-1998	Bldg 304	80428662	4,343,500	35,750	
Apr-1998	Diamond Head Park	14087805	59,607,675	277,970	
Apr-1998	Battery Harlow	4402022	148,345	1,168	
Apr-1998	Birkhimer EOC	94500632	4,037,470	74,070	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Apr-1998	FAA	7180137	7,017,610	59,395	
Apr-1998	Battery 407	5064437	716,659	7,742	
Apr-1998	Cannon Club	14991355			
Apr-1998	Cannon Club (Harlow)	93737807	10,447,415	175,835	
May-1998	Bldg 301	7029377	47,285,260	156,795	
May-1998	Bldg 303	94500633	3,063,125	58,915	
May-1998	Bldg 304	80428662	4,369,435	25,935	
May-1998	Diamond Head Park	14087805	59,912,210	304,535	
May-1998	Battery Harlow	4402022	149,760	1,415	
May-1998	Birkhimer EOC	94500632	4,095,315	57,845	
May-1998	FAA	7180137	7,073,765	56,155	
May-1998	Battery 407	5064437	723,481	6,822	
May-1998	Cannon Club	14991355			
May-1998	Cannon Club (Harlow)	93737807	10,618,685	171,270	
Jul-1998	Bldg 301	7029377	47,589,065	303,805	
Jul-1998	Bldg 303	94500633	3,142,230	79,105	
Jul-1998	Bldg 304	80428662	4,430,620	61,185	
Jul-1998	Diamond Head Park	14087805	60,814,560	902,350	
Jul-1998	Battery Harlow	4402022	150,811	1,051	
Jul-1998	Birkhimer EOC	94500632	4,206,350	111,035	
Jul-1998	FAA	7180137	7,191,030	117,265	
Jul-1998	Battery 407	5064437	734,667	11,186	
Jul-1998	Cannon Club	14991355			
Jul-1998	Cannon Club (Harlow)	93737807	11,106,815	488,130	
Aug-1998	Bldg 301	7029377	47,912,070	323,005	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption
Aug-1998	Bldg 303	94500633	3,194,360	52,130
Aug-1998	Bldg 304	80428662	4,448,460	17,840
Aug-1998	Diamond Head Park	14087805	61,309,410	494,850
Aug-1998	Battery Harlow	4402022	151,170	359
Aug-1998	Birkhimer EOC	94500632	4,265,820	59,470
Aug-1998	FAA	7180137	7,250,205	59,175
Aug-1998	Battery 407	5064437	740,096	5,429
Aug-1998	Cannon Club	14991355		
Aug-1998	Cannon Club (Harlow)	93737807	11,421,797	314,982
Sep-1998	Bldg 301	7029377	48,082,900	170,830
Sep-1998	Bldg 303	94500633	3,268,220	73,860
Sep-1998	Bldg 304	80428662	4,488,360	39,900
Sep-1998	Diamond Head Park	14087805	61,748,170	438,760
Sep-1998	Battery Harlow	4402022	151,998	828
Sep-1998	Birkhimer EOC	94500632	4,378,190	112,370
Sep-1998	FAA	7180137	7,314,190	63,985
Sep-1998	Battery 407	5064437	746,074	5,978
Sep-1998	Cannon Club	14991355		
Sep-1998	Cannon Club (Harlow)	93737807	11,671,320	249,523
Oct-1998	Bldg 301	7029377	48,399,880	316,980
Oct-1998	Bldg 303	94500633	3,356,375	88,155
Oct-1998	Bldg 304	80428662	4,507,530	19,170
Oct-1998	Diamond Head Park	14087805	62,174,840	426,670
Oct-1998	Battery Harlow	4402022	152,317	319
Oct-1998	Birkhimer EOC	94500632	4,440,380	62,190
Oct-1998	FAA	7180137	7,380,565	66,375

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Oct-1998	Battery 407	5064437	752,861	6,787	
Oct-1998	Cannon Club	14991355			
Oct-1998	Cannon Club (Harlow)	93737807	12,008,150	336,830	
Nov-1998	Bldg 301	7029377	48,426,820	26,940	
Nov-1998	Bldg 303	94500633	3,379,755	23,380	
Nov-1998	Bldg 304	80428662	4,525,450	17,920	
Nov-1998	Diamond Head Park	14087805	62,449,355	274,515	
Nov-1998	Battery Harlow	4402022	152,518	201	
Nov-1998	Birkhimer EOC	94500632	4,446,685		
Nov-1998	FAA	7180137	7,428,810	48,245	
Nov-1998	Battery 407	5064437	755,686	2,825	
Nov-1998	Cannon Club	14991355			
Nov-1998	Cannon Club (Harlow)	93737807	12,116,075	107,925	
Dec-1998	Bldg 301	7029377	48,621,790	194,970	
Dec-1998	Bldg 303	94500633	3,423,790	44,035	
Dec-1998	Bldg 304	80428662	4,570,230	44,780	
Dec-1998	Diamond Head Park	14087805	62,940,570	491,215	
Dec-1998	Battery Harlow	4402022	152,812	294	
Dec-1998	Birkhimer EOC	94500632	4,538,265	91,580	
Dec-1998	FAA	7180137	7,493,220	64,410	
Dec-1998	Battery 407	5064437	766,373	10,687	
Dec-1998	Cannon Club	14991355			
Dec-1998	Cannon Club (Harlow)	93737807	12,130,680	14,605	
Jan-1999	Bldg 301	7029377	48,639,640	17,850	
Jan-1999	Bldg 303	94500633	3,443,720	19,930	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Jan-1999	Bldg 304	80428662	4,577,940	7,710	
Jan-1999	Diamond Head Park	14087805	63,191,130	250,560	
Jan-1999	Battery Harlow	4402022	152,945	133	
Jan-1999	Birkhimer EOC	94500632	4,556,640	18,375	
Jan-1999	FAA	7180137	7,542,730	49,510	
Jan-1999	Battery 407	5064437	772,887	6,514	
Jan-1999	Cannon Club	14991355			
Jan-1999	Cannon Club (Harlow)	93737807	12,148,945	18,265	
Feb-1999	Bldg 301	7029377	48,666,580	26,940	
Feb-1999	Bldg 303	94500633	3,475,265	31,545	
Feb-1999	Bldg 304	80428662	4,587,095	9,155	
Feb-1999	Diamond Head Park	14087805	63,446,730	255,600	
Feb-1999	Battery Harlow	4402022	153,213	268	
Feb-1999	Birkhimer EOC	94500632	4,600,946	44,306	
Feb-1999	FAA	7180137	7,584,235	41,505	
Feb-1999	Battery 407	5064437	779,874	6,987	
Feb-1999	Cannon Club	14991355			
Feb-1999	Cannon Club (Harlow)	93737807	12,182,870	33,925	
Mar-1999	Bldg 301	7029377	48,886,315	219,735	
Mar-1999	Bldg 303	94500633	3,509,280	34,015	
Mar-1999	Bldg 304	80428662	4,596,960	9,865	
Mar-1999	Diamond Head Park	14087805	63,723,515	276,785	
Mar-1999	Battery Harlow	4402022	153,967	754	
Mar-1999	Birkhimer EOC	94500632	4,662,485	61,539	
Mar-1999	FAA	7180137	7,633,940	49,705	
Mar-1999	Battery 407	5064437	791,047	11,173	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption
Mar-1999	Cannon Club	14991355		
Mar-1999	Cannon Club (Harlow)	93737807	12,226,940	44,070
Apr-1999	Bldg 301	7029377	48,953,420	67,105
Apr-1999	Bldg 303	94500633	3,534,160	24,880
Apr-1999	Bldg 304	80428662	4,612,825	15,865
Apr-1999	Diamond Head Park	14087805	63,982,775	259,260
Apr-1999	Battery Harlow	4402022	154,114	147
Apr-1999	Birkhimer EOC	94500632	4,715,155	52,670
Apr-1999	FAA	7180137	7,685,655	51,715
Apr-1999	Battery 407	5064437	797,691	6,644
Apr-1999	Cannon Club	14991355		
Apr-1999	Cannon Club (Harlow)	93737807	12,364,400	137,460
May-1999	Bldg 301	7029377	49,132,420	179,000
May-1999	Bldg 303	94500633	3,573,620	39,460
May-1999	Bldg 304	80428662	4,622,885	10,060
May-1999	Diamond Head Park	14087805	64,229,160	246,385
May-1999	Battery Harlow	4402022	154,114	0
May-1999	Birkhimer EOC	94500632	4,919,790	204,635
May-1999	FAA	7180137	7,731,770	46,115
May-1999	Battery 407	5064437	802,694	5,003
May-1999	Cannon Club	14991355		
May-1999	Cannon Club (Harlow)	93737807	12,606,090	241,690
Jun-1999	Bldg 301	7029377	49,473,485	341,065
Jun-1999	Bldg 303	94500633	3,621,180	47,560
Jun-1999	Bldg 304	80428662	4,632,225	9,340

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Jun-1999	Diamond Head Park	14087805	64,509,965	280,805	
Jun-1999	Battery Harlow	4402022	154,114	0	
Jun-1999	Birkhimer EOC	94500632	4,972,520	52,730	
Jun-1999	FAA	7180137	7,788,545	56,775	
Jun-1999	Battery 407	5064437	808,252	5,558	
Jun-1999	Cannon Club	14991355			
Jun-1999	Cannon Club (Harlow)	93737807	12,841,392	235,302	
Jul-1999	Bldg 301	7029377	49,887,830	414,345	
Jul-1999	Bldg 303	94500633	3,685,230	64,050	
Jul-1999	Bldg 304	80428662	4,746,650	114,425	
Jul-1999	Diamond Head Park	14087805	64,780,870	270,905	
Jul-1999	Battery Harlow	4402022	154,114	0	
Jul-1999	Birkhimer EOC	94500632	5,073,290	100,770	
Jul-1999	FAA	7180137	7,852,900	64,355	
Jul-1999	Battery 407	5064437	816,727	8,475	
Jul-1999	Cannon Club	14991355			
Jul-1999	Cannon Club (Harlow)	93737807	13,090,210	248,818	
Aug-1999	Bldg 301	7029377	50,138,430	250,600	
Aug-1999	Bldg 303	94500633	3,732,625	47,395	
Aug-1999	Bldg 304	80428662	4,908,430	161,780	
Aug-1999	Diamond Head Park	14087805	65,234,935	454,065	
Aug-1999	Battery Harlow	4402022	154,114	0	
Aug-1999	Birkhimer EOC	94500632	5,210,860	137,570	
Aug-1999	FAA	7180137	7,915,925	63,025	
Aug-1999	Battery 407	5064437	826,813	10,086	
Aug-1999	Cannon Club	14991355			

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Aug-1999	Cannon Club (Harlow)	93737807	13,322,775	232,565	
Sep-1999	Bldg 301	7029377	50,387,390	248,960	
Sep-1999	Bldg 303	94500633	3,798,340	65,715	
Sep-1999	Bldg 304	80428662	4,937,225	28,795	
Sep-1999	Diamond Head Park	14087805	65,569,550	334,615	
Sep-1999	Battery Harlow	4402022	154,114	0	
Sep-1999	Birkhimer EOC	94500632	5,270,597	59,737	
Sep-1999	FAA	7180137	7,985,270	69,345	
Sep-1999	Battery 407	5064437	832,905	6,092	
Sep-1999	Cannon Club	14991355			
Sep-1999	Cannon Club (Harlow)	93737807	13,556,155	233,380	
Oct-1999	Bldg 301	7029377	50,465,760	78,370	
Oct-1999	Bldg 303	94500633	3,838,720	40,380	
Oct-1999	Bldg 304	80428662	4,952,960	15,735	
Oct-1999	Diamond Head Park	14087805	65,901,490	331,940	
Oct-1999	Battery Harlow	4402022	1,244	1,244	
Oct-1999	Birkhimer EOC	94500632	5,314,520	43,923	
Oct-1999	FAA	7180137	8,044,765	59,495	
Oct-1999	Battery 407	5064437	838,111	5,206	
Oct-1999	Cannon Club	14991355			
Oct-1999	Cannon Club (Harlow)	93737807	13,558,600	2,445	
Nov-1999	Bldg 301	7029377	50,502,600	36,840	
Nov-1999	Bldg 303	94500633	3,872,900	34,180	
Nov-1999	Bldg 304	80428662	4,967,400	14,440	
Nov-1999	Diamond Head Park	14087805	66,243,900	342,410	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption
Nov-1999	Battery Harlow	4402022	1,540	296
Nov-1999	Birkhimer EOC	94500632	5,359,700	45,180
Nov-1999	FAA	7180137	8,094,400	49,635
Nov-1999	Battery 407	5064437	845,900	7,789
Nov-1999	Cannon Club	14991355		
Nov-1999	Cannon Club (Harlow)	93737807	13,558,600	0
Dec-1999	Bldg 301	7029377	50,634,750	132,150
Dec-1999	Bldg 303	94500633	3,891,590	18,690
Dec-1999	Bldg 304	80428662	4,986,195	18,795
Dec-1999	Diamond Head Park	14087805	66,549,520	305,620
Dec-1999	Battery Harlow	4402022	7,526	5,986
Dec-1999	Birkhimer EOC	94500632	5,396,655	36,955
Dec-1999	FAA	7180137	8,138,430	44,030
Dec-1999	Battery 407	5064437	856,630	10,730
Dec-1999	Cannon Club	14991355		
Dec-1999	Cannon Club (Harlow)	93737807	13,558,605	5
Jan-2000	Bldg 301	7029377	50,652,645	17,895
Jan-2000	Bldg 303	94500633	3,920,760	29,170
Jan-2000	Bldg 304	80428662	4,999,715	13,520
Jan-2000	Diamond Head Park	14087805	66,876,601	327,081
Jan-2000	Battery Harlow	4402022	10,216	2,690
Jan-2000	Birkhimer EOC	94500632	5,430,575	33,920
Jan-2000	FAA	7180137	8,190,368	51,938
Jan-2000	Battery 407	5064437	865,771	9,141
Jan-2000	Cannon Club	14991355		
Jan-2000	Cannon Club (Harlow)	93737807	13,558,605	0

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Feb-2000	Bldg 301	7029377	50,672,815	20,170	
Feb-2000	Bldg 303	94500633	3,972,535	51,775	
Feb-2000	Bldg 304	80428662	5,016,435	16,720	
Feb-2000	Diamond Head Park	14087805	67,249,655	373,054	
Feb-2000	Battery Harlow	4402022	23,441	13,225	
Feb-2000	Birkhimer EOC	94500632	5,491,235	60,660	
Feb-2000	FAA	7180137	8,267,355	76,987	
Feb-2000	Battery 407	5064437	874,304	8,533	
Feb-2000	Cannon Club	14991355			
Feb-2000	Cannon Club (Harlow)	93737807	13,558,605	0	
Apr-2000	Bldg 301	7029377	50,996,183	323,368	
Apr-2000	Bldg 303	94500633	4,060,894	88,359	
Apr-2000	Bldg 304	80428662	5,060,894	44,459	
Apr-2000	Diamond Head Park	14087805	67,935,938	686,283	
Apr-2000	Battery Harlow	4402022	79,981	56,540	
Apr-2000	Birkhimer EOC	94500632	5,570,862	79,627	
Apr-2000	FAA	7180137	8,394,137	126,782	
Apr-2000	Battery 407	5064437	886,765	12,461	
Apr-2000	Cannon Club	14991355			
Apr-2000	Cannon Club (Harlow)	93737807	13,558,605	0	
May-2000	Bldg 301	7029377	51,022,398	26,215	
May-2000	Bldg 303	94500633	4,173,850	112,956	
May-2000	Bldg 304	80428662	5,095,360	34,466	
May-2000	Diamond Head Park	14087805	68,241,855	305,917	
May-2000	Battery Harlow	4402022	112,365	32,384	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
May-2000	Birkhimer EOC	94500632	5,621,778	50,916	
May-2000	FAA	7180137	8,454,795	60,658	
May-2000	Battery 407	5064437	893,167	6,402	
May-2000	Cannon Club	14991355			
May-2000	Cannon Club (Harlow)	93737807	13,558,605	0	
Jun-2000	Bldg 301	7029377	51,869,068	846,670	
Jun-2000	Bldg 303	94500633	4,222,035	48,185	
Jun-2000	Bldg 304	80428662	5,150,710	55,350	
Jun-2000	Diamond Head Park	14087805	68,554,080	312,225	
Jun-2000	Battery Harlow	4402022	117,034	4,669	
Jun-2000	Birkhimer EOC	94500632	5,682,443	60,665	
Jun-2000	FAA	7180137	8,507,515	52,720	
Jun-2000	Battery 407	5064437	900,498	7,331	
Jun-2000	Cannon Club	14991355			
Jun-2000	Cannon Club (Harlow)	93737807	13,558,605	0	
Jul-2000	Bldg 301	7029377	52,071,245	202,177	
Jul-2000	Bldg 303	94500633	4,265,175	43,140	
Jul-2000	Bldg 304	80428662	5,174,942	24,232	
Jul-2000	Diamond Head Park	14087805	68,860,550	306,470	
Jul-2000	Battery Harlow	4402022	135,736	18,702	
Jul-2000	Birkhimer EOC	94500632	5,801,894	119,451	
Jul-2000	FAA	7180137	8,555,219	47,704	
Jul-2000	Battery 407	5064437	906,117	5,619	
Jul-2000	Cannon Club	14991355			
Jul-2000	Cannon Club (Harlow)	93737807	13,558,605	0	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Aug-2000	Bldg 301	7029377	52,813,145	741,900	
Aug-2000	Bldg 303	94500633	4,382,375	117,200	
Aug-2000	Bldg 304	80428662	5,209,788	34,846	
Aug-2000	Diamond Head Park	14087805	69,309,890	449,340	
Aug-2000	Battery Harlow	4402022	151,565	15,829	
Aug-2000	Birkhimer EOC	94500632	5,834,660	32,766	
Aug-2000	FAA	7180137	8,611,210	55,991	
Aug-2000	Battery 407	5064437	915,065	8,948	
Aug-2000	Cannon Club	14991355			
Aug-2000	Cannon Club (Harlow)	93737807	13,558,605	0	
Sep-2000	Bldg 301	7029377	53,378,745	565,600	
Sep-2000	Bldg 303	94500633	4,463,550	81,175	
Sep-2000	Bldg 304	80428662	5,232,990	23,202	
Sep-2000	Diamond Head Park	14087805	69,705,390	395,500	
Sep-2000	Battery Harlow	4402022	160,002	8,437	
Sep-2000	Birkhimer EOC	94500632	5,879,468	44,808	
Sep-2000	FAA	7180137	8,662,348	51,138	
Sep-2000	Battery 407	5064437	922,139	7,074	
Sep-2000	Cannon Club	14991355			
Sep-2000	Cannon Club (Harlow)	93737807	13,558,605	0	1,176,934
Oct-2000	Bldg 301	7029377	53,874,080	495,335	
Oct-2000	Bldg 303	94500633	4,513,830	50,280	
Oct-2000	Bldg 304	80428662	5,270,515	37,525	
Oct-2000	Diamond Head Park	14087805	70,007,318	301,928	
Oct-2000	Battery Harlow	4402022	164,744	4,742	
Oct-2000	Birkhimer EOC	94500632	5,892,905	13,437	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Oct-2000	FAA	7180137	8,706,703	44,355	
Oct-2000	Battery 407	5064437	926,217	4,078	
Oct-2000	Cannon Club	14991355			
Oct-2000	Cannon Club (Harlow)	93737807	13,559,284	679	
					952,359
Nov-2000	Bldg 301	7029377	54,132,750	258,670	
Nov-2000	Bldg 303	94500633	4,583,865	70,035	
Nov-2000	Bldg 304	80428662	5,307,388	36,873	
Nov-2000	Diamond Head Park	14087805	70,444,785	437,467	
Nov-2000	Battery Harlow	4402022	174,344	9,600	
Nov-2000	Birkhimer EOC	94500632	5,930,010	37,105	
Nov-2000	FAA	7180137	8,748,698	41,995	
Nov-2000	Battery 407	5064437	934,347	8,130	
Nov-2000	Cannon Club	14991355			
Nov-2000	Cannon Club (Harlow)	93737807	13,562,150	2,866	
					902,741
Dec-2000	Bldg 301	7029377	54,417,375	284,625	
Dec-2000	Bldg 303	94500633	4,654,368	70,503	
Dec-2000	Bldg 304	80428662	5,345,070	37,682	
Dec-2000	Diamond Head Park	14087805	70,870,465	425,680	
Dec-2000	Battery Harlow	4402022	347,329	172,985	
Dec-2000	Birkhimer EOC	94500632	5,958,515	28,505	
Dec-2000	FAA	7180137	8,773,308	24,610	
Dec-2000	Battery 407	5064437	938,179	3,832	
Dec-2000	Cannon Club	14991355			
Dec-2000	Cannon Club (Harlow)	93737807	13,562,310	160	
					1,048,582

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Jan-2001	Bldg 301	7029377	55,828,528	1,411,153	
Jan-2001	Bldg 303	94500633	4,710,210	55,842	
Jan-2001	Bldg 304	80428662	5,378,891	33,821	
Jan-2001	Diamond Head Park	14087805	71,121,460	250,995	
Jan-2001	Battery Harlow	4402022	420,499	73,170	
Jan-2001	Birkhimer EOC	94500632	6,021,590	63,075	
Jan-2001	FAA	7180137	8,787,350	14,042	
Jan-2001	Battery 407	5064437	948,841	10,662	
Jan-2001	Cannon Club	14991355			
Jan-2001	Cannon Club (Harlow)	93737807	13,564,415	2,105	1,914,865
Feb-2001	Bldg 301	7029377	56,828,708	1,000,180	
Feb-2001	Bldg 303	94500633	4,762,350	52,140	
Feb-2001	Bldg 304	80428662	5,406,258	27,367	
Feb-2001	Diamond Head Park	14087805	71,359,350	237,890	
Feb-2001	Battery Harlow	4402022	608,526	188,027	
Feb-2001	Birkhimer EOC	94500632	6,115,378	93,788	
Feb-2001	FAA	7180137	8,794,248	6,898	
Feb-2001	Battery 407	5064437	953,257	4,416	
Feb-2001	Cannon Club	14991355			
Feb-2001	Cannon Club (Harlow)	93737807	13,566,040	1,625	1,612,331
Mar-2001	Bldg 301	7029377	58,425,210	1,596,502	
Mar-2001	Bldg 303	94500633	4,834,510	72,160	
Mar-2001	Bldg 304	80428662	5,453,070	46,812	
Mar-2001	Diamond Head Park	14087805	71,693,000	333,650	
Mar-2001	Battery Harlow	99459639	751,350	142,824	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Mar-2001	Birkhimer EOC	94500632	6,157,410	42,032	
Mar-2001	FAA	7180137	8,912,500	118,252	
Mar-2001	Battery 407	5064437	957,237	3,980	
Mar-2001	Cannon Club	14991355			
Mar-2001	Cannon Club (Harlow)	93737807	13,570,840	4,800	2,361,012
Apr-2001	Bldg 301	7029377	60,273,155	1,847,945	
Apr-2001	Bldg 303	94500633	4,891,730	57,220	
Apr-2001	Bldg 304	80428662	5,489,020	35,950	
Apr-2001	Diamond Head Park	14087805	71,918,120	225,120	
Apr-2001	Battery Harlow	99459639	786,846	35,496	
Apr-2001	Birkhimer EOC	94500632	6,172,452	15,042	
Apr-2001	FAA	7180137	9,108,555	196,055	
Apr-2001	Battery 407	5064437	969,165	11,928	
Apr-2001	Cannon Club	14991355			
Apr-2001	Cannon Club (Harlow)	93737807	13,583,130	12,290	2,437,046
May-2001	Bldg 301	7029377	61,699,576	1,426,421	
May-2001	Bldg 303	94500633	4,998,545	106,815	
May-2001	Bldg 304	80428662	5,527,784	38,764	
May-2001	Diamond Head Park	14087805	72,262,440	344,320	
May-2001	Battery Harlow	99459639	823,625	36,779	
May-2001	Birkhimer EOC	94500632	6,215,950	43,498	
May-2001	FAA	7180137			
May-2001	Battery 407	5064437	963,199	-5,966	
May-2001	Cannon Club	14991355			
May-2001	Cannon Club (Harlow)	93737807	13,598,750	15,620	2,006,251

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Jun-2001	Bldg 301	7029377	63,726,990	2,027,414	
Jun-2001	Bldg 303	94500633	5,071,390	72,845	
Jun-2001	Bldg 304	80428662	5,607,990	80,206	
Jun-2001	Diamond Head Park	14087805	72,591,120	328,680	
Jun-2001	Battery Harlow	99459639	839,489	15,864	
Jun-2001	Birkhimer EOC	94500632	6,386,389	170,439	
Jun-2001	FAA	7180137			
Jun-2001	Battery 407	5064437	964,661	1,462	
Jun-2001	Cannon Club	14991355			
Jun-2001	Cannon Club (Harlow)	93737807	13,598,760	10	
Jul-2001	Bldg 301	7029377	64,955,105	1,228,115	
Jul-2001	Bldg 303	94500633	5,162,750	91,360	
Jul-2001	Bldg 304	80428662	5,650,057	42,067	
Jul-2001	Diamond Head Park	14087805	73,019,835	428,715	
Jul-2001	Battery Harlow	99459639	11,204	-828,285	
Jul-2001	Birkhimer EOC	94500632	6,460,060	73,671	
Jul-2001	FAA	7180137			
Jul-2001	Battery 407	5064437	967,926	3,265	
Jul-2001	Cannon Club	14991355			
Jul-2001	Cannon Club (Harlow)	93737807	13,598,760	0	
Aug-2001	Bldg 301	7029377	67,613,130	2,658,025	
Aug-2001	Bldg 303	94500633	5,333,880	171,130	
Aug-2001	Bldg 304	80428662	5,676,708	26,651	
Aug-2001	Diamond Head Park	14087805	73,471,265	451,430	
Aug-2001	Battery Harlow	99459639	21,266	10,062	
Aug-2001	Birkhimer EOC	94500632	6,501,810	41,750	

DIAMOND HEAD STATE MONUMENT
Water Meter Readings

Month	Location	Meter No.	Meter Readings	Consumption	
Aug-2001	FAA	7180137			
Aug-2001	Battery 407	5064437	975,861	7,935	
Aug-2001	Cannon Club	14991355			
Aug-2001	Cannon Club (Harlow)	93737807	13,598,760	0	

Wastewater

Visitors/year = 1,000,000
Visitors/day = 1,000,000/365 = 2740 visitors/day, use 3,000
Employees = 25
Sewage Generation
Source: Wastewater Engineering, Third Edition, Metcalf & Eddy
Visitors: 4-8 gpd use 5 gpd
Employees: 7-16 gpd use 15 gpd

* Average Flow = ave. daily per capita

Visitors = 3,000 visitors/day × 5 gpd = 15,000 gpd
employees = 25 employees × 15 gpd = 375
15,375 gpd
= 10.6 gpm

* Maximum flow = ave. flow × flow factor
= 10.6 gpm × 5 → 53 gpm.

* Dry Weather Infiltration/Inflow = 5 gpcd
= 3025 persons × 5 gpcd = 15,125 gpd
= 10.5 gpm

* Design Ave Flow = Ave. flow + dry weather I/I
= 10.6 gpm + 10.5 gpm = 21.1 gpm.

* Design Maximum Flow = max. flow + dry weather I/I
= 53 gpm + 10.5 gpm = 63.5 gpm

* Wet Weather I/I = 7250 gpd × 300 acres = 375,000 gpd = 260 gpm
Design Peak Flow = Design Max. Flow + Wet Weather I/I
= 63.5 gpm + 260 gpm = 324 gpm

* Source: Design Standards of the Department of Wastewater Management, Volume 1, City and County of Honolulu, July 1993.

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

WATER SYSTEM QUANTITIES

12" WATER LINE
- REUSE EXIST. 12" LINE FROM D.H. ROAD TO TOP OF KAPAHULU TUNNEL
- 1200 LF - FROM KAPAHULU TUNNEL TO VISITOR CENTER

16" WATER LINE
- 3400 LF - FROM VISITOR CENTER TO TUNNEL 407

8" WATER LINE
- 1000 LF - FROM 12" LINE NEAR V.C. TO HYDRANT IN FRONT OF V.C.
- 100 LF - FROM 12" LINE TO VISITOR CENTER
1100LF

6" WATER LINE
- 50LF - FROM 8" LINE TO HYDRANT #1 IN FRONT OF V.C.
- 12 LF - FROM 12" LINE TO HYDRANT #2 IN BACK OF V.C.
- 12 LF - FROM 16" LINE TO HYDRANT #3 IN BACK OF V.C.
- 150LF - FROM 16" LINE TO HYDRANT #4 ADJACENT TO V.C.
- 12 LF - FROM 16" LINE TO HYDRANT #5 NEAR CARETAKER'S RESIDENCE
- 12LF - FROM 16" LINE TO HYDRANT #6 AT TUNNEL 407

248 LF

4" WATER LINE
- 700LF - FROM 8" LINE TO EXIST. COMFORT STATION

2" WATER LINE
- 600LF - FROM 12" LINE TO BIRKHIMER
- 500 LF - FROM 4" LINE TO COMFORT STATION NEAREST KAPAHULU TUNNEL
- 20 LF - FROM 4" LINE TO EXIST. COMFORT STATION
- 900 LF - FROM 4" LINE TO COMFORT STATION AT FIRING RANGE
- 60 LF - FROM 16" LINE TO CARETAKER'S RESIDENCE
- 120LF - FROM 16" LINE TO TUNNEL 407

1200LF

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT: Diamond Head State Monument	JOB NO.	SHEET OF
		DATE	

SEWER SYSTEM QUANTITIES

8" SEWER GRAVITY LINE

- 650 LF - FROM VISITOR CENTER TO LIFT STATION	4 MANHOLES
- 1600 LF - FROM TOP OF KAHALA TUNNEL TO C&C SYSTEM	5 M.H.
2250 LF	

6" SEWER FORCE MAIN

- 1200 LF - FROM LIFT STATION TO TOP OF KAHALA TUNNEL

6" SEWER GRAVITY LINE

- 3500 LF - FROM TUNNEL 407 TO 8" LINE IN FRONT OF V.C.	15 M.H.
- 300 LF - FROM BIRKHIMER TO V.C.	2 M.H.
- 1200 LF - FROM COMFORT STATION AT FIRING RANG TO LIFT STATION	6 M.H
- 20 LF - FROM EXIST. COMFORT STATION TO 6" LINE	
- 500 LF - FROM COMFORT STATION NEAREST KAPAHOLU TUNNEL TO 6" LINE	1 M.H.
- 60 LF - FROM CARETAKER'S RESIDENCE TO 6" LINE	
5580 LF	33 M.H.

DESCRIPTION	**Mitsunaga & Associates, Inc.**	BY:	CHECKED
	PROJECT: Diamond Head State Monument	JOB NO.	SHEET OF
		DATE	

IRRIGATION SYSTEM

IRRIGATION DEMAND

- 40.1 ACRES (PBR) = 1,790,000 SQ. FT. (1 ACRE IRRIGATED W/ POTABLE)
- DEMAND = 6900 GPD/ACRE
- AVERAGE DAILY DEMAND = (40.1)(6900) = 280,000 GPD

- ASSUME WELL CAPACITY = 100,000 GPD (24 HRS)
- PUMP FOR 18 HRS/DAY
- EFFECTIVE WELL CAPACITY = 100,000 GPD $(\frac{18}{24})$ = 75,000 GPD
- NO. OF WELLS = 280,000/75,000 = 3.7, USE 4 WELLS SPACED AT 1,000'

IRRIGATION WELLS

- WELL #1 (ACROSS 18TH AVE) - ELEV. = 135
- WELL #2 (ACROSS CHAPEL) - ELEV. = 160
- WELL #3 (AT BLD. 49 SITE) - ELEV. = 155
- WELL #4 (BELOW CANNON CLUB PARKING) - ELEV. = 110
- 4 PUMPS

IRRIGATION SYSTEM

- 4" IRRIGATION LINES
  - 3000 LF - CONNECTING WELLS
  - 1500 LF - FROM WELLS TO TOP OF KAPAHULU TUNNEL
  - 2200 LF - FROM TOP OF KAPAHULU TUNNEL TO WETLAND

  6700 LF

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT: Diamond Head State Monument	JOB NO.	SHEET OF
		DATE	

STORM DRAIN

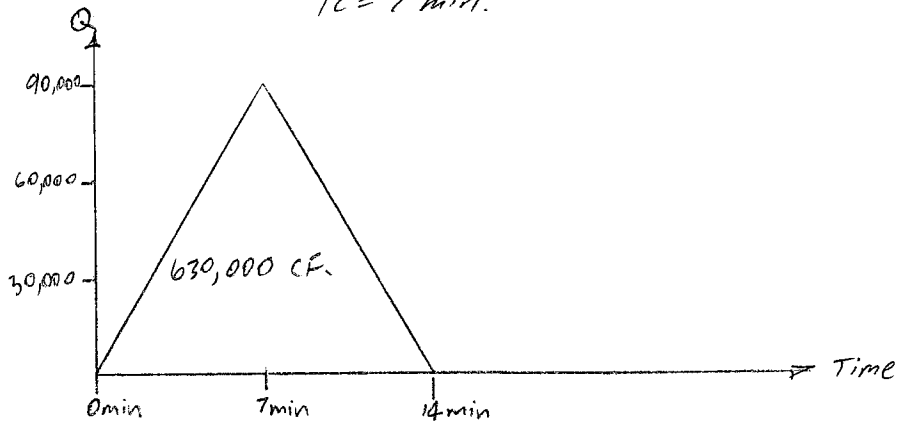
LIFT STATION DESIGN

CRATER AREA = 250 ACRES.

PEAK DISCHARGE = 1500 CFS (Plate 6) = 90,000 cfm

Concentration Time $T_c = 0.0076\left(\sqrt{\frac{L^3}{H}}\right)^{0.77}$ $L = 3000$, $H = 540$

$T_c = 7$ min.



Storage Area:

EL = 200 : Area = 80,000 SF. (assumed pond water surface)
EL = 210 : Area = 450,000 SF

let X = flood level above pond water surface.

Storage Volume $V = \left(\frac{450,000 - 80,000}{10\ ft}\right) \times \frac{X(2)80,000}{2} \times$

$V = 18,500X^2 + 80,000X$

For $V = 630,000$, $X = 4.06$ ft. rise in water level

∴ flood elev. = 204

TIME TO DRAIN

For pump flowing at 3,000 gpm:

630,000 cf = 4,700,000 gal.

$T = \frac{V}{Q}$

$T = \frac{4,700,000}{3,000}$

$T = 1,567$ min $\left(\frac{1\ hr}{60\ min}\right)$

$T = 26$ hours

FLOODED AREA

$A = \left(\frac{450,000 - 80,000}{10}\right)(4) + 80,000 = 228,000$ SF

Area = 5.2 ACRES

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
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		DATE	

DRAINAGE

CULVERT #1 - TUNNEL 407 ACCESS RD. NEAREST TO CRATER RD.

TRIBUTARY AREA: 265,000 SQ FT.
A = 6.1 ACRES.

RUNOFF COEFFICIENT: C = 0.9

RAINFALL INTENSITY:

$K = \sqrt{\frac{L^3}{H}} = \sqrt{\frac{150^3}{75}} = 212.$

USE T_c = 5 MIN.

CORRECTION FACTOR = 2.8

FOR T_m = 10 YR., I = 2.0.

$I_c = (2.0)(2.8) = 5.6$

$Q = CIA$
$Q = (0.9)(5.6)(6.1)$
$Q = 30.1$ CFS

18" PIPE, [illegible]

NORMAL DEPTH = 1.1 FT
VELOCITY = 20 FPS

24" PIPE,

NORMAL DEPTH = 0.9 FT
VELOCITY = 20 FPS

USE 18" PIPE, 4 - 18"Ø x 45' LONG = 180 LF

TRENCH: 2'x4'x 180' = 1440 CF = 53 CY

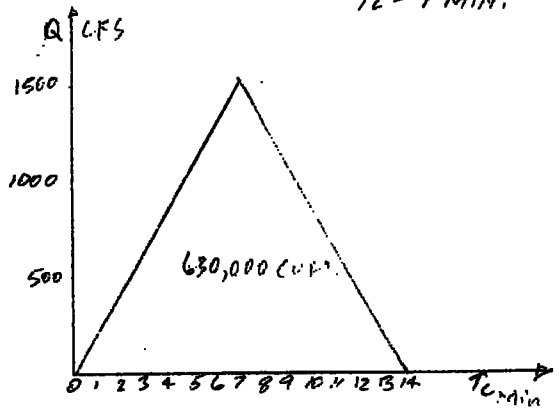
DISCHARGE PIPE

CRATER AREA: 250 ACRES

PEAK DISCHARGE = 1500 CFS (PLATE 6)

CONCENTRATION TIME $T_c = 0.0078\left(\sqrt{\frac{L^3}{H}}\right)^{0.77}$, L = 3000, H = 540

T_c = 7 MIN.



FOR 18" RCP, S = 0.1, FULL FLOW
Q = 32 CFS

TIME TO DRAIN = $\frac{630,000}{32}$ = 5.5 HOURS

USE 18" RCP
FORCE MAIN: 450 LF (12")
GRAVITY LINE: 1750 LF (18")
TOTAL: 2200 LF

TRENCH: 2'X4'X 2200' = 17,600 CF
= 652 CY

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

DRAINAGE SYSTEM

12" RCP FORCE MAIN

-600 LF - FROM LIFT STATION TO TOP OF KAHALA TUNNEL

18" RCP GRAVITY DRAIN LINE

- 1350 LF - FROM TOP OF KAHALA TUNNEL TO C&C STORM DRAIN

24" CMP CULVERTS

- 40 LF (9 EA) ALONG TROLLEY ROAD, INCL. HEAD WALL FOR EACH
- 75 LF (2 EA) ALONG TROLLEY ROAD, BETWEEN FIRING RANGE AND KAPAHULU TUNNEL

510 LF

MANHOLES

-4 EA - ALONG 18" GRAVITY LINE

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT: Diamond Head Gate Monument	JOB NO.	SHEET OF
		DATE	

WALKING PATHS

CONC. WALKWAY - ADA COMPLIANT - MIN. WIDTH = 6'-0"

- 2900 LF - FROM V.C. TO WETLAND
- 3000 LF - PICNIC AREA
- 1700 LF - V.C. TO FISHAL RANGE
- 200 LF - INTERIM VISITOR PARKING TO V.C.

7600 LF TOTAL

HIKING TRAILS - NON-ADA - WIDTH = 6'-0"

- 6700 LF - CRATER FLOOR
- 4100 LF - BATTER HULLINGS TO TUNNEL 407 (PROVIDE RAILINGS)
- 1100 LF - FIRING RANGE TO FLAT TOP RESERVOIR
- 3000 LF - TUNNEL 407 TO SUMMIT TRAL (PROVIDE RAILINGS)

14,900 LF

WETLAND IMPROVEMENTS

POND

- AREA = 80,000 SQ FT.
- DEPTH = 6 FEET AVE. w/ 5:1 SLOPE SIDES (EXCAVATE 1 FT. EXTRA FOR LINER)
- ELEV. = 198.0
- AREA GRADED AROUND POND 120,000 SQ. FT.
- TOTAL EXCAVATION = 21,000 CU. YD.

RUBBER LINER

- AREA = 80,000 SQ. FT.

SOIL OVER RUBBER LINER

- DEPTH = 12 IN.

IRRIGATION PUMP

- SERVICE CRATER FROM WETLAND
- 50 LF - 4" IRRIGATION LINE FROM POND TO PUMP

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT: Diamond Head State Monument	JOB NO.	SHEET OF
		DATE	

EXISTING ROADWAY IMPROVEMENTS

1½" A/C OVERLAY - INTERIOR OF CRATER

- 1600 LF X 12 FT WIDE - FROM KAPAHULU TUNNEL TO FAA LINK SITE (2133 SQ YDS)
- 600 LF X 10 FT. WIDE - ROAD TO BATTERY HULINGS (667 SQ. YDS.)
- 1300 LF X 12 FT WIDE - ROAD TO BATTERY BIRKHEIMER + 40 FT X 130 FT PARKING (2311 SQ. YDS.)

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

DEMOLITION

A/C PAVEMENT

- 37,500 SQ. YD. - CRATER INTERIOR

BUILDING FOUNDATION AND SLAB

- 9,800 SQ. YD. - FAA, HNG (301, 303, 304), MISC. BLDGS. IN VICINITY

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

APPROXIMATE QUANTITIES

CANNON CLUB PARKING. (1)

CLEARING & GRUBING.	4.7 ACRES
CUT & FILL PARKING LOT : Excavation = 3890 CY, FILL = 11,750 CY TROLLEY ROAD : Excavation = 4180 CY, FILL = 1110 CY	7040 CY IMPORTED BORROW
FINE GRADING	11,300 SY
6" BASE COURSE	850 CY
2" A/C PAVEMENT	5100 SY
CONC. CURB.	3800 LF

ACROSS KCC PARKING (2)

CLEARING & GRUBING	5.6 ACRES
CUT & FILL (Excavation - 6890 CY, Embankment = 8050)	2510 CY IMPORTED BORROW
FINE GRADING	11,100 SY
6" BASE COURSE	1600 CY
2" A/C PAVEMENT	9,500 SY
CONC. CURB	4,100 LF.

VISITOR CENTER #1

CLEARING & GRUBING	1.7 ACRES
CUT & FILL	10,300 CY CUT
6" GRAVITY SEWER LINE (TUNNEL 407)	3120 LF.
8" GRAVITY SEWER LINE (V.C. - MH = 760', FM - CONN = 1450')	2210 LF
8" SEWER FORCE MAIN	700 LF
~~6" & 8" SEWER TRENCH~~	~~2200 CY~~
SEWER MANHOLES	19 EA.
16" WATER LINE	6100 LF
~~16" WATER LINE TRENCH EXCAVATION & BACKFILL~~	~~8300 CY~~
8" WATER LINE	50 LF
~~8" WATER LINE TRENCH EXCAVATION & BACKFILL~~	~~17 CY~~
2" WATER LINE	50 LF
~~2" WATER LINE TRENCH~~	~~11 CY~~

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

VISITOR CENTER #1

CLEARING & GRUBING	1.7 ACRES
CUT & FILL	35,200 CY
6" GRAVITY SEWER LINE (TUNNEL 407)	5120 LF
8" GRAVITY SEWER LINE (V.C.-LS.= 1210, FM-CONN.= 1430)	2640 LF
8" SEWER FORCE MAIN	700 LF
~~6" & 8" SEWER TRENCH~~	~~2460 CY~~
SEWER MANHOLES	21 EA.
16" WATER LINE (TUNNEL 407)	6100 LF
8" WATER LINE (V.C.)	50 LF
~~8" WATER LINE TRENCH~~	~~17 CY~~
2" WATER LINE (BIRKHEIMER)	50 LF
~~2" WATER LINE TRENCH~~	~~11 CY~~

VISITOR CENTER #2

CLEARING & GRUBING	1.7 ACRES
CUT & FILL	31,700 CY
6" GRAVITY SEWER LINE (TUNNEL 407)	5220 LF
8" GRAVITY SEWER LINE (V.C.-LS.= 1320, FM-CONN= 1430)	2750 LF
8" SEWER FORCE MAIN	700 LF
~~6" & 8" SEWER TRENCH~~	~~2470 CY~~
SEWER MANHOLES	23 EA.
16" WATER LINE (TUNNEL 407)	6100 LF
8" WATER LINE (V.C.)	1400 LF
~~8" WATER LINE TRENCH~~	~~520 CY~~
2" WATER LINE (BIRKHEIMER)	50 LF
~~2" WATER LINE TRENCH~~	~~11 CY~~

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

VISITOR CENTER #4

CLEARING & GRUBBING	1.7 ACRES.
CUT & FILL	54,100 CY
8" GRAVITY SEWER LINE (V.C.-L.S.=2649 FM-(ONN=1430)	4070 LF
4" FORCE MAIN	700 LF
~~8" SEWER TRENCH~~	~~1600 CY~~
SEWER MAN HOLES	16 EA.
16" WATER LINE	6100 LF
8" WATER LINE	50 LF
~~8" WATER LINE TRENCH~~	~~17 CY~~
2" WATER LINE	510 LF
~~2" WATER LINE TRENCH~~	~~11 CY~~

TUNNEL 427 ACCESS ROAD

ACCESS ROAD: 2,600 FT x 25 FT	7200 SY
TURN AROUND AREA: 100 FT x 300 FT	3300 SY
CONC. CURB (2X2600 + 2X300 + 100)	5900 LF
18" DRAIN PIPE (4X35')	140 LF
~~18" PIPE TRENCH~~	~~31 CY~~
HEAD WALL (2 x 4)	8 EA.

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

WATER SUPPLY LINE

WATER LINE DIST.

FROM STREET TO ENTRANCE OF TUNNEL

ΔELEV. ≈ 110' ELEV. = 160'

DIST. ≈ 1000'

FROM ENTRANCE OF KAPAHULU TUNNEL TO EXIT OF TUNNEL

ΔELEV. ≈ 30.0'

DIST. ≈ 550'

SITE #1 :

DIST. FROM KAPAHULU TUNNEL ≈ 1200'

ΔEL. ≈ 50'

SITE #2 :

DIST. FROM KAPAHULU TUNNEL = 0

ΔEL. = 0

SITE #3 :

DIST. FROM KAPAHULU TUNNEL ≈ 1500'

ΔEL ≈ 40'

SITE #4 : (FIRE FLOW)

DIST. FROM KAPAHULU TUNNEL ≈ 4550' ELEV. = 290'

ΔEL. ≈ 10'

FIRE FLOW DIST. = 1000 + 550 + 4550

= 6100 FT.

ΔELEV. = +110 + 30 − 10

= +130 FT

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
	PROJECT:	JOB NO.	SHEET OF
		DATE	

Improve existing Makapuu Ave/Diamond Head Road intersection to channelized/signalized intersection.

Diamond Head Road on same alignment as existing

Add one lane to DH side of DH Rd.

Add curb on widened side of street.

Add 8' shoulder on widened side of street

Assume 8' average cut:

Clearing & Grubbing

W = 12' + 8' + 6' + 5' = 31'

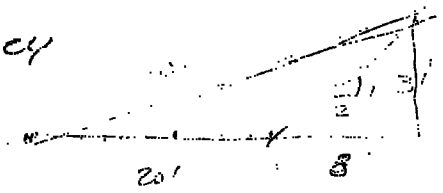
L = 900'

Area = 31' × 900' = 27,900 = 0.6 AC

Excavation

Area = $\frac{1}{2} \times 3 \times 8' - \frac{1}{2} \times 3 \times 6$ = 33 SF

Vol. = 33 sf × 900' = 29,700 CF = 1,100 CY



AC Pavement

W = 12'

L = 900'

Area = 12 × 900 = 10,800 SF = 1,200 SY

Aggregate base course (6")

Vol. = 12' × 900' × $\frac{6}{12}$ = 5,400 CF = 200 CY

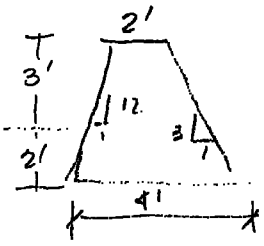
Striping

L = 900' × 2 = 1800 LF

Conc. curb = 900'

Rock Retaining Wall

3' high



area = 5' × $\frac{2'+4'}{2}$ = 15 SF/LF

length = 900'

Volume = 15 SF/LF × 900' = 13,500 CF = 500 CY

DESCRIPTION	Mitsunaga & Associates, Inc.	BY:	CHECKED
Intersection of Makapuu Ave	PROJECT: Diamond Head Wilderness Park	JOB NO.	SHEET OF 1
		DATE	

Appendix C

Water, Sewer and Drainage General Plans

Battery Harlow

Controlled Gate for EOC, Service & Emergency Vehicles

Entry Control

State Park Baseyard

McCorriston

Bus Stop

Traffic Signal

Chapel

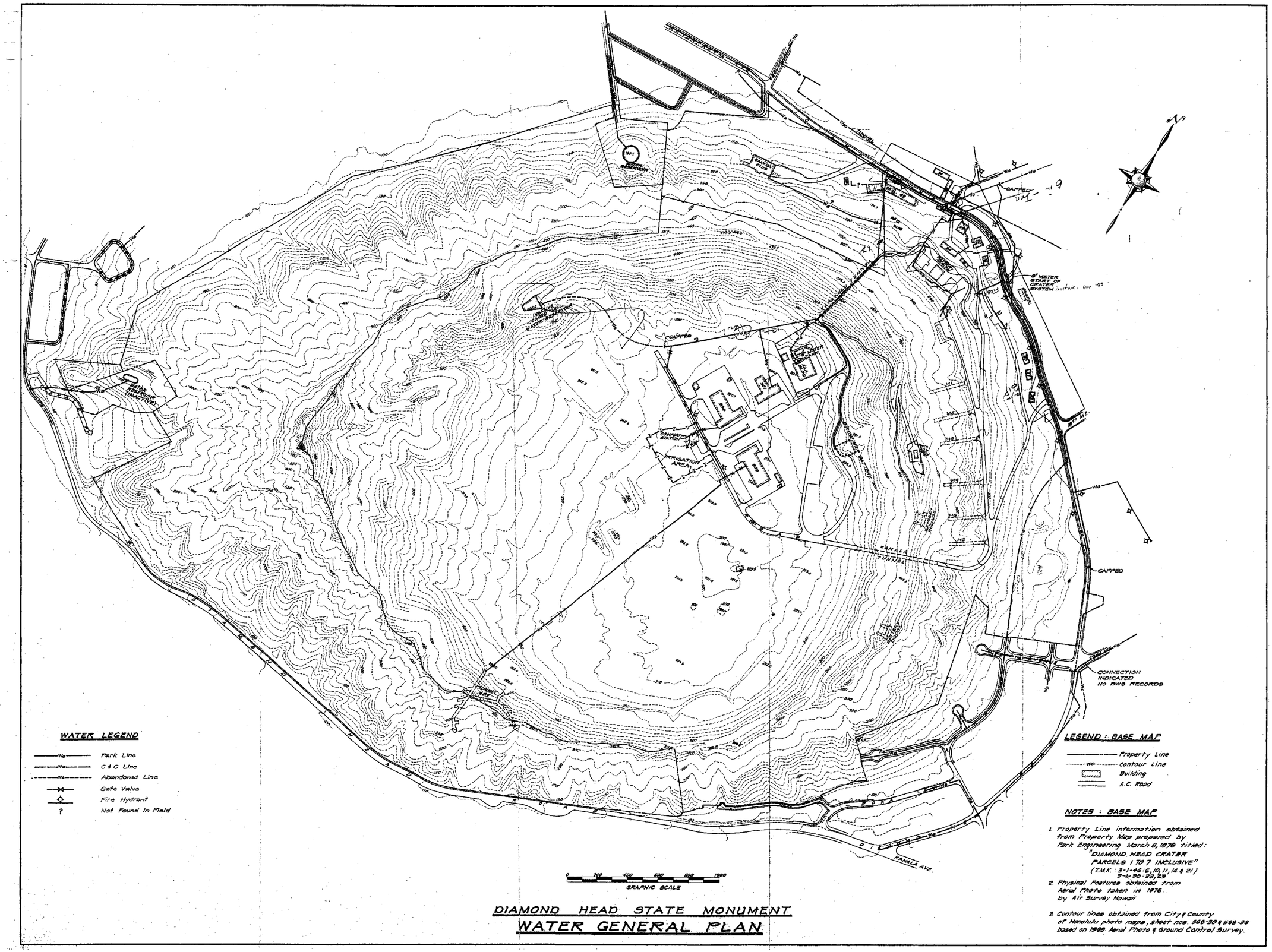
Bus Stop

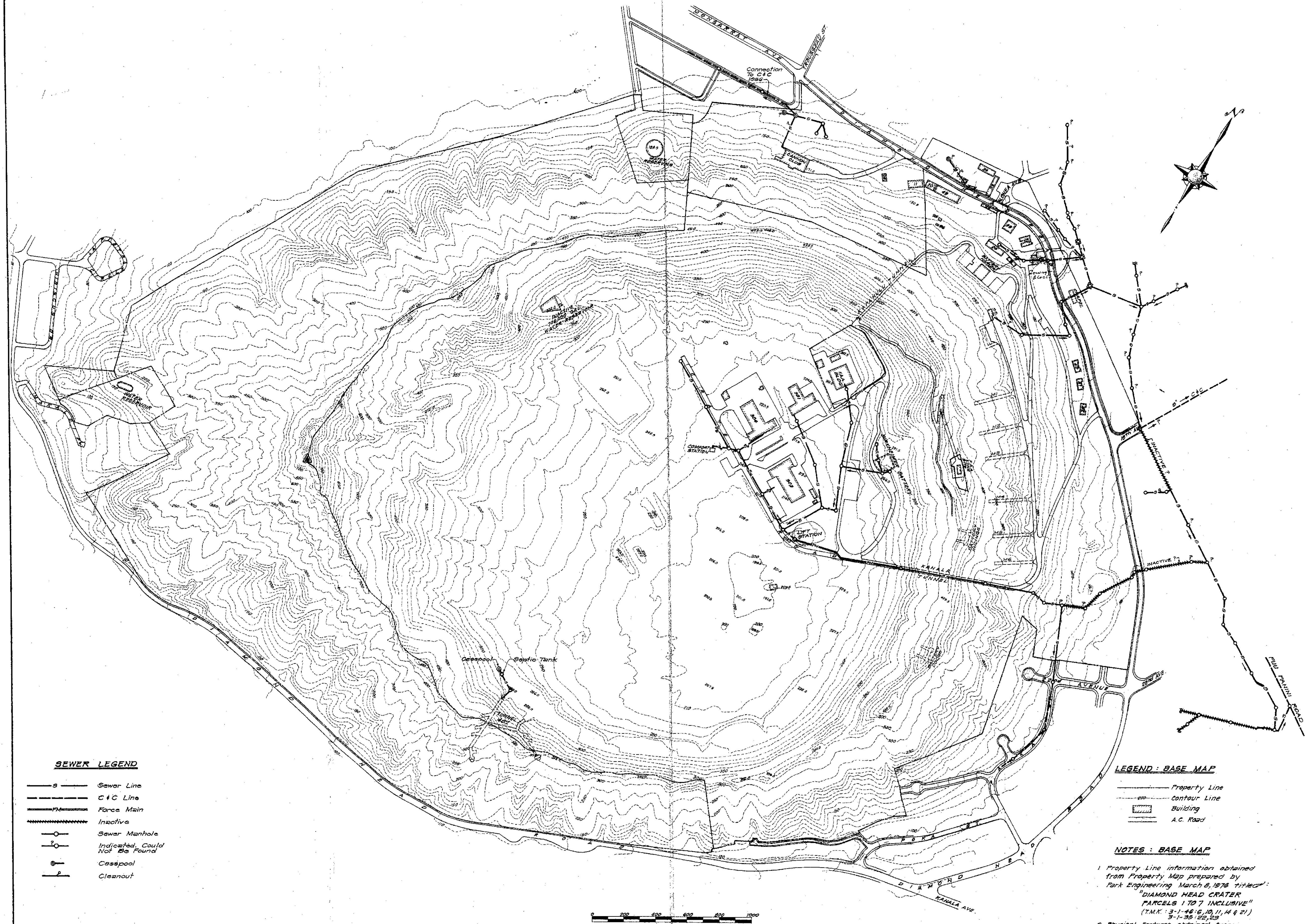
Kapiolani Community College

Alohea Avenue

Makapuu Avenue

Existing Sidewalk Does Not Meet ADA Guidelines


WATER LEGEND
We Mark Line
We C & C Line
We Abandoned Line
Gate Valve
Fire Hydrant
? Not Found In Field
0 200 400 600 800 1000
GRAPHIC SCALE
LEGEND : BASE MAP
Property Line
Contour Line
Building
A.C. Road
NOTES : BASE MAP
1. Property Line information obtained from Property Map prepared by Park Engineering March 8, 1976 titled: "DIAMOND HEAD CRATER PARCELS 1 TO 7 INCLUSIVE" (T.M.K. : 3-1-46:6,10,11,14 & 21) 3-1-36:125,129
2. Physical features obtained from Aerial Photo taken in 1976 by Air Survey Hawaii
3. Contour lines obtained from City & County of Honolulu photo maps, sheet nos. 568-30 & 568-36 based on 1969 Aerial Photo & Ground Control Survey.
DIAMOND HEAD STATE MONUMENT
WATER GENERAL PLAN
KAMALA AVE.
CAPPED
CONNECTION INDICATED NO BWS RECORDS
6" METER SYSTEM
IRRIGATION AREA
COMFORT STATION
PAVILION CLUB



SEWER LEGEND

- Sewer Line
- C & C Line
- Force Main
- Inactive
- Sewer Manhole
- Indicated, Could Not Be Found
- Cesspool
- Cleanout

0 200 400 600 800 1000
GRAPHIC SCALE

LEGEND : BASE MAP

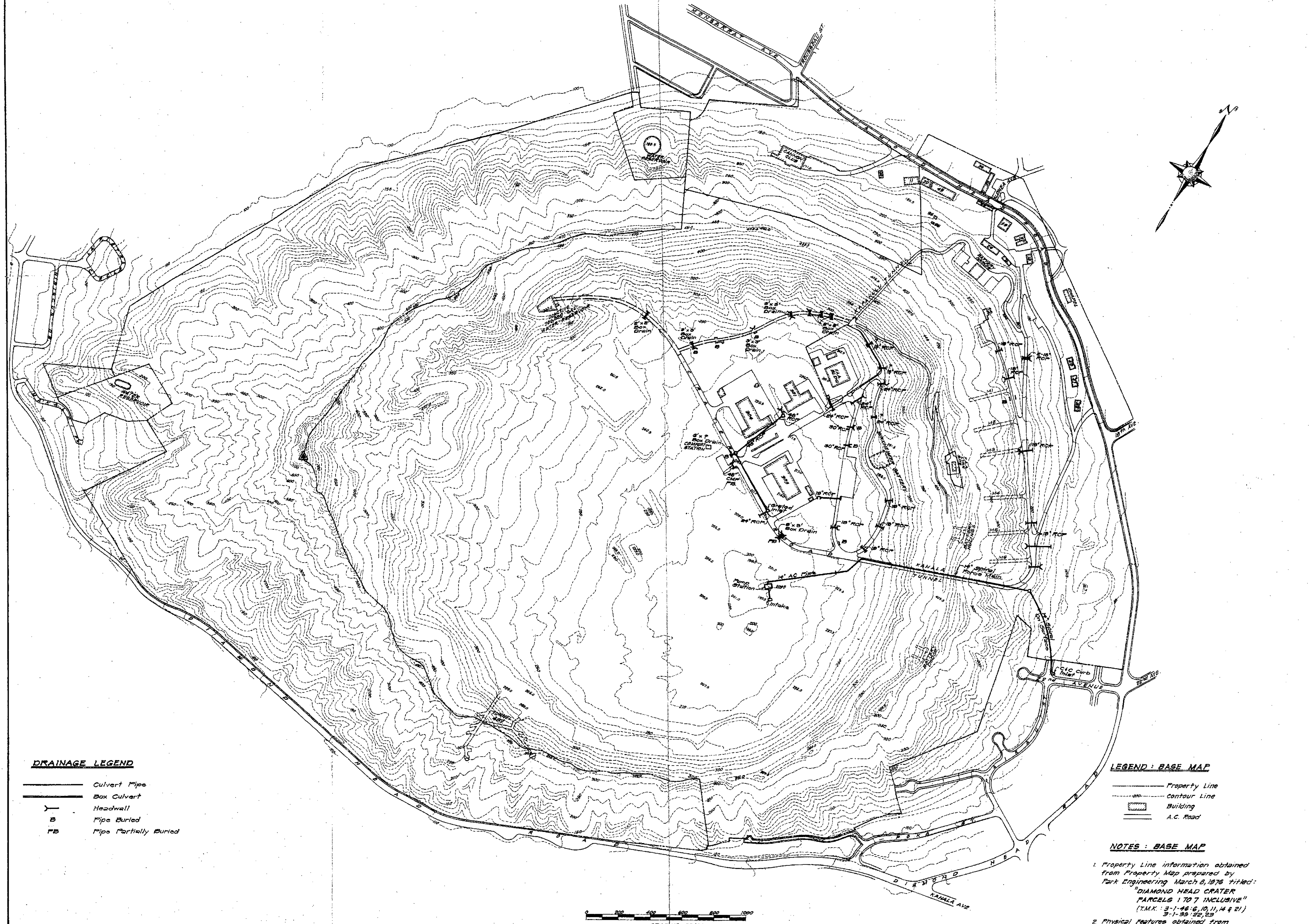
- Property Line
- Contour Line
- Building
- A.C. Road

NOTES : BASE MAP

1. Property Line information obtained from Property Map prepared by Park Engineering March 8, 1976 titled: "DIAMOND HEAD CRATER PARCELS 1 TO 7 INCLUSIVE" (T.M.K. : 3-1-46 : 6, 10, 11, 14 & 21) 3-1-35 : 22, 23
2. Physical Features obtained from Aerial Photo taken in 1976. by Air Survey Hawaii
3. Contour lines obtained from City & County of Honolulu photo maps ; sheet nos. 56[illegible]-30 & 56B-36 based on 1969 Aerial Photo & Ground Control Survey.

DIAMOND HEAD STATE MONUMENT

SEWER GENERAL PLAN



NOTES : BASE MAP

1. Property Line information obtained from Property Map prepared by Park Engineering March 8, 1976 titled: "DIAMOND HEAD CRATER PARCELS 1 TO 7 INCLUSIVE" (T.M.K.: 3-1-46:6, 10, 11, 14 & 21) 3-1-35: 22, 23
2. Physical features obtained from Aerial Photo taken in 1976. by Air Survey Hawaii
3. Contour lines obtained from City & County of Honolulu photo maps, sheet nos. 568-30 & 568-36 based on 1969 Aerial Photo & Ground Control Survey.

DIAMOND HEAD STATE MONUMENT
DRAINAGE GENERAL PLAN

Appendix B

Survey Findings for Visitor / Interpretive Center

Diamond Head State Monument

Survey Findings for Visitor / Interpretive Center

Prepared for:
State Department of Land and Natural Resources

Prepared by:
PBR HAWAII

June 2001

INTRODUCTION

BACKGROUND AND OBJECTIVES

Diamond Head became an official State Monument in 1962. Originally, the park only consisted of the lands around the outside slopes of the crater, enough to protect this famous profile in Hawaii. Eventually, the Department of Land and Natural Resources, Division of State Parks became the sole agency responsible for overseeing the monument. After an extensive planning process involving several different parties, a master plan for the monument was adopted in 1979.

In 1997, the State Legislature recognized the need to update the 1979 Plan for Diamond Head. Visitor counts at Diamond Head had increased significantly, from approximately 41,000 visitors a year after the plan was adopted, to approximately 1,000,000 visitors in 1996.

PBR HAWAII has been hired to assist the Division of State Parks updating the 1979 Master Plan. A Visitor/Interpretive Center is an integral part of the overall Master Plan. To ensure a long-term interpretive program (an interim plan has already been developed by State Parks) is designed to fit the needs of visitors to the Monument, a survey was conducted. The purpose of the survey was to collect demographic information on visitors along with their interests with regard to the Monument and opinions on the park and information presented. It should be noted that to ensure the relevancy of an interpretive program, surveys should be conducted periodically to verify observed trends.

SURVEY METHODOLOGY

On May 10, 2001, and May 12, 2001, surveys were conducted to collect information on visitors to the Monument. The survey instrument was designed to determine 1) who is coming to the park; 2) what visitors expect at the monument; 3) how visitors learn about and plan their visit; 4) what their opinions are of current facilities; and 5) their main interests and reasons for visiting. The survey was created to last not more than five minutes, so as to not distract users for an extended period and to allow for more surveys to be collected.

A team of four interviewers, two English speaking and two Japanese speaking, administered the surveys. Because of the high number of Japanese visitors to the monument, Japanese speaking interviewers were felt necessary to get a more accurate representation. The survey was administered near the entrance to the park, between the information kiosk and the restrooms, with the aim of attracting visitors who had entered the park beyond the parking lot. Surveys were targeted at visitors leaving the park, but were not limited to those who hiked the trail. While many users don't complete the hike to the summit, due to time or physical constraints, it was felt that these individuals' information was important to the development of a visitor interpretive program, as a Visitor/Interpretive Center may be all they see of the monument.

Peak visitation hours to the park are roughly between 10 AM and noon. Surveys were administered from 9AM to noon, and from 1PM to 3PM on each of the survey dates. The two survey periods were also administered on a weekday and a weekend, to allow for a differing visitor make-up, especially for Hawaii residents. The fact that surveys were not conducted during

early morning or late afternoon times means that the ratio of residents to non-residents may be skewed however, as many residents use the park during these times for exercise.

The study collected survey information from 327 visitors over the two days, on a total of 180 surveys. It was felt that visitor counts on the days surveyed were lower than average. The interviewers questioned 151 people on the first day (weekday) and 176 on the second (weekend), with the majority of visitors interviewed during the morning hours. Based on the number surveyed, the margin of error for the survey was to approximately 5.5%.

Table 1: Visitor Breakdown by Day and Time

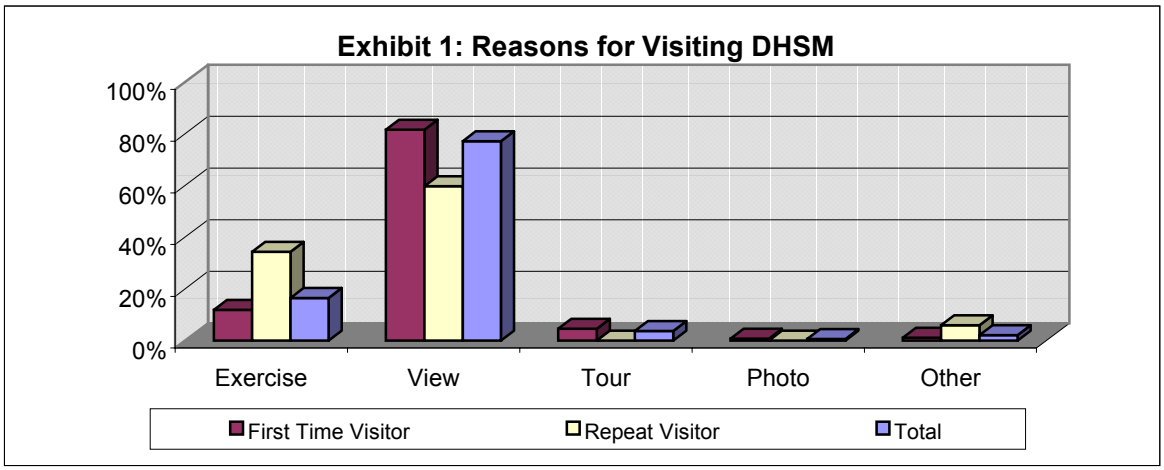
		Number Surveyed	Resident	Non-Resident
5/10/01	**AM**	105	3	102
(151 total)	**PM**	46	2	44
5/12/01	**AM**	120	17	103
(176 total)	**PM**	56	15	41

According to DLNR State Parks revenues from the days surveyed, 13.9 percent of all park visitors were interviewed on May 10th , and 13.4 percent of park visitors were surveyed on May 12th. Park revenues account for all visitors to the park except those with annual passes and those who drive through but do not leave their vehicles.

FINDINGS

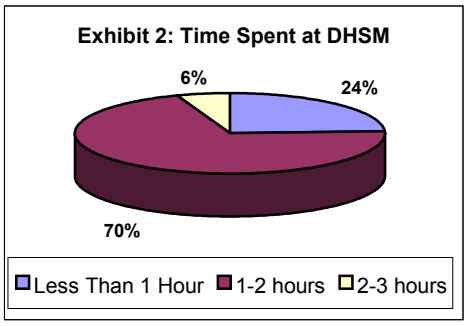
REASON FOR VISIT

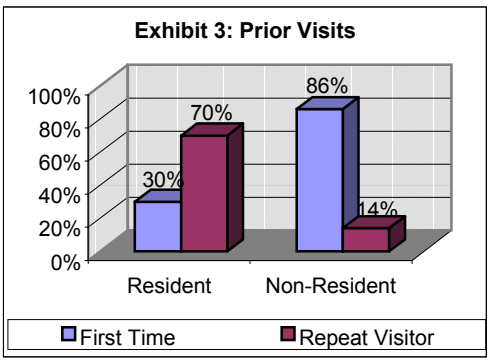
Visitors were asked their primary reason for visiting Diamond Head and their answers were consolidated into five categories: hike/exercise, see view, on a tour, photographic opportunities, and other. Not surprisingly, an overwhelming majority of visitors listed their primary reason for visiting as "the view," (77 percent). The next most frequently reported answer was "to hike or get exercise." Seventeen percent of visitors cited this as their reason for visiting. Other answers, such as tour groups, photography and visiting with friends, made up the remaining 7 percent of answers. Visitor's reasons for visiting were also broken down by whether or not they were a repeat visitor to the park (see Exhibit 1). As would be expected, repeat visitors used the park for exercise more than other visitors.



TIME SPENT AT PARK

Visitors were also asked the amount of time they spent in the park during their visit, and were offered the categories: less than 1 hour, 1 to 2 hours, 2-3 hours, and over 3 hours. The majority of visitors, 70 percent, spent between one and two hours at the park, while 24 percent spent less than an hour, and 6 percent stayed between 2 and 3 hours. No visitors reported staying over 3 hours at the park. It is reasonable to infer that those visitors spending under an hour at the park did not hike the trail.





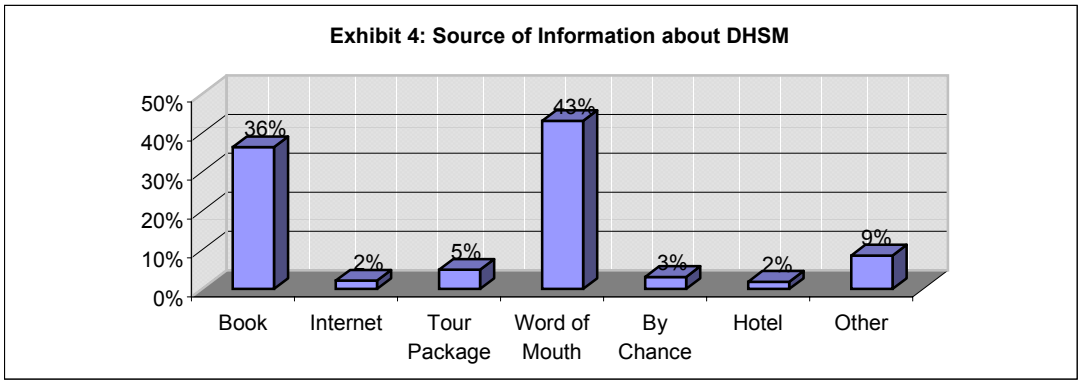
NUMBER OF PRIOR VISITS

The majority of those visiting the park (79 percent) were first time visitors. Of the returning visitors, 42 percent had visited only one other time, 36 percent had visited 2 to 3 other times, and 22 percent had visited the park 4 or more times.

The majority of residents were repeat visitors, (70 percent), while as expected, most non-residents were first time visitors (see Exhibit 3).

SOURCE OF INFORMATION

The majority of visitors surveyed at DHSM received their information about the park from a book (36%) or word of mouth (43%). Other sources included the internet (2%), tour packages (5%), hotel information (2%), chance (3%), and other (9%). Many of those who responded as "other" said they learned about the park because of its reputation, from television shows, or because they were former residents.



TOPICS OF INTEREST

One important goal of the survey was to ascertain which aspects of Diamond Head visitors were most interested in. To accomplish this, people were asked to rank their interest in six different aspects of Diamond Head from 1 to 5, with five being most interested. The categories to be ranked were: 1) geologic history, 2) flora/fauna, 3) military history, 4) cultural history, 5) views from crater, and 6) use of the crater for exercise.

"Views" and "exercise" had the highest average interest levels, with "views" averaging 4.65 on the 1-5 scale. Each of the other topics ranked between 3.04 and 3.44, with "military history" having the lowest average. This is due primarily to the fact that military received the highest number of "1s" or least interested rankings (see Exhibit 5).

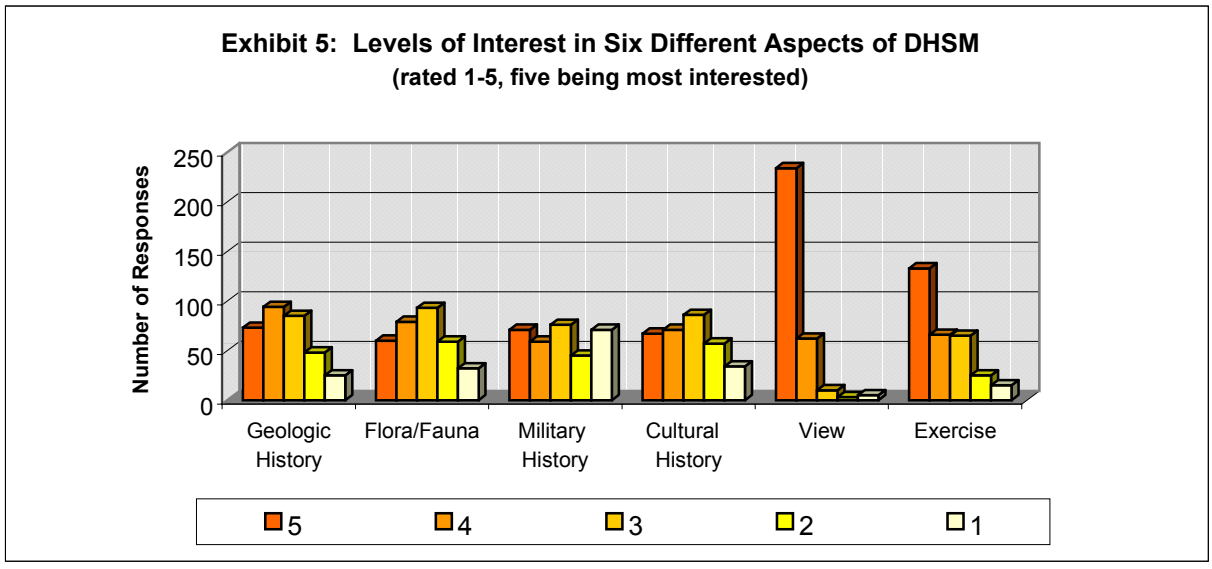
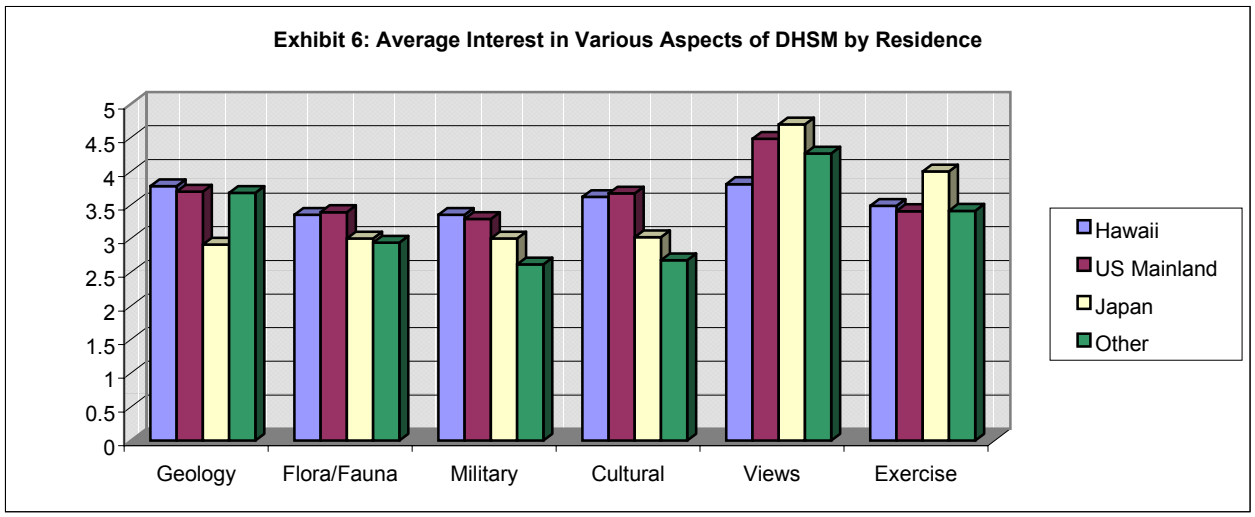


Table 2: Average Interest Level in Various Aspects of DHSM (1-5)					
Geology	Flora/Fauna	Military	Cultural	Views	Exercise
3.44	3.24	3.04	3.25	4.65	3.91

Interest levels were also broken down by the visitor's origin or home. Categories included Hawaii residents, US Mainland residents, Japanese residents, and others. Responses were generally similar, however, Hawaii and Mainland visitors showed more interest in the various historical aspects of the Monument than visitors from other countries.



EXPECTATIONS AND EXPLANATIONS

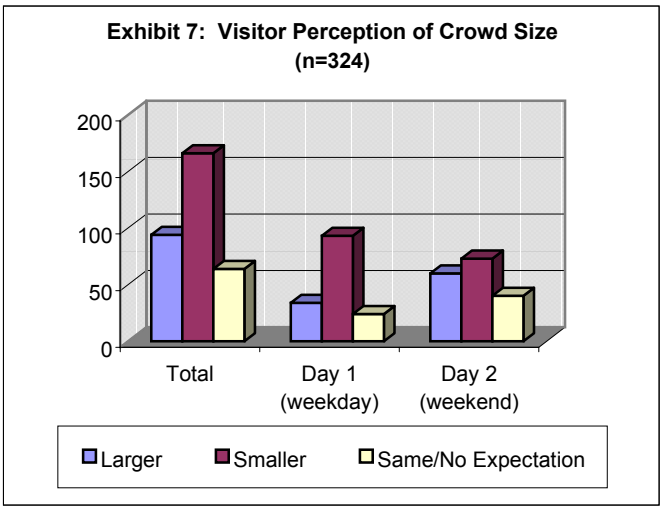
Visitors were asked if they had any expectations prior to their visit which proved to be incorrect. This was primarily to ascertain if the information people came equipped with was giving them false impressions or expectations. Survey respondents replied overwhelmingly that this was not the case. Eighty-eight percent claimed they had no incorrect expectations prior to the visit.

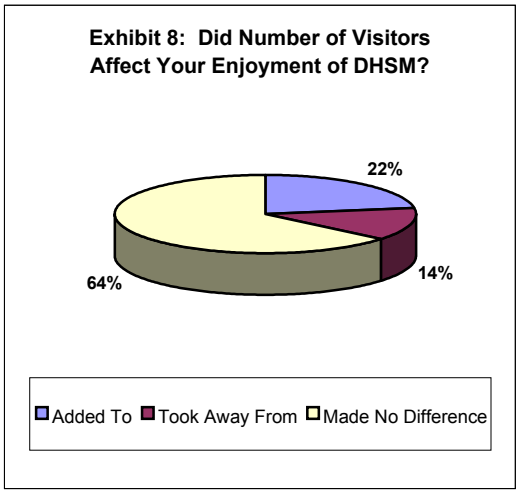
The majority of false expectations dealt with the time it took to hike the trail, longer or shorter than expected, and general information about the trail. Almost all of the false expectations were items that could be easily addressed. However, one pair of visitors responded that they "didn't know they would be inside the crater" and several others claimed that it was "much more beautiful than they expected."

Another question administered to visitors attempted to ascertain if there were any topics visitors felt should be better explained. Once again, visitors answered in large numbers that they were satisfied with given information. Eighty-two percent said there were "no other topics they would like explained further." Of those who wanted more information, the majority wanted more historical information, followed by information on the climate, the trail itself, flora/fauna, and lastly, directional information inside and outside of the park.

CROWD PERCEPTION

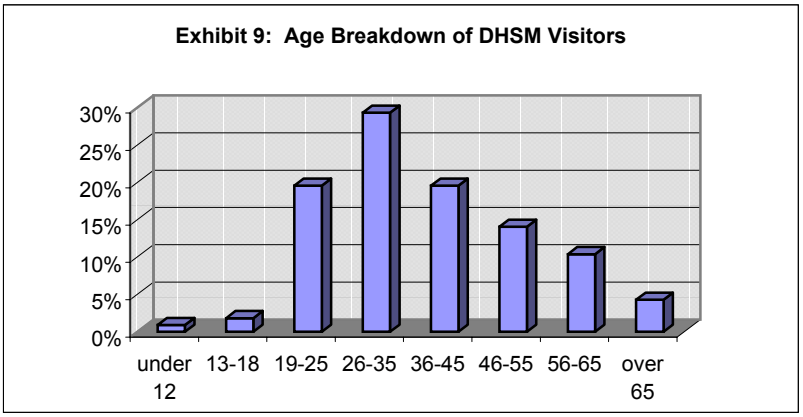
One of the questions asked on the survey was whether the number of visitors at the park was larger, smaller, or the same as expected. Visitors were then asked if the number of visitors added to their enjoyment, took away from their enjoyment, or made no difference. The two days surveyed were not considered "high visitation days" by State Parks and park visitors generally felt the crowd was smaller than they expected. Only 14 percent of the respondents felt the number of visitors took away from their enjoyment of the Monument. They also felt that other park visitors added to the park experience and their enjoyment. Several visitors actually mentioned how nice people were at the park and the encouragement they gained from people coming down from the lookout to "keep going, it's worth it."





DEMOGRAPHICS

Demographic data was another important purpose of the Diamond Head survey. Before beginning a project like a permanent interpretive program, it is necessary to know who you are planning for.



AGE AND GENDER

For starters, the age breakdown of visitors to Diamond Head seems to indicate that there are very few people under the age of 19 at the park. This is misleading, however, because many families with children were less likely to take time for the survey, as the kids had short attention spans for such things. However, another survey recently administered at the park also showed small numbers of children under the age of 19, with that age group comprising only 5 percent of those surveyed (Hawaii Trail Analysis).

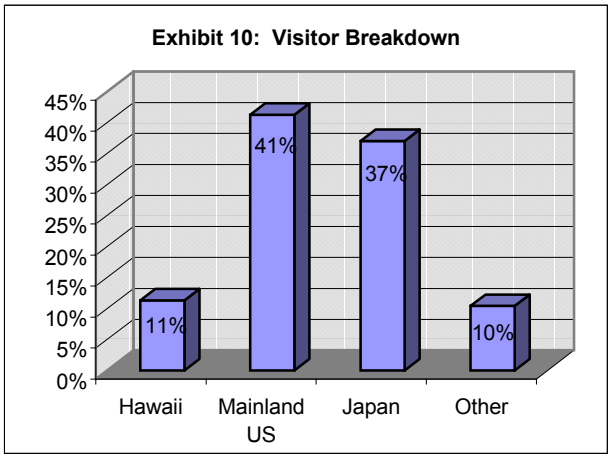
Disregarding the "missing" children, the graph shows a relatively normal curve or distribution of visitors, with the majority of visitors between the ages of 26 and 35.

There were more females surveyed than males, with males comprising only 45 percent. This is also similar to the findings from the Trail Analysis survey mentioned earlier.

RESIDENT V. NON-RESIDENT

The majority of visitors to Diamond Head State Monument are also visitors to the state, with 89 percent of those surveyed non-residents. Of the Hawaii visitors, all were from the island of Oahu.

Of the non-residents, the majority were westbound visitors from the mainland. Eastbound, Japanese visitors make up the second highest percentage of visitors surveyed at 37 percent, almost equaling Mainland visitors.



This visitor breakdown can also be seen in the responses to the "primary language" question on the survey. Again, 37 percent reported Japanese as their primary language. This data is helpful in determining how information should be presented in an interpretive program. If all information were presented in English, the program would reach just over half of the visitors to the park. However, if information is presented in Japanese and English, as is now the practice, approximately 96 percent of visitors will be reached.

APPENDICES

Appendix B-1	Statistical Summary Sheet
Appendix B-2	Summary of Visitor Recommendations and Comments
Appendix B-3	Survey Instrument

Appendix B-1

Diamond Head Survey Summary Statistics

Sex	
Male	Female
147 (45%)	180 (55%)

Primary Language		
English	Japanese	Other
193 (59%)	120 (37%)	14 (4%)

Age							
under 12	13-18	19-25	26-35	36-45	46-55	56-65	over 65
3 (1%)	6 (2%)	64 (20%)	96 (29%)	64 (20%)	46 (14%)	34 (10%)	14 (4%)

Hawaii Resident			
Yes	No		
	US	Japan	Other
37 (11%)	135 (47%)	121 (41%)	34 (12%)

Able to find the park entrance easily?		Time Spent at Park			Primary Reason for Visit				
Yes	No	less than 1 hour	1 to 2 hours	2 to 3 hours	Hike/ Exercise	View	Tour	Photo	Other
276 (84%)	51 (16%)	79 (24%)	229 (70%)	18 (6%)	54 (17%)	252 (77%)	12 (4%)	2 (1%)	7 (2%)

First Time		Number of Prior Visits			Source of Information about Park							Larger or smaller crowd than		
Yes	No	1	2--3	4 or more	Book	Internet	Tour Package	Word of Mouth	By Chance	Hotel	Other	Larger	Smaller	No expectation
260 (79%)	67 (21%)	21 (42%)	18 (36%)	11 (22%)	119 (36%)	7 (2%)	16 (5%)	141 (43%)	10 (3%)	6 (2%)	28 (9%)	94 (29%)	166 (51%)	64 (20%)

Crowd size add too or take away from enjoyment		
Add	Take away	No difference
70 (22%)	43 (14%)	199 (64%)

Incorrect Expectations prior to visit?	
Yes	No
38 (12%)	289 (88%)

Are there any topics you would have liked explained further?							
Climate	Cultural History	Directions	Trail Info	Flora/ Fauna	Geology	History	Lookout Map
6 (10%)	8 (13%)	2 (4%)	5 (8%)	5 (8%)	9 (15%)	23 (38%)	2 (4%)

Interest in Aspects of Diamond Head														
Geologic					Flora/Fauna					Military				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
25 (8%)	48 (15%)	85 (26%)	94 (29%)	73 (22%)	32 (10%)	59 (18%)	93 (29%)	79 (24%)	60 (19%)	71 (22%)	45 (14%)	76 (24%)	59 (18%)	71 (22%)

Interest in Aspects of Diamond Head														
Cultural History					Views					Exercise				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
34 (11%)	57 (18%)	86 (27%)	71 (23%)	67 (21%)	5 (2%)	3 (1%)	10 (20%)	62 (20%)	234 (75%)	15 (5%)	25 (8%)	65 (21%)	66 (22%)	133 (44%)

Appendix B-2

Diamond Head Visitor Survey Recommendations and Comments

Visitor Recommendations:

- Add a lift for the elderly and disabled to get to top.
- Add a museum.
- Add a restaurant.
- Add a views map at lookout in Japanese.
- Add benches along the trail.
- Add distance markers along trail.
- Add flora/fauna signs, water and seats along trail.
- Add handrail on the way down the trail.
- Add information signs at different points along trail.
- Add more directions to the parking area.
- Add more restrooms.
- Add more signs from H-1 to the park.
- Add more signs from Waikiki to monument.
- Add more signs on history of monument.
- Add more trails.
- Add more trashcans and signs about keeping the park clean.
- Add more water fountains.
- Add numbered stakes along trail to match map on brochure.
- Add reflective tape on spiral stairs.
- Add restrooms at top (lookout).
- Add signs at tunnel for people walking to the park.
- Add small concession stands.
- Clean the graffiti from the bunkers.
- Clean trash around trail and bunkers.
- Don't change anything.
- Explain bunkers better.
- Give more information at the lookout.
- Give more military information.
- Have a ranger to give short talks at kiosk area.
- Keep natural.
- Light the spiral stairway.
- Light the tunnel.
- Make a bigger platform at lookout.
- Offer convenience store with water, film, sunblock, etc.
- Offer food at park.
- Offer paper towels in bathroom.
- Offer rental flashlights at kiosk.
- Open up more of inside of crater, more roads.
- Pad the bunker exit to protect people's heads.
- Put a guide at the lookout to give more information
- Remove fee for residents.
- Remove National Guard buildings and make natural.
- Remove vendors.
- Warn about need for water.
- Warn that pavement will end at the beginning of hike.
- Widen the trail at points.

Visitor Comments:

- Add some flat trails.
- Appreciate the $10 yearly pass.
- Beautiful place, nice people.
- Don't like the vendors.
- Enlarge the opening from the bunker to the lookout.
- Need more picnic tables in the shade.
- Need to extend bus service to inside the crater, tired by the time they reach the trail.
- Restore bunker with signs, pictures, lighting.
- Well done.
- Worth visiting.
- Would like better sign out front.

Appendix B-3

DIAMOND HEAD VISITOR INTERPRETIVE CENTER SURVEY

Date: _____ Time: _____ Observer: _____ # in Group: _____

1. Is this your first time to DHSM?

1 2 3 4

□ □ □ □ a. Yes

□ □ □ □ b. No

2. If no, number of prior visits?

1 2 3 4

□ □ □ □ a. 1

□ □ □ □ b. 2 – 3

□ □ □ □ c. 4 or more

_____ - date of most recent visit

3. Are you a Hawaii resident?

□ Yes: Island _____ □ Yes: Island_____

□ No: State/Country □ No: State/Country

_____ _____

□ Yes: Island _____ □ Yes: Island_____

□ No: State/Country □ No: State/Country

_____ _____

4. What was your primary reason for today's visit?

1 2 3 4

□ □ □ □ a. Hike/Exercise

□ □ □ □ b. See the View

□ □ □ □ c. On Tour

□ □ □ □ d. Photography

□ □ □ □ e. Learn about DHSM

□ □ □ □ f. Other _____

5. How did you learn about the park?

1 2 3 4

□ □ □ □ a. Book

□ □ □ □ b. Internet

□ □ □ □ c. Tour package

□ □ □ □ d. Word of Mouth

□ □ □ □ e. By Chance

□ □ □ □ f. Hotel

□ □ □ □ g. Other _____

6. Were you able to find the park entrance easily?

1 2 3 4

□ □ □ □ a. Yes

□ □ □ □ b. No

7. If no, where were you coming from? _____

_____

8. How long did you spend, or do you plan to spend at the park today?

1 2 3 4

□ □ □ □ a. less than 1 hour

□ □ □ □ b. 1 to 2 hours

□ □ □ □ c. 2 to 3 hours

□ □ □ □ d. over 3 hours

□ □ □ □ e. don't know

9. Was the number of visitors today larger or smaller than you expected?

1 2 3 4

□ □ □ □ a. Larger

□ □ □ □ b. Smaller

10. Did the number of visitors Add To, Take Away From, or make No Difference in your enjoyment of the park today?

1 2 3 4

□ □ □ □ a. Added to enjoyment

□ □ □ □ b. Took away from enjoyment

□ □ □ □ c. Made no difference

11. Please rate you interest in the following aspects of Diamond Head from 1 to 5 (5 being most important)

1 2 3 4

□ □ □ □ a. Geologic History

□ □ □ □ b. Flora/Fauna

□ □ □ □ c. Military History

□ □ □ □ d. Cultural History

□ □ □ □ e. Views

□ □ □ □ f. Exercise

12. Are there any topics/questions you would have liked further explained?

_____

_____

13. Do you have any recommendations to make your visit more enjoyable?

_____

_____

14. Did you have any expectations prior to your visit to DHSM that proved to be incorrect?

1 2 3 4

□ □ □ □ a. Yes, please explain _____

□ □ □ □ b. No

Demographics

15. Sex

1	2	3	4		
☐	☐	☐	☐	a.	Male
☐	☐	☐	☐	b.	Female

16. What is your primary language?

1 _____

2 _____

3 _____

4 _____

17. Age

1	2	3	4		
☐	☐	☐	☐	a.	under 12
☐	☐	☐	☐	b.	13-18
☐	☐	☐	☐	c.	19-25
☐	☐	☐	☐	d.	26-35
☐	☐	☐	☐	e.	36-45
☐	☐	☐	☐	f.	46-55
☐	☐	☐	☐	g.	56-65
☐	☐	☐	☐	h.	over 65

Additional Comments:

_____

_____

_____

_____

_____

_____

Appendix C

Preliminary Cost Estimate

Preliminary Cost Estimate (Revised)

for

DIAMOND HEAD STATE MONUMENT MASTER PLAN

Honolulu, Hawaii

Prepared For: PBR Hawaii

December 18, 2002

Rider Hunt Levett & Bailey®

Rider Hunt Levett & Bailey Ltd
A Property and Construction Consultancy

Pacific Tower, Suite 1340
1001 Bishop Street
Honolulu, Hawaii 96813

Tel: (808) 521-2641
Fax: (808) 521-3296
Email: hawaii@riderhunt.com

18th Dec 2002

Mr. Vincent Shigekuni
PBR Hawaii
Pacific Tower, Suite 650
1001 Bishop Steet
HONOLULU, HAWAII, 96813

Dear Mr. Shigekuni

RE: DIAMOND HEAD MASTER PLAN

Following our earlier correspondence and review of the preliminary documents we have completed a Preliminary Draft estimate for your review. The estimate is based on the construction of the visitor /interpretive center, new trails, new roads, wetland area, and generally upgrading existing facilities within the crater. As the project involves numerous phases we have broken the costs out into the various phases. We have also broken out the cost for the Visitor / Interpretive center, and the cost for the Auditorium. The costs are as follows:

PHASE 1 - EXCLUDED

PHASE 2 - $13,185,000

PHASE 3 - $2,660,000

PHASE 4 - $7,345,000

PHASE 5 - 2,765,000

It should be noted that the following items have been specifically excluded form the estimate:

- Staging/Phasing Costs
- Hazardous material abatement
- Utility charges
- Land Acquisition
- Soft costs of construction
- Professional fees
- Items marked as "Excl." in the estimate
- Escalation

Should you have any questions or comments regarding the estimate, please do not hesitate to contact myself or Paul Brussow on 521-2641.

Yours faithfully,

Paul McGeroy for

Paul N Brussow

Associate Principal

DIAMOND HEAD MASTER PLAN

PHASE 2

TOTAL COST SUMMARY

GFA: Gross floor area

Zone	Level	GFA SF	Cost /SF	Total Cost
A	**REMOVE THE FAA/CERAP BUILDING**			
A1	Site Improvement			Nil
A2	Building Work			Nil
A3	Site Utilities			Nil
A4	Landscape			Nil
B	**NEW VISITOR/INTERPRETIVE CENTER**			
B1	Site Improvement			4,610,000
B2	Building Work	12,995	324.36	4,215,000
B3	Future Building	2,300	232.61	535,000
B4	Site Utilities			775,000
B5	Landscape			510,000
		15,295	**$695.98**	**$10,645,000**
C	**ROADWAY TO REAR OF BUILDING**			
C1	Site Improvement			200,000
C2	Building Work			Nil
C3	Site Utilities			120,000
C4	Landscape			Nil
				$320,000
D	**REMOVE OVERHEAD UTILITY LINES**			
D1	Site Improvements			100,000
D2	Building Work			Nil
D3	Site Utilities			Nil
D4	Landscape			Nil
				$100,000
E	**TRAILS TO FLAT TOP RESERVOIR**			
E1	Site Improvements			15,000
E2	Building Work			Nil
E3	Site Utilities			Nil
E4	Landscape			65,000
				$80,000
F	**NEW TRAILS TO SEARCH LIGHT**			
F1	Site Improvements			130,000
F2	Building Work			Nil
F3	Site Utilities			Nil
	Carried forward			130,000

TOTAL COST SUMMARY

GFA: Gross floor area

Zone	Level	GFA SF	Cost /SF	Total Cost
F	**NEW TRAILS TO SEARCH LIGHT** - Continued			
	Brought forward			130,000
F4	Landscaping			265,000
				$395,000
G	**MULTI USE PATH ALONG DH ROAD**			
G1	Site Improvement			740,000
G2	Building Work			Nil
G3	Site Utilities			Nil
G4	Landscape			Nil
				$740,000
	Totals	**15,295**	**$802.88**	**$12,280,000**

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER
B1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clearing and grubbing	Acre	11.30	2500.00	28,250
2	Excavation to embankment	CY	5,300	25.00	132,500
3	Embankment from off-site	CY	80,000	35.00	2,800,000
4	6" Aggregate base course	CY	1,850	40.00	74,000
5	2" Asphalt concrete pavement mix No. IV	CY	9,350	12.00	112,200
6	4" Concrete walkway	SY	2,650	40.00	106,000
7	Concrete curb and gutter	LF	4,900	20.00	98,000
	Element XP total				3,350,950
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			837,737
	Element MA total				837,737
PL	CONTINGENCY				
1	Design contingency	Item			421,313
	Element PL total				421,313
			Total		4,610,000

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER — GFA 12995 SF
B2 Building Work — Cost/SF $324.36

Item	Description	Unit	Qty	Rate	$
SB	SUBSTRUCTURE				
1	Slab preparation	SF	12,995	0.70	9,097
2	4" Slab on grade including sub base material	SF	12,995	9.00	116,955
3	Foundation system	SF	12,995	5.35	69,523
4	Reinforced concrete slab on grade to ADA ramp	SF	1,380	9.00	12,420
	Element SB total			16.01/SF	207,995
CL	COLUMNS				
1	Reinforced concrete columns, complete incl rebar and formwork	LF	396	75.00	29,700
2	Wooden columns, complete	LF	252	15.00	3,780
	Element CL total			2.58/SF	33,480
RF	ROOF				
1	Roof structue complete	SF	21,000	18.00	378,000
2	Copper roof covering system	SF	26,329	14.00	368,606
3	Copper guttering and dounspouts, incl specialty fittings	LF	1,623	25.00	40,575
4	Trellis structure, complete, incl columns	SF	980	24.00	23,520
	Element RF total			62.39/SF	810,701
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	4,225	14.00	59,150
2	Lava rock veneer to exterior walls	SF	4,225	24.00	101,400
3	Lava rock walls through the site	SF	9,000	30.00	270,000
4	Water proof membrane to planted areas	SF	2,960	5.50	16,280
	Element EW total			34.38/SF	446,830
WW	WINDOWS				
1	Windows including frame and hardware	SF	3,900	42.00	163,800
	Element WW total			12.60/SF	163,800
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	5	1450.00	7,250
			Page Total		1,670,056

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER — GFA 12995 SF
B2 Building Work — Cost/SF $324.36

Item	Description	Unit	Qty	Rate	$
2	Double external doors, incl glazing, frame and hardware	Pr	6	2250.00	13,500
	Element ED total			1.60/SF	20,750
NW	INTERNAL WALLS				
1	Internal walls throughout the buildings	SF	4,500	11.50	51,750
2	Furring to internal face of external walls	SF	4,225	4.00	16,900
	Element NW total			5.28/SF	68,650
ND	INTERNAL DOORS				
1	Single internal doors, incl frame and hardware	No	8	1150.00	9,200
2	Double internal doors incl, frame and hardware	Pr	3	1950.00	5,850
	Element ND total			1.16/SF	15,050
WF	WALL FINISHES				
1	Internal wall finish throughout the buildings	SF	13,225	6.20	81,995
	Element WF total			6.31/SF	81,995
FF	FLOOR FINISHES				
1	Floor finish to main exhibit building	SF	7,900	24.00	189,600
2	Floor finish to office/gift shop	SY	179	42.00	7,518
3	Floor finish to restroom area	SF	1,100	11.00	12,100
4	Floor finish to covered walkway areas	SF	2,962	3.50	10,367
	Element FF total			16.90/SF	219,585
CF	CEILING FINISHES				
1	Ceiling finish to main exhibit building	SF	7,900	6.80	53,720
2	Ceiling finish to office/gift shop	SF	1,610	6.80	10,948
3	Ceiling finish to restroom area	SF	1,100	4.50	4,950
4	Ceiling finish over coverd walkway area	SF	2,962	9.50	28,139
	Element CF total			7.52/SF	97,757
	Page Total				496,537

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER — GFA 12995 SF

B2 Building Work — Cost/SF $324.36

Item	Description	Unit	Qty	Rate	$
FT	FITMENTS				
1	Allownace for fitments to main exhibit building	SF	7,900	5.20	41,080
2	Allowance for fitments to office/gift shop	SF	1,610	3.20	5,152
3	Allowance for fitments to restroom facilites	SF	1,100	6.80	7,480
4	Railing set on top of lava rock wall. approx height 4'	LF	935	95.00	88,825
5	Allowance for information kiosk	Item			20,000
	Element FT total			12.51/SF	162,537
PF	PLUMBING FIXTURES				
1	Water closets	No	12	2600.00	31,200
2	Urinals	No	4	2200.00	8,800
3	Lavatories	No	5	2200.00	11,000
	Element PF total			3.92/SF	51,000
AC	AIR CONDITIONING				
1	Air conditioning throughout the buildings	SF	12,800	28.00	358,400
	Element AC total			27.58/SF	358,400
FP	FIRE PROTECTION				
1	Fire sprinkler system throughout the building	SF	12,995	4.50	58,478
	Element FP total			4.50/SF	58,478
LP	ELECTRIC LIGHT AND POWER				
1	Light and power to the buildings	SF	12,995	18.00	233,910
	Element LP total			18.00/SF	233,910
CM	COMMUNICATIONS				
1	Data and communications	SF	12,995	2.50	32,488
	Element CM total			2.50/SF	32,488
	Page Total				896,813

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER — GFA 12995 SF

B2 Building Work — Cost/SF $324.36

Item	Description	Unit	Qty	Rate	$
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			765,850
	Element MA total			58.93/SF	765,850
PL	CONTINGENCY				
1	Design Contingency	Item			385,744
	Element PL total			29.68/SF	385,744
			Total		4,215,000

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER — **GFA 2300 SF**

B3 Future Building — **Cost/SF $232.61**

Item	Description	Unit	Qty	Rate	$
SB	SUBSTRUCTURE				
1	Slab preparation	SF	2,300	0.70	1,610
2	4" Slab on grade including sub base material	SF	2,300	9.00	20,700
3	Foundation system	SF	2,300	5.35	12,305
	Element SB total			15.05/SF	34,615
CL	COLUMNS				
1	Reinforced concrete columns, complete incl rebar and formwork	LF	72	75.00	5,400
	Element CL total			2.35/SF	5,400
RF	ROOF				
1	Roof structue complete	SF	2,550	18.00	45,900
2	Copper roof covering system	SF	2,851	14.00	39,914
3	Copper guttering and dounspouts, incl specialty fittings	LF	336	25.00	8,400
	Element RF total			40.96/SF	94,214
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	500	14.00	7,000
2	Lava rock veneer to exterior walls	SF	500	24.00	12,000
	Element EW total			8.26/SF	19,000
WW	WINDOWS				
1	Windows including frame and hardware	SF	250	42.00	10,500
	Element WW total			4.57/SF	10,500
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	2	1450.00	2,900
2	Double external doors, incl glazing, frame and hardware	Pr	2	2250.00	4,500
	Element ED total			3.22/SF	7,400
	Page Total				171,129

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER — GFA 2300 SF
B3 Future Building — Cost/SF $232.61

Item	Description	Unit	Qty	Rate	$
NW	INTERNAL WALLS				
1	Internal walls throughout the building	SF	1,100	11.50	12,650
2	Furring to internal face of external walls	SF	500	4.00	2,000
	Element NW total			6.37/SF	14,650
ND	INTERNAL DOORS				
1	Single internal doors, incl frame and hardware	No	2	1150.00	2,300
2	Double internal doors incl, frame and hardware	Pr	2	1950.00	3,900
	Element ND total			2.70/SF	6,200
WF	WALL FINISHES				
1	Internal wall finish throughout the building	SF	2,700	6.20	16,740
	Element WF total			7.28/SF	16,740
FF	FLOOR FINISHES				
1	Floor finish throughout the building	SF	2,300	14.00	32,200
	Element FF total			14.00/SF	32,200
CF	CEILING FINISHES				
1	Ceiling finish throughout the building	SF	2,300	6.80	15,640
	Element CF total			6.80/SF	15,640
FT	FITMENTS				
1	Allowance for fitments to future building	SF	2,325	4.00	9,300
	Element FT total			4.04/SF	9,300
AC	AIR CONDITIONING				
1	Air conditioning throughout the buildings	SF	2,300	28.00	64,400
	Element AC total			28.00/SF	64,400
			Page Total		159,130

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER — GFA 2300 SF
B3 Future Building — Cost/SF $232.61

Item	Description	Unit	Qty	Rate	$
FP	FIRE PROTECTION				
1	Fire sprinkler system throughout the building	SF	2,300	4.50	10,350
	Element FP total			4.50/SF	10,350
LP	ELECTRIC LIGHT AND POWER				
1	Light and power to the buildings	SF	2,300	18.00	41,400
	Element LP total			18.00/SF	41,400
CM	COMMUNICATIONS				
1	Data and communications	SF	2,300	2.50	5,750
	Element CM total			2.50/SF	5,750
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			96,940
	Element MA total			42.15/SF	96,940
PL	CONTINGENCY				
1	Design Contingency	Item			50,301
	Element PL total			21.87/SF	50,301
			Total		535,000

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER
B4 Site Utilities

Item	Description	Unit	Qty	Rate	$
XW	EXTERNAL WATER SUPPLY				
1	Furnish and install 16" pipe, in place complete	LF	1,950	95.00	185,250
2	Furnish and install 6" pipe, in place complete	LF	400	65.00	26,000
3	Fire hydrant	No	5	2500.00	12,500
4	Install 6" water meter, in place complete	No	1	7000.00	7,000
5	Chlorination and testing	Item			4,000
	Element XW total				234,750
XK	EXTERNAL STORMWATER DRAINAGE				
1	Furnish and install 24" drain pipe, in place complete	LF	400	65.00	26,000
2	Furnish and install 18" drain pipe, in place complete	LF	1,150	50.00	57,500
3	Drainage inlet	No	15	5000.00	75,000
	Element XK total				158,500
XD	EXTERNAL SEWER DRAINAGE				
1	Furnish and install 8" sewer pipe, in place complete	LF	650	41.00	26,650
2	Furnish and install 6" sewer pipe, in place complete	LF	65	36.00	2,340
3	Furnish and install 8" sewer force main, in place complete	LF	950	75.00	71,250
4	Sewer manhole	No	6	5000.00	30,000
5	Sewage lift station	No	1	40000.00	40,000
	Element XD total				170,240
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			140,872
	Element MA total				140,872
PL	CONTINGENCY				
1	Design contingency	Item			70,638
	Element PL total				70,638
			Total		**775,000**

ITEM DETAILS

B NEW VISITOR/INTERPRETIVE CENTER
B5 Landscape

Item	Description	Unit	Qty	Rate	$
XL	LANDSCAPING AND IMPROVEMENTS				
1	Large canopy shade trees	No	4	1200.00	4,800
2	Loulu palm	No	31	800.00	24,800
3	Medium canopy shade tree	No	49	400.00	19,600
4	Screen plantings	No	59	250.00	14,750
5	Accent shrubs and groundcovers	No	305	20.00	6,100
6	Native vines	No	14	20.00	280
7	Fountain shrub and groundcovers	SF	23,727	3.00	71,181
8	Tifon 419 bermuda grass	SF	92,327	0.20	18,465
9	Slim edge plastic header	LF	1,838	3.00	5,514
10	Imported/screen topsoil	CY	2,150	35.00	75,250
11	Automatic irrigation system	SF	116,054	1.00	116,054
12	90 Days formal maintenance period	SF	116,054	0.10	11,605
	Element XL total				368,399
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			92,099
	Element MA total				92,099
PL	CONTINGENCY				
1	Design contingency	Item			49,502
	Element PL total				49,502
			Total		510,000

ITEM DETAILS

C ROADWAY TO REAR OF BUILDING
C1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub area for new roadway	SF	21,000	0.50	10,500
2	Allowance for miscellaneous earthworks to prepare roadway	Item			35,000
3	6" Aggregate base course	SY	1,556	22.00	34,232
4	2" Asphalt concrete pavement mix	SY	1,556	18.00	28,008
5	Concrete curb	LF	1,400	22.00	30,800
6	Allowance for signage and striping	Item			6,000
	Element XP total				144,540
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			36,135
	Element MA total				36,135
PL	CONTINGENCY				
1	Design contingency	Item			19,325
	Element PL total				19,325
			Total		200,000

ITEM DETAILS

C ROADWAY TO REAR OF BUILDING
C3 Site Utilities

Item	Description	Unit	Qty	Rate	$
XE	EXTERNAL ELECTRIC LIGHT AND POWER				
1	Trench excavation incl. backfill and utility lines	LF	700	56.00	39,200
2	Allowance for street lighting, incl poles	No	11	4500.00	49,500
	Element XE total				88,700
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			22,175
	Element MA total				22,175
PL	CONTINGENCY				
1	Design contingency	Item			9,125
	Element PL total				9,125
			Total		120,000

ITEM DETAILS

D REMOVE OVERHEAD UTILITY LINES
D1 Site Improvements

Item	Description	Unit	Qty	Rate	$
XE	EXTERNAL ELECTRIC LIGHT AND POWER				
1	Remove existing overhead power lines	LF	500	10.00	5,000
2	Trench excavation for new utility lines, including backfill	LF	900	45.00	40,500
3	Utility lines	LF	900	11.00	9,900
4	Electrical handhole	No	1	4500.00	4,500
5	Connection to existing service	Item			5,000
6	Utility lines along existing system	LF	960	8.00	7,680
	Element XE total				72,580
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			16,895
	Element MA total				16,895
PL	CONTINGENCY				
1	Design contingency	Item			10,525
	Element PL total				10,525
			Total		100,000

ITEM DETAILS

E TRAILS TO FLAT TOP RESERVOIR
E1 Site Improvements

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub area for new trails	Acre	0.58	5500.00	3,190
2	Allowance for miscellaneous earthworks	SF	1,680	0.95	1,596
3	Allowance for miscellaneous stairs, handrails etc	SY	747	8.50	6,350
	Element XP total				11,136
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			2,784
	Element MA total				2,784
PL	CONTINGENCY				
1	Design contigency	Item			1,080
	Element PL total				1,080
			Total		15,000

ITEM DETAILS

E TRAILS TO FLAT TOP RESERVOIR
E4 Landscape

Item	Description	Unit	Qty	Rate	$
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	Prepare subbase for concrete slab	SF	144	6.00	864
2	Concrete slab on grade to accomodate new picnic benches	SF	144	7.50	1,080
3	Picnic table, incl bench	No	3	3000.00	9,000
4	Shade structure over picnic table area (assume 200 sf)	No	1	20000.00	20,000
5	Allownace for signage/information booth at lookouts	No	1	15000.00	15,000
	Element XR total				45,944
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			11,486
	Element MA total				11,486
PL	CONTINGENCY				
1	Design contingency	Item			7,570
	Element PL total				7,570
			Total		**65,000**

ITEM DETAILS

F NEW TRAILS TO SEARCH LIGHT
F1 Site Improvements

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub area for new trails	SF	35,025	0.50	17,513
2	Allowance for miscellaneous earthworks	SF	2,335	1.50	3,503
3	Allowance for miscellaneous stairs, handrails etc	SY	2,595	8.50	22,058
	Element XP total				43,074
XN	BOUNDARY WALLS, FENCING AND GATES				
1	Allowance for miscellaneous features at battery dodge and gun emplacements	No	6	8500.00	51,000
	Element XN total				51,000
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			23,518
	Element MA total				23,518
PL	CONTINGENCY				
1	Design contigency	Item			12,408
	Element PL total				12,408
			Total		130,000

ITEM DETAILS

F NEW TRAILS TO SEARCH LIGHT
F4 Landscaping

Item	Description	Unit	Qty	Rate	$
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	Prepare sub base for concrete slab	SF	864	4.00	3,456
2	Concrete slab on grade to accomodate new picnic benches	SF	864	7.50	6,480
3	Picnic table, incl bench	No	18	3000.00	54,000
4	Shade structure over picnic table areas (assume 200sf)	No	6	20000.00	120,000
5	Allowance for miscellaneous signage	Item			8,500
	Element XR total				192,436
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			48,110
	Element MA total				48,110
PL	CONTINGENCY				
1	Design contingency	Item			24,454
	Element PL total				24,454
				Total	**265,000**

ITEM DETAILS

G MULTI USE PATH ALONG DH ROAD
G1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub area for new multi user bike path	SF	36,800	0.90	33,120
2	Allowance for miscellaneous earthworks to prepare roadway	Item			2,000
3	6" Aggregate base course	SY	4,089	16.00	65,424
4	Concrete slab on grade walkway	SF	36,800	8.50	312,800
5	Concrete curb	LF	7,360	14.00	103,040
6	Allowance for signage and striping	Item			20,655
	Element XP total				537,039
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			134,260
	Element MA total				134,260
PL	CONTINGENCY				
1	Design contingency	Item			68,701
	Element PL total				68,701
				Total	740,000

TOTAL COST SUMMARY

GFA: Gross floor area

Zone	Level	GFA SF	Cost /SF	Total Cost
A	**AUDITORIUM**			
A1	Site Improvement			10,000
A2	Building Work	2,500	342.00	855,000
A3	Landscape			40,000
		2,500	**$362.00**	**$905,000**
	Totals	**2,500**	**$362.00**	**$905,000**

ITEM DETAILS

A ADDITORIUM
A1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clearing and grubbing	SF	2,500	2.80	7,000
	Element XP total				7,000
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			2,100
	Element MA total				2,100
PL	CONTINGENCY				
1	Design contingency	Item			900
	Element PL total				900
				Total	10,000

ITEM DETAILS

A AUDITORIUM — GFA 2500 SF
A2 Building Work — Cost/SF $342.00

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Site fencing to protect existing structures during construction	Item			25,000
	Element XP total			10.00/SF	25,000
SB	SUBSTRUCTURE				
1	Slab preparation	SF	2,500	1.10	2,750
2	4" Slab on grade including sub base material	SF	2,500	10.00	25,000
3	Foundation system	SF	2,500	6.10	15,250
4	Reinforced concrete slab on grade to ADA ramp	SF	2,500	9.85	24,625
	Element SB total			27.05/SF	67,625
CL	COLUMNS				
1	Reinforced concrete columns, complete incl rebar and formwork	LF	72	84.00	6,048
2	Wooden columns, complete	LF	36	17.50	630
	Element CL total			2.67/SF	6,678
RF	ROOF				
1	Roof structue complete	SF	3,960	19.50	77,220
2	Copper roof covering system	SF	4,428	16.10	71,291
3	Copper guttering and dounspouts, incl specialty fittings	LF	326	28.00	9,128
	Element RF total			63.06/SF	157,639
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	1,250	15.50	19,375
2	Lava rock veneer to exterior walls	SF	1,250	27.50	34,375
3	Lava rock walls through the site	SF	500	32.00	16,000
	Element EW total			27.90/SF	69,750
WW	WINDOWS				
1	Windows including frame and hardware	SF	600	43.00	25,800
	Element WW total			10.32/SF	25,800
			Page Total		352,492

ITEM DETAILS

A AUDITORIUM — GFA 3500 SF

A2 Building Work — Cost/SF $342.00

Item	Description	Unit	Qty	Rate	$
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	2	1450.00	2,900
2	Double external doors, incl glazing, frame and hardware	Pr	7	2250.00	15,750
	Element ED total			7.46/SF	18,650
NW	INTERNAL WALLS				
1	Internal walls throughout the buildings	SF	800	13.00	10,400
2	Furring to internal face of external walls	SF	1,250	4.50	5,625
	Element NW total			6.41/SF	16,025
ND	INTERNAL DOORS				
1	Single internal doors, incl frame and hardware	No	2	1150.00	2,300
2	Double internal doors incl, frame and hardware	Pr	2	1950.00	3,900
	Element ND total			2.48/SF	6,200
WF	WALL FINISHES				
1	Internal wall finish throughout the buildings	SF	2,850	7.10	20,235
	Element WF total			8.09/SF	20,235
FF	FLOOR FINISHES				
1	Floor finish to auditorium	SY	250	42.00	10,500
2	Floor finish to covered walkway	SF	250	4.00	1,000
	Element FF total			4.60/SF	11,500
CF	CEILING FINISHES				
1	Ceiling finishes auditorium	SF	2,250	9.00	20,250
	Element CF total			8.10/SF	20,250
FT	FITMENTS				
1	Allowance for fitments to auditorium	SF	2,250	5.20	11,700
			Page Total		104,560

ITEM DETAILS

A AUDITORIUM — GFA 2500 SF
A2 Building Work — Cost/SF $342.00

Item	Description	Unit	Qty	Rate	$
2	Allowance for theater seating	No	120	250.00	30,000
3	Audio visual equipment	Item			Excl.
	Element FT total			16.68/SF	41,700
AC	AIR CONDITIONING				
1	Air conditioning throughout the buildings	SF	2,250	28.00	63,000
	Element AC total			25.20/SF	63,000
FP	FIRE PROTECTION				
1	Fire sprinkler system throughout the building	SF	2,500	5.50	13,750
	Element FP total			5.50/SF	13,750
LP	ELECTRIC LIGHT AND POWER				
1	Light and power	SF	2,500	19.50	48,750
	Element LP total			19.50/SF	48,750
CM	COMMUNICATIONS				
1	Data and communications	SF	2,500	3.50	8,750
	Element CM total			3.50/SF	8,750
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			155,325
	Element MA total			62.13/SF	155,325
PL	CONTINGENCY				
1	Design Contingency	Item			78,373
	Element PL total			31.35/SF	78,373
			Total		855,000

ITEM DETAILS

A AUDITORIUM
A3 Landscape

Item	Description	Unit	Qty	Rate	$
XL	LANDSCAPING AND IMPROVEMENTS				
1	Loulu palm	No	9	800.00	7,200
2	Medium canopy shade tree	No	4	400.00	1,600
3	Accent shrubs and groundcovers	No	60	20.00	1,200
4	Fountain shrub and groundcovers	SF	2,300	3.00	6,900
5	Tifon 419 bermuda grass	SF	2,250	0.20	450
6	Imported/screen topsoil	CY	84	35.00	2,940
7	Automatic irrigation system	SF	4,550	1.50	6,825
8	90 Days formal maintenance period	SF	4,550	0.40	1,820
	Element XL total				28,935
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			7,449
	Element MA total				7,449
PL	CONTINGENCY				
1	Design contingency	Item			3,616
	Element PL total				3,616
			Total		40,000

DIAMOND HEAD MASTER PLAN

PHASE 3

DIAMOND HEAD MASTER PLAN

TOTAL COST SUMMARY

GFA: Gross floor area

Zone	Level	GFA SF	Cost /SF	Total Cost
A	**NEW CARETAKERS RESIDENCE**			
A1	Site Improvement			20,000
A2	Building Work	1,500	216.67	325,000
A3	Site Utilities			Nil
A4	Landscaping			65,000
		1,500	**$273.33**	**$410,000**
B	**NEW TRAILS TO TUNNEL 407**			
B1	Site Improvement			35,000
B2	Building Work			Nil
B3	Site Utilities			Nil
B4	Landscaping			Nil
				$35,000
C	**NEW TRAILS TO SUMMIT**			
C1	Site Improvement			20,000
C2	Building Work			Nil
C3	Site Utilities			Nil
C4	Landscaping			55,000
				$75,000
D	**Remove DOD Buildings**			
D1	Site Improvement			1,100,000
D2	Building Work			Nil
D3	Site Utilities			Nil
D4	Landscape			Nil
				$1,100,000
E	**Renovate and Open Tunnel 407**			
E1	Site Improvement			410,000
E2	Building Work	1,500	153.33	230,000
E3	Site Utilities			400,000
E4	Landscape			Nil
		1,500	**$693.33**	**$1,040,000**
	Totals	**3,000**	**$886.67**	**$2,660,000**

ITEM DETAILS

A NEW CARETAKERS RESIDENCE
A1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clearing and grubbing for carpark area	SF	5,000	0.60	3,000
2	6" Aggregate base course	CY	112	45.00	5,040
3	2" Asphalt concrete mix	CY	38	28.00	1,064
4	Concrete curb and gutter	LF	250	24.00	6,000
	Element XP total				15,104
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			3,775
	Element MA total				3,775
PL	CONTINGENCY				
1	Design contingency	Item			1,121
	Element PL total				1,121
			Total		20,000

ITEM DETAILS

A NEW CARETAKERS RESIDENCE — **GFA 1500 SF**

A2 Building Work — **Cost/SF $216.67**

Item	Description	Unit	Qty	Rate	$
SB	SUBSTRUCTURE				
1	Slab preparation	SF	1,500	1.50	2,250
2	4" Slab on grade including sub base material	SF	1,500	8.00	12,000
3	Foundation system	SF	1,500	3.35	5,025
	Element SB total			12.85/SF	19,275
RF	ROOF				
1	Roof structue complete	SF	1,786	18.00	32,148
2	Copper roof covering system	SF	1,997	11.00	21,967
3	Copper guttering and dounspouts, incl specialty fittings	LF	170	25.00	4,250
	Element RF total			38.91/SF	58,365
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	1,548	13.50	20,898
	Element EW total			13.93/SF	20,898
WW	WINDOWS				
1	Windows including frame and hardware	SF	465	42.00	19,530
	Element WW total			13.02/SF	19,530
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	2	1450.00	2,900
2	Double external doors, incl glazing, frame and hardware	Pr	1	2250.00	2,250
	Element ED total			3.43/SF	5,150
NW	INTERNAL WALLS				
1	Internal walls throughout the buildings	SF	702	11.50	8,073
	Element NW total			5.38/SF	8,073
			Page Total		131,291

ITEM DETAILS

A NEW CARETAKERS RESIDENCE — **GFA 1500 SF**

A2 Building Work — **Cost/SF $216.67**

Item	Description	Unit	Qty	Rate	$
ND	INTERNAL DOORS				
1	Single internal doors, incl frame and hardware	No	4	1150.00	4,600
	Element ND total			3.07/SF	4,600
WF	WALL FINISHES				
1	Internal wall finish throughout the buildings	SF	2,952	1.00	2,952
	Element WF total			1.97/SF	2,952
FF	FLOOR FINISHES				
1	Floor finishes throughout the building	SF	1,500	6.50	9,750
	Element FF total			6.50/SF	9,750
CF	CEILING FINISHES				
1	Ceiling finish throughout the building	SF	1,500	7.50	11,250
	Element CF total			7.50/SF	11,250
FT	FITMENTS				
1	Allownace for fitments throughout the building	SF	1,500	3.50	5,250
2	Allowance for fitments to kitchen	Item			6,500
3	Allowance for fitments to bathroom	Item			3,500
	Element FT total			10.17/SF	15,250
PF	PLUMBING FIXTURES				
1	Water closets	No	1	2700.00	2,700
2	Lavatories	No	1	2300.00	2,300
	Element PF total			3.33/SF	5,000
AC	AIR CONDITIONING				
1	Air conditioning throughout the buildings	SF	1,500	18.00	27,000
	Element AC total			18.00/SF	27,000
	Page Total				75,802

ITEM DETAILS

A NEW CARETAKERS RESIDENCE — **GFA 1500 SF**

A2 Building Work — **Cost/SF $216.67**

Item	Description	Unit	Qty	Rate	$
FP	FIRE PROTECTION				
1	Fire sprinkler system throughout the building	SF	1,500	3.90	5,850
	Element FP total			3.90/SF	5,850
LP	ELECTRIC LIGHT AND POWER				
1	Light and power to the buildings	SF	1,500	14.50	21,750
	Element LP total			14.50/SF	21,750
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			58,673
	Element MA total			39.12/SF	58,673
PL	CONTINGENCY				
1	Design contingency	Item			31,634
	Element PL total			21.09/SF	31,634
			Total		325,000

ITEM DETAILS

A NEW CARETAKERS RESIDENCE
A4 Landscaping

Item	Description	Unit	Qty	Rate	$
XW	EXTERNAL WATER SUPPLY				
1	Furnish and install water pipe in place, complete	LF	500	65.00	32,500
2	Fire hydrant	No	2	2500.00	5,000
3	Water meter	Item			7,000
4	Chlorination and testing	Item			3,500
	Element XW total				48,000
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			12,000
	Element MA total				12,000
PL	CONTINGENCY				
1	Design Contingency	Item			5,000
	Element PL total				5,000
			Total		65,000

ITEM DETAILS

B NEW TRAILS TO TUNNEL 407
B1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub area for new trails	Acre	0.44	5500.00	2,420
2	Allowance for miscellaneous earthworks	SF	1,260	3.50	4,410
3	Allowance for miscellaneous stair, handrails etc	SY	560	15.50	8,680
4	Allowance for signage	Item			8,500
	Element XP total				24,010
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			6,002
	Element MA total				6,002
PL	CONTINGENCY				
1	Design contigency	Item			4,988
	Element PL total				4,988
			Total		35,000

ITEM DETAILS

C NEW TRAILS TO SUMMIT
C1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub area for new trails	Acre	0.78	3500.00	2,730
2	Allowance for miscellaneous earthworks	SF	2,265	0.90	2,039
3	Allowance for miscellaneous stairs, handrails etc	SY	1,007	8.50	8,560
	Element XP total				13,329
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			3,332
	Element MA total				3,332
PL	CONTINGENCY				
1	Design contigency	Item			3,339
	Element PL total				3,339
			Total		20,000

ITEM DETAILS

C NEW TRAILS TO SUMMIT
C4 Landscaping

Item	Description	Unit	Qty	Rate	$
XL	LANDSCAPING AND IMPROVEMENTS				
1	Proposed outdoor teaching space	Item			10,000
	Element XL total				10,000
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	Prepare subbase for concrete slab	SF	144	6.00	864
2	Concrete slab on grade to accomodate new picnic benches	SF	144	7.50	1,080
3	Picnic table, incl bench	No	3	3000.00	9,000
4	Shade structure over picnic table area (assume 200 sf)	No	1	20000.00	20,000
	Element XR total				30,944
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			10,236
	Element MA total				10,236
PL	CONTINGENCY				
1	Design contingency	Item			3,820
	Element PL total				3,820
			Total		55,000

ITEM DETAILS

D Remove DOD Buildings
D1 Site Improvement

Item	Description	Unit	Qty	Rate	$
AR	ALTERATIONS AND RENOVATIONS TO EXISTING BUILDINGS				
1	Demolish existing DOD buildings, incl making good demolished area	SF	48,761	8.00	390,088
2	Demolish existing surface parking area around DOD buildings	SF	228,170	1.80	410,706
	Element AR total				800,794
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			200,200
	Element MA total				200,200
PL	CONTINGENCY				
1	Design Contingency	Item			99,006
	Element PL total				99,006
			Total		1,100,000

ITEM DETAILS

E Renovate and Open Tunnel 407
E1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XB	OUTBUILDINGS AND COVERED WAYS				
1	Allowance for painting to tunnels	SF	36,000	1.20	43,200
2	Allowance for miscellaneous work to lookouts incl signage	No	3	85000.00	255,000
	Element XB total				298,200
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			74,550
	Element MA total				74,550
PL	CONTINGENCY				
1	Design contingency	Item			37,250
	Element PL total				37,250
			Total		410,000

ITEM DETAILS

E Renovate and Open Tunnel 407 — GFA 1500 SF

E2 Building Work — Cost/SF $153.33

Item	Description	Unit	Qty	Rate	$
SB	SUBSTRUCTURE				
1	Slab preparation	SF	1,500	0.70	1,050
2	4" Slab on grade including sub base material	SF	1,500	10.00	15,000
3	Foundation system	SF	1,500	5.35	8,025
	Element SB total			16.05/SF	24,075
RF	ROOF				
1	Roof structue complete	SF	1,786	18.00	32,148
2	Tile roof covering	SF	1,997	9.00	17,973
3	Guttering and dounspouts, incl specialty fittings	LF	170	18.00	3,060
	Element RF total			35.45/SF	53,181
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	1,548	11.50	17,802
	Element EW total			11.87/SF	17,802
WW	WINDOWS				
1	Windows including frame and hardware	SF	233	42.00	9,786
	Element WW total			6.52/SF	9,786
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	2	1450.00	2,900
	Element ED total			1.93/SF	2,900
NW	INTERNAL WALLS				
1	Internal walls throughout the comfort station	SF	954	11.50	10,971
	Element NW total			7.31/SF	10,971
ND	INTERNAL DOORS				
	Page Total				118,715

ITEM DETAILS

E Renovate and Open Tunnel 407 — **GFA 1500 SF**

E2 Building Work — **Cost/SF $153.33**

Item	Description	Unit	Qty	Rate	$
1	Single internal doors, incl frame and hardware	No	4	1150.00	4,600
	Element ND total			3.07/SF	4,600
WF	WALL FINISHES				
1	Internal wall finish throughout the buildings	SF	3,456	1.00	3,456
2	Paint to tunnel walls	Item			5,000
	Element WF total			5.64/SF	8,456
FF	FLOOR FINISHES				
1	Floor finishes throughout the building	SF	1,500	1.50	2,250
	Element FF total			1.50/SF	2,250
CF	CEILING FINISHES				
1	Paint to exposed ceiling structure	SF	1,500	1.20	1,800
	Element CF total			1.20/SF	1,800
FT	FITMENTS				
1	Allownace for fitments throughout the building	No	6	500.00	3,000
	Element FT total			2.00/SF	3,000
PF	PLUMBING FIXTURES				
1	Water closets	No	6	2200.00	13,200
2	Lavatories	No	4	1800.00	7,200
3	Urinals	No	2	1650.00	3,300
	Element PF total			15.80/SF	23,700
LP	ELECTRIC LIGHT AND POWER				
1	Light and power to the buildings	SF	1,500	3.90	5,850
	Element LP total			3.90/SF	5,850
	Page Total				49,656

ITEM DETAILS

E Renovate and Open Tunnel 407 — GFA 1500 SF

E2 Building Work — Cost/SF $153.33

Item	Description	Unit	Qty	Rate	$
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			42,092
	Element MA total			28.06/SF	42,092
PL	CONTINGENCY				
1	Design contingency	Item			19,537
	Element PL total			13.02/SF	19,537
	Total				230,000

ITEM DETAILS

E Renovate and Open Tunnel 407
E3 Site Utilities

Item	Description	Unit	Qty	Rate	$
XE	EXTERNAL ELECTRIC LIGHT AND POWER				
1	Improvements to existing lights in tunnel	LF	1,500	65.00	97,500
2	Allowance for new lighting system to lookouts	Item			45,000
	Element XE total				142,500
XW	EXTERNAL WATER SUPPLY				
1	Furnish and install water pipe to supply water to new water fountain	LF	1,500	45.00	67,500
2	Water fountain to tunnel 407	Item			25,000
	Element XW total				92,500
XD	EXTERNAL SEWER DRAINAGE				
1	Furnish and install sewer pipe , inplace complete	LF	1,500	38.00	57,000
	Element XD total				57,000
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			73,000
	Element MA total				73,000
LP	ELECTRIC LIGHT AND POWER				
1	Design contingency	Item			35,000
	Element LP total				35,000
			Total		400,000

DIAMOND HEAD MASTER PLAN

PHASE 4

TOTAL COST SUMMARY

GFA: Gross floor area

Zone	Level	GFA SF	Cost /SF	Total Cost
A	**IMPROVEMENTS TO WETLAND AREA**			
A1	Site Improvement			855,000
A2	Building Work			Nil
A3	Site Utilities			Nil
A4	Landscaping			235,000
				$1,090,000
B	**NEW TRAILS TO WETLAND AREA**			
B1	Site Improvement			1,725,000
B2	Building Work			Nil
B3	Site Utilities			Nil
B4	Landscaping			330,000
				$2,055,000
C	**NEW PICNIC AREAS**			
C1	Site Improvement			85,000
C2	Building Work			Nil
C3	Site Utilities			Nil
C4	Landscaping			Nil
				$85,000
D	**ADDITIONAL PEDESTRIAN TRIALS**			
D1	Site Improvement			185,000
D2	Building Work			Nil
D3	Site Utilities			Nil
D4	Landscape			Nil
				$185,000
E	**NEW COMFORT STATIONS**			
E1	Site Improvement			Nil
E2	Building Work	3,000	150.00	450,000
E3	Site Utilities			Nil
E4	Landscape			Nil
		3,000	**$150.00**	**$450,000**
F	**LINEAR PARK ALONG DH ROAD**			
F1	Site Improvement			620,000
F2	Building Work			Nil
F3	Site Utilities			Nil
F4	Landscaping			Nil
				$620,000

TOTAL COST SUMMARY

GFA: Gross floor area

Zone	Level	GFA SF	Cost /SF	Total Cost
G	**NEW NA LA 'AU ARBORETUM**			
G1	Site Improvement			Nil
G2	Building Work			Nil
G3	Site Utilities			Nil
G4	Landscaping			175,000
				$175,000
H	**NEW DRYLAND FOREST**			
H1	Site Improvement			Nil
H2	Building Work			Nil
H3	Site Utilities			Nil
H4	Landscaping			2,685,000
				$2,685,000
	Totals	**3,000**	**$2448.33**	**$7,345,000**

ITEM DETAILS

A IMPROVEMENTS TO WETLAND AREA
A1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub	Acre	1.00	2500.00	2,500
2	Excavation for new wetland (assume 4')	CY	6,460	25.00	161,500
	Element XP total				164,000
XW	EXTERNAL WATER SUPPLY				
1	Tap into school well	Item			15,000
2	Run water line from school to wetland area	LF	3,500	115.00	402,500
3	Pumping station	Item			40,000
	Element XW total				457,500
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			155,375
	Element MA total				155,375
PL	CONTINGENCY				
1	Design Contingency	Item			78,125
	Element PL total				78,125
			Total		855,000

ITEM DETAILS

A IMPROVEMENTS TO WETLAND AREA
A4 Landscaping

Item	Description	Unit	Qty	Rate	$
XL	LANDSCAPING AND IMPROVEMENTS				
1	Glassing to areas around the wetland	SF	42,000	0.40	16,800
2	Shrubs at various locations throughout the grassed area	SF	42,000	1.30	54,600
3	Allowance for additional landscaping throughout the wetland	Item			90,000
4	Proposed outdoor teaching space	Item			10,000
	Element XL total				171,400
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			42,850
	Element MA total				42,850
PL	CONTINGENCY				
1	Design contingency	Item			20,750
	Element PL total				20,750
			Total		235,000

ITEM DETAILS

B NEW TRAILS TO WETLAND AREA
B1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Prepare sub base for new concrete path	SF	97,900	1.50	146,850
	Element XP total				146,850
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	4" Concrete paving slab on grade, complete	SF	97,900	8.50	832,150
2	Finish surface to concrete slab	SF	97,900	1.35	132,165
3	Wooden walkway bridge over water	SF	2,400	28.50	68,400
4	Guardrails to wooden walkway bridge, approx 3' high	LF	1,000	45.00	45,000
5	Wooden framed shade structure to bridge (assume 100 sf)	No	2	15000.00	30,000
	Element XR total				1,107,715
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			313,650
	Element MA total				313,650
PL	CONTINGENCY				
1	Design contigency	Item			156,785
	Element PL total				156,785
			Total		1,725,000

ITEM DETAILS

B NEW TRAILS TO WETLAND AREA
B4 Landscaping

Item	Description	Unit	Qty	Rate	$
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	Prepare sub base for concrete slab	SF	1,008	4.00	4,032
2	Concrete slab on grade to accomodate new picnic benches	SF	1,008	7.50	7,560
3	Picnic table, incl bench	No	21	3000.00	63,000
4	Shade structure over picnic table areas (assume 200sf)	No	6	20000.00	120,000
5	Allowance for signage at various locations	Item			45,000
	Element XR total				239,592
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			59,898
	Element MA total				59,898
PL	CONTINGENCY				
1	Design contingency	Item			30,510
	Element PL total				30,510
			Total		330,000

ITEM DETAILS

C NEW PICNIC AREAS
C1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	Prepare sub base for concrete slab	SF	288	4.00	1,152
2	Concrete slab on grade to accomodate new picnic benches	SF	288	7.50	2,160
3	Picnic table, incl bench	No	6	3000.00	18,000
4	Shade structure over picnic table areas (assume 200sf)	No	2	20000.00	40,000
	Element XR total				61,312
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			15,330
	Element MA total				15,330
PL	CONTINGENCY				
1	Design contingency	Item			8,358
	Element PL total				8,358
			Total		85,000

ITEM DETAILS

D ADDITIONAL PEDESTRIAN TRIALS
D1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub area for new trails	Acre	3.04	5500.00	16,720
2	Allowance for miscellaneous earthworks	SF	8,815	0.95	8,374
3	Allowance for miscellaneous stairs, handrails etc	SY	9,795	8.50	83,258
4	Allowance for signage at various locations	Item			25,000
	Element XP total				133,352
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			33,338
	Element MA total				33,338
PL	CONTINGENCY				
1	Design contigency	Item			18,310
	Element PL total				18,310
				Total	185,000

ITEM DETAILS

E NEW COMFORT STATIONS — **GFA 1500 SF**

E2 Building Work — **Cost/SF $150.00**

Item	Description	Unit	Qty	Rate	$
SB	SUBSTRUCTURE				
1	Slab preparation	SF	1,500	0.70	1,050
2	4" Slab on grade including sub base material	SF	1,500	10.00	15,000
3	Foundation system	SF	1,500	5.35	8,025
	Element SB total			16.05/SF	24,075
RF	ROOF				
1	Roof structue complete	SF	1,786	18.00	32,148
2	Tile roof covering	SF	1,997	9.00	17,973
3	Guttering and dounspouts, incl specialty fittings	LF	170	18.00	3,060
	Element RF total			35.45/SF	53,181
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	1,548	11.50	17,802
	Element EW total			11.87/SF	17,802
WW	WINDOWS				
1	Windows including frame and hardware	SF	233	42.00	9,786
	Element WW total			6.52/SF	9,786
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	2	1450.00	2,900
	Element ED total			1.93/SF	2,900
NW	INTERNAL WALLS				
1	Internal walls throughout the comfort station	SF	954	11.50	10,971
	Element NW total			7.31/SF	10,971
ND	INTERNAL DOORS				
	Page Total				118,715

ITEM DETAILS

E NEW COMFORT STATIONS — GFA 1500 SF

E2 Building Work — Cost/SF $150.00

Item	Description	Unit	Qty	Rate	$
1	Single internal doors, incl frame and hardware	No	4	1150.00	4,600
	Element ND total			3.07/SF	4,600
WF	WALL FINISHES				
1	Internal wall finish throughout the buildings	SF	3,456	1.00	3,456
	Element WF total			2.30/SF	3,456
FF	FLOOR FINISHES				
1	Floor finishes throughout the building	SF	1,500	1.50	2,250
	Element FF total			1.50/SF	2,250
CF	CEILING FINISHES				
1	Paint to exposed ceiling structure	SF	1,500	1.20	1,800
	Element CF total			1.20/SF	1,800
FT	FITMENTS				
1	Allownace for fitments throughout the building	No	6	500.00	3,000
	Element FT total			2.00/SF	3,000
PF	PLUMBING FIXTURES				
1	Water closets	No	6	2200.00	13,200
2	Lavatories	No	4	1800.00	7,200
3	Urinals	No	2	1650.00	3,300
	Element PF total			15.80/SF	23,700
LP	ELECTRIC LIGHT AND POWER				
1	Light and power to the buildings	SF	1,500	3.90	5,850
	Element LP total			3.90/SF	5,850
	Page Total				44,656

ITEM DETAILS

E NEW COMFORT STATIONS **GFA 1500 SF**
E2 Building Work **Cost/SF $150.00**

Item	Description	Unit	Qty	Rate	$
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			40,842
	Element MA total			27.23/SF	40,842
PL	CONTINGENCY				
1	Design contingency	Item			20,787
	Element PL total			13.86/SF	20,787
			Total		225,000

ITEM DETAILS

F LINEAR PARK ALONG DH ROAD
F1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	4" Aggregate basecourse to new surface carpark	SY	1,014	23.00	23,322
2	Prepare subgrade to surface carpark	SY	1,014	4.00	4,056
3	Curbs to new carpark	LF	710	22.00	15,620
4	2" A/C pavement	SY	1,014	25.00	25,350
5	Striping and signage	Item			10,000
	Element XR total				78,348
XL	LANDSCAPING AND IMPROVEMENTS				
1	Prepare existing surface to accomoadte new grass	SY	41,834	3.50	146,419
2	Grass seeding	SF	376,500	0.20	75,300
3	New large trees along the linear park	No	27	1200.00	32,400
4	New small trees along the linear park	No	13	800.00	10,400
5	New curbs along edges of park	LF	7,530	14.00	105,420
	Element XL total				369,939
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			112,070
	Element MA total				112,070
PL	CONTINGENCY				
1	Design contingency	Item			59,643
	Element PL total				59,643
			Total		620,000

ITEM DETAILS

G NEW NA LA 'AU ARBORETUM
G4 Landscaping

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub	Acre	1.00	3500.00	3,500
	Element XP total				3,500
XL	LANDSCAPING AND IMPROVEMENTS				
1	Large canopy shade tree	No	2	1200.00	2,400
2	Loulu palm	No	10	800.00	8,000
3	Medium canopy shade tree	No	15	400.00	6,000
4	Screen plantings	No	25	250.00	6,250
5	Accent shrubs and groundcovers	No	100	20.00	2,000
6	Native vines	No	3	20.00	60
7	Foundation shrub and groundcovers	SF	4,386	3.00	13,158
8	Tifon 419 bermuda grass	SF	17,093	0.20	3,419
9	Slim edge plastic header	LF	323	3.00	969
10	Imported/screened topsoil	CY	148	35.00	5,180
11	Automatic irrigation system	SF	21,500	1.00	21,500
12	Allowance for miscellaneous additional landscaping	Item			50,000
13	90 Days formal maintenance period	SF	21,500	0.10	2,150
	Element XL total				121,086
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			31,150
	Element MA total				31,150
PL	CONTINGENCY				
1	Design contingency	Item			19,264
	Element PL total				19,264
			Total		175,000

ITEM DETAILS

H NEW DRYLAND FOREST
H4 Landscaping

Item	Description	Unit	Qty	Rate	$
XL	LANDSCAPING AND IMPROVEMENTS				
1	Prepare existing surface for new dryland forest	Acre	60.74	3500.00	212,590
2	Grass seeding to lawn areas	SF	297,794	0.20	259,559
3	Grass seeding to grass lands areas	SF	347,968	0.15	202,195
4	Allowance for miscellaneous shrubs to lawn areas	SF	297,794	0.30	389,338
5	Allowance for miscellaneous shrubs to grass lands areas	SF	347,968	0.20	269,594
6	Large trees to lawn areas	No	39	1200.00	46,800
7	Small trees to lawn areas	No	156	800.00	124,800
8	Large trees to grass lands area	No	27	1200.00	32,400
9	Small trees to grass lands area	No	145	800.00	116,000
10	Water fountains	No	6	50000.00	300,000
	Element XL total				1,953,276
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			488,320
	Element MA total				488,320
PL	CONTINGENCY				
1	Design contingency	Item			243,404
	Element PL total				243,404
			Total		2,685,000

DIAMOND HEAD MASTER PLAN

PHASE 5

TOTAL COST SUMMARY

GFA: Gross floor area

Zone Level	GFA SF	Cost /SF	Total Cost
A ACQUISITATION OF THE CANNON CLUB			
A1 Site Improvement			Excl.
A2 Building Work			Excl.
A3 Site Utilities			Excl.
A4 Landscape			Excl.
B PEOPLE MOVER SYSTEM			
B1 Site Improvement			Excl.
B2 Building Work			Excl.
B3 Site Utilities			Excl.
B4 Landscape			Excl.
C NEW MAKAPU'U AVE. INTERSECTION			
C1 Site Improvement			210,000
C2 Building Work			Nil
C3 Site Utilities			220,000
C4 Landscape			Nil
			$430,000
D ALLOW ENTRY AT KAPAHULU TUNNEL			
D1 Site Improvements			85,000
D2 Building Work			Incl.
D3 Site Utilities			Incl.
D4 Landscape			Incl.
			$85,000
E TRAFFIC FLOW AT KAHALA ENTRY			
E1 Site Improvements			Nil
E2 Building Work			160,000
E3 Site Utilities			Nil
E4 Landscape			Nil
			$160,000
F CLOSE DIAMOND HEAD ENTRY			
F1 Site Improvements			Incl.
F2 Building Work			Incl.
F3 Site Utilities			Incl.
F4 Landscape			Incl.

TOTAL COST SUMMARY

GFA: Gross floor area

Zone	Level	GFA SF	Cost /SF	Total Cost
G	**PEDESTRIAN ACCESS AT KAPAHULU**			
G1	Site Improvements			45,000
G2	Building Work			Nil
G3	Site Utilities			Nil
G4	Landscape			Nil
				$45,000
H	**COMPLETE ROADWAY IN CRATER FLOOR**			
H1	Site Improvements			965,000
H2	Building Work			Nil
H3	Site Utilities			565,000
H4	Landscaping			Nil
				$1,530,000
I	**NEW COMFORT STATION**			
I1	Site Improvement			290,000
I2	Building Work	1,500	150.00	225,000
I3	Site Utilities			Nil
I4	Landscape			Nil
		1,500	**$343.33**	**$515,000**
	Totals	**1,500**	**$1843.33**	**$2,765,000**

ITEM DETAILS

C NEW MAKAPU'U AVE. INTERSECTION
C1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub area for new entry at makapu'u ave	SF	8,500	2.50	21,250
2	Allowance for miscellaneous earthworks to new roadway	Item			7,500
3	6" Aggregate base course	SY	945	16.00	15,120
4	2" Asphalt concrete pavement mix	SY	945	15.00	14,175
5	4" Concrete walkway	SY	945	55.00	51,975
6	Concrete curb	LF	340	14.00	4,760
7	Slurry seal existing intersection	SY	908	4.00	3,632
8	Allowance for reworking existing curbs and gutters	LF	100	14.00	1,400
9	Allowance for signage and striping	Item			7,150
10	Allowance for entry feature	Item			25,000
	Element XP total				151,962
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			37,990
	Element MA total				37,990
PL	CONTINGENCY				
1	Design contingency	Item			20,048
	Element PL total				20,048
	Total				210,000

ITEM DETAILS

C NEW MAKAPU'U AVE. INTERSECTION
C3 Site Utilities

Item	Description	Unit	Qty	Rate	$
XE	EXTERNAL ELECTRIC LIGHT AND POWER				
1	New traffic signal at Makapu'u intersection	Item			134,000
2	Allowance for miscellaneous relocation of existing electrical services	Item			25,000
	Element XE total				159,000
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			39,750
	Element MA total				39,750
PL	CONTINGENCY				
1	Design contingency	Item			21,250
	Element PL total				21,250
			Total		220,000

ITEM DETAILS

D ALLOW ENTRY AT KAPAHULU TUNNEL
D1 Site Improvements

Item	Description	Unit	Qty	Rate	$
WF	WALL FINISHES				
1	Paint to interior face of tunnel	SF	16,500	1.00	16,500
	Element WF total				16,500
XE	EXTERNAL ELECTRIC LIGHT AND POWER				
1	Allowance for iminimal upgrades to existing tunnel lighting	Item			40,000
	Element XE total				40,000
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	Allowance for re-striping to existing roadway	Item			5,000
	Element XR total				5,000
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			15,375
	Element MA total				15,375
PL	CONTINGENCY				
1	Design contingency	Item			8,125
	Element PL total				8,125
				Total	85,000

ITEM DETAILS

E TRAFFIC FLOW AT KAHALA ENTRY
E2 Building Work

Item	Description	Unit	Qty	Rate	$
XN	BOUNDARY WALLS, FENCING AND GATES				
1	Allowance for automatic gate at kahala tunnel to control traffic flow	Item			35,000
	Element XN total				35,000
XE	EXTERNAL ELECTRIC LIGHT AND POWER				
1	Furnish and install electrical lines to power gate	LF	1,000	55.00	55,000
2	Aloowance for lighting at gate area	Item			25,000
	Element XE total				80,000
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			28,750
	Element MA total				28,750
PL	CONTINGENCY				
1	Design contingency	Item			16,250
	Element PL total				16,250
			Total		160,000

ITEM DETAILS

G PEDESTRIAN ACCESS AT KAPAHULU
G1 Site Improvements

Item	Description	Unit	Qty	Rate	$
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	4" Concrete sidewalk at kapahulu tunnel entrance	SY	367	55.00	20,185
2	Curb along new sidewalk	LF	550	14.00	7,700
3	Miscellaneous re working to striping and signage	Item			5,000
	Element XR total				32,885
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			8,220
	Element MA total				8,220
PL	CONTINGENCY				
1	Design Contingency	Item			3,895
	Element PL total				3,895
			Total		45,000

ITEM DETAILS

H COMPLETE ROADWAY IN CRATER FLOOR
H1 Site Improvements

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clear and grub area for new roadway	Acre	3.05	3500.00	10,675
2	Allowance for miscellaneous earthworks to prepare roadway	Item			25,000
3	6" Aggregate base course	SY	11,778	16.00	188,448
4	2" Asphalt concrete pavement mix	SY	21,334	15.00	320,010
5	Concrete curb	LF	9,600	14.00	134,400
6	Allowance for signage and striping	Item			20,000
	Element XP total				698,533
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			174,633
	Element MA total				174,633
PL	CONTINGENCY				
1	Design contingency	Item			91,834
	Element PL total				91,834
	Total				965,000

ITEM DETAILS

H COMPLETE ROADWAY IN CRATER FLOOR
H3 Site Utilities

Item	Description	Unit	Qty	Rate	$
XE	EXTERNAL ELECTRIC LIGHT AND POWER				
1	Trench excavation incl. backfill and utility lines	LF	4,800	56.00	268,800
2	Allowance for street lighting, incl poles	No	32	4500.00	144,000
	Element XE total				412,800
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			103,200
	Element MA total				103,200
PL	CONTINGENCY				
1	Design contingency	Item			49,000
	Element PL total				49,000
			Total		565,000

ITEM DETAILS

I NEW COMFORT STATION
I1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XR	ROADS, FOOTPATHS AND PAVED AREAS				
1	4" Aggregate basecourse to new surface carpark	SY	3,556	23.00	81,788
2	Prepare subgrade to surface carpark	SY	3,556	4.00	14,224
3	Curbs to new carpark	LF	800	22.00	17,600
4	2" A/C pavement	SY	3,556	25.00	88,900
5	Striping and signage	Item			8,100
	Element XR total				210,612
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			52,650
	Element MA total				52,650
PL	CONTINGENCY				
1	Design contingency	Item			26,738
	Element PL total				26,738
				Total	290,000

ITEM DETAILS

I NEW COMFORT STATION — GFA 1500 SF
I2 Building Work — Cost/SF $150.00

Item	Description	Unit	Qty	Rate	$
SB	SUBSTRUCTURE				
1	Slab preparation	SF	1,500	0.70	1,050
2	4" Slab on grade including sub base material	SF	1,500	10.00	15,000
3	Foundation system	SF	1,500	5.35	8,025
	Element SB total			16.05/SF	24,075
RF	ROOF				
1	Roof structue complete	SF	1,786	18.00	32,148
2	Tile roof covering	SF	1,997	9.00	17,973
3	Guttering and dounspouts, incl specialty fittings	LF	170	18.00	3,060
	Element RF total			35.45/SF	53,181
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	1,548	11.50	17,802
	Element EW total			11.87/SF	17,802
WW	WINDOWS				
1	Windows including frame and hardware	SF	233	42.00	9,786
	Element WW total			6.52/SF	9,786
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	2	1450.00	2,900
	Element ED total			1.93/SF	2,900
NW	INTERNAL WALLS				
1	Internal walls throughout the comfort station	SF	954	11.50	10,971
	Element NW total			7.31/SF	10,971
ND	INTERNAL DOORS				
	Page Total				118,715

ITEM DETAILS

I NEW COMFORT STATION — GFA 1500 SF
I2 Building Work — Cost/SF $150.00

Item	Description	Unit	Qty	Rate	$
1	Single internal doors, incl frame and hardware	No	4	1150.00	4,600
	Element ND total			3.07/SF	4,600
WF	WALL FINISHES				
1	Internal wall finish throughout the buildings	SF	3,456	1.00	3,456
	Element WF total			2.30/SF	3,456
FF	FLOOR FINISHES				
1	Floor finishes throughout the building	SF	1,500	1.50	2,250
	Element FF total			1.50/SF	2,250
CF	CEILING FINISHES				
1	Paint to exposed ceiling structure	SF	1,500	1.20	1,800
	Element CF total			1.20/SF	1,800
FT	FITMENTS				
1	Allownace for fitments throughout the building	No	6	500.00	3,000
	Element FT total			2.00/SF	3,000
PF	PLUMBING FIXTURES				
1	Water closets	No	6	2200.00	13,200
2	Lavatories	No	4	1800.00	7,200
3	Urinals	No	2	1650.00	3,300
	Element PF total			15.80/SF	23,700
LP	ELECTRIC LIGHT AND POWER				
1	Light and power to the buildings	SF	1,500	3.90	5,850
	Element LP total			3.90/SF	5,850
	Page Total				44,656

ITEM DETAILS

I NEW COMFORT STATION — GFA 1500 SF
I2 Building Work — Cost/SF $150.00

Item	Description	Unit	Qty	Rate	$
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			40,842
	Element MA total			27.23/SF	40,842
PL	CONTINGENCY				
1	Design contingency	Item			20,787
	Element PL total			13.86/SF	20,787
	Total				225,000

VISITOR / INTERPRETIVE CENTER

(W/O AUDITORIUM)

TOTAL COST SUMMARY

GFA: Gross floor area

Zone	Level	GFA SF	Cost /SF	Total Cost
A	**NEW VISITOR/INTERPRETIVE CENTER**			
A1	Site Improvement			4,610,000
A2	Building Work	12,995	324.36	4,215,000
A3	Future Building	2,300	232.61	535,000
A4	Site Utilities			775,000
A5	Landscape			510,000
		15,295	**$695.98**	**$10,645,000**
	Totals	**15,295**	**$695.98**	**$10,645,000**

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER
A1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clearing and grubbing	Acre	11.30	2500.00	28,250
2	Excavation to embankment	CY	5,300	25.00	132,500
3	Embankment from off-site	CY	80,000	35.00	2,800,000
4	6" Aggregate base course	CY	1,850	40.00	74,000
5	2" Asphalt concrete pavement mix No. IV	CY	9,350	12.00	112,200
6	4" Concrete walkway	SY	2,650	40.00	106,000
7	Concrete curb and gutter	LF	4,900	20.00	98,000
	Element XP total				3,350,950
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			837,737
	Element MA total				837,737
PL	CONTINGENCY				
1	Design contingency	Item			421,313
	Element PL total				421,313
			Total		4,610,000

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER — GFA 12995 SF

A2 Building Work — Cost/SF $324.36

Item	Description	Unit	Qty	Rate	$
SB	SUBSTRUCTURE				
1	Slab preparation	SF	12,995	0.70	9,097
2	4" Slab on grade including sub base material	SF	12,995	9.00	116,955
3	Foundation system	SF	12,995	5.35	69,523
4	Reinforced concrete slab on grade to ADA ramp	SF	1,380	9.00	12,420
	Element SB total			16.01/SF	207,995
CL	COLUMNS				
1	Reinforced concrete columns, complete incl rebar and formwork	LF	396	75.00	29,700
2	Wooden columns, complete	LF	252	15.00	3,780
	Element CL total			2.58/SF	33,480
RF	ROOF				
1	Roof structue complete	SF	21,000	18.00	378,000
2	Copper roof covering system	SF	26,329	14.00	368,606
3	Copper guttering and dounspouts, incl specialty fittings	LF	1,623	25.00	40,575
4	Trellis structure, complete, incl columns	SF	980	24.00	23,520
	Element RF total			62.39/SF	810,701
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	4,225	14.00	59,150
2	Lava rock veneer to exterior walls	SF	4,225	24.00	101,400
3	Lava rock walls through the site	SF	9,000	30.00	270,000
4	Water proof membrane to planted areas	SF	2,960	5.50	16,280
	Element EW total			34.38/SF	446,830
WW	WINDOWS				
1	Windows including frame and hardware	SF	3,900	42.00	163,800
	Element WW total			12.60/SF	163,800
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	5	1450.00	7,250
	Page Total				1,670,056

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER — GFA 12995 SF

A2 Building Work — Cost/SF $324.36

Item	Description	Unit	Qty	Rate	$
2	Double external doors, incl glazing, frame and hardware	Pr	6	2250.00	13,500
	Element ED total			1.60/SF	20,750
NW	INTERNAL WALLS				
1	Internal walls throughout the buildings	SF	4,500	11.50	51,750
2	Furring to internal face of external walls	SF	4,225	4.00	16,900
	Element NW total			5.28/SF	68,650
ND	INTERNAL DOORS				
1	Single internal doors, incl frame and hardware	No	8	1150.00	9,200
2	Double internal doors incl, frame and hardware	Pr	3	1950.00	5,850
	Element ND total			1.16/SF	15,050
WF	WALL FINISHES				
1	Internal wall finish throughout the buildings	SF	13,225	6.20	81,995
	Element WF total			6.31/SF	81,995
FF	FLOOR FINISHES				
1	Floor finish to main exhibit building	SF	7,900	24.00	189,600
2	Floor finish to office/gift shop	SY	179	42.00	7,518
3	Floor finish to restroom area	SF	1,100	11.00	12,100
4	Floor finish to covered walkway areas	SF	2,962	3.50	10,367
	Element FF total			16.90/SF	219,585
CF	CEILING FINISHES				
1	Ceiling finish to main exhibit building	SF	7,900	6.80	53,720
2	Ceiling finish to office/gift shop	SF	1,610	6.80	10,948
3	Ceiling finish to restroom area	SF	1,100	4.50	4,950
4	Ceiling finish over coverd walkway area	SF	2,962	9.50	28,139
	Element CF total			7.52/SF	97,757
	Page Total				496,537

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER — GFA 12995 SF
A2 Building Work — Cost/SF $324.36

Item	Description	Unit	Qty	Rate	$
FT	FITMENTS				
1	Allownace for fitments to main exhibit building	SF	7,900	5.20	41,080
2	Allowance for fitments to office/gift shop	SF	1,610	3.20	5,152
3	Allowance for fitments to restroom facilites	SF	1,100	6.80	7,480
4	Railing set on top of lava rock wall. approx height 4'	LF	935	95.00	88,825
5	Allowance for information kiosk	Item			20,000
	Element FT total			12.51/SF	162,537
PF	PLUMBING FIXTURES				
1	Water closets	No	12	2600.00	31,200
2	Urinals	No	4	2200.00	8,800
3	Lavatories	No	5	2200.00	11,000
	Element PF total			3.92/SF	51,000
AC	AIR CONDITIONING				
1	Air conditioning throughout the buildings	SF	12,800	28.00	358,400
	Element AC total			27.58/SF	358,400
FP	FIRE PROTECTION				
1	Fire sprinkler system throughout the building	SF	12,995	4.50	58,478
	Element FP total			4.50/SF	58,478
LP	ELECTRIC LIGHT AND POWER				
1	Light and power to the buildings	SF	12,995	18.00	233,910
	Element LP total			18.00/SF	233,910
CM	COMMUNICATIONS				
1	Data and communications	SF	12,995	2.50	32,488
	Element CM total			2.50/SF	32,488
	Page Total				896,813

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER — **GFA 12995 SF**

A2 Building Work — **Cost/SF $324.36**

Item	Description	Unit	Qty	Rate	$
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			765,850
	Element MA total			58.93/SF	765,850
PL	CONTINGENCY				
1	Design Contingency	Item			385,744
	Element PL total			29.68/SF	385,744
	Total				**4,215,000**

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER — **GFA 2300 SF**

A3 Future Building — **Cost/SF $232.61**

Item	Description	Unit	Qty	Rate	$
SB	SUBSTRUCTURE				
1	Slab preparation	SF	2,300	0.70	1,610
2	4" Slab on grade including sub base material	SF	2,300	9.00	20,700
3	Foundation system	SF	2,300	5.35	12,305
	Element SB total			15.05/SF	34,615
CL	COLUMNS				
1	Reinforced concrete columns, complete incl rebar and formwork	LF	72	75.00	5,400
	Element CL total			2.35/SF	5,400
RF	ROOF				
1	Roof structue complete	SF	2,550	18.00	45,900
2	Copper roof covering system	SF	2,851	14.00	39,914
3	Copper guttering and dounspouts, incl specialty fittings	LF	336	25.00	8,400
	Element RF total			40.96/SF	94,214
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	500	14.00	7,000
2	Lava rock veneer to exterior walls	SF	500	24.00	12,000
	Element EW total			8.26/SF	19,000
WW	WINDOWS				
1	Windows including frame and hardware	SF	250	42.00	10,500
	Element WW total			4.57/SF	10,500
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	2	1450.00	2,900
2	Double external doors, incl glazing, frame and hardware	Pr	2	2250.00	4,500
	Element ED total			3.22/SF	7,400
			Page Total		171,129

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER — GFA 2300 SF
A3 Future Building — Cost/SF $232.61

Item	Description	Unit	Qty	Rate	$
NW	INTERNAL WALLS				
1	Internal walls throughout the building	SF	1,100	11.50	12,650
2	Furring to internal face of external walls	SF	500	4.00	2,000
	Element NW total			6.37/SF	14,650
ND	INTERNAL DOORS				
1	Single internal doors, incl frame and hardware	No	2	1150.00	2,300
2	Double internal doors incl, frame and hardware	Pr	2	1950.00	3,900
	Element ND total			2.70/SF	6,200
WF	WALL FINISHES				
1	Internal wall finish throughout the building	SF	2,700	6.20	16,740
	Element WF total			7.28/SF	16,740
FF	FLOOR FINISHES				
1	Floor finish throughout the building	SF	2,300	14.00	32,200
	Element FF total			14.00/SF	32,200
CF	CEILING FINISHES				
1	Ceiling finish throughout the building	SF	2,300	6.80	15,640
	Element CF total			6.80/SF	15,640
FT	FITMENTS				
1	Allowance for fitments to future building	SF	2,325	4.00	9,300
	Element FT total			4.04/SF	9,300
AC	AIR CONDITIONING				
1	Air conditioning throughout the buildings	SF	2,300	28.00	64,400
	Element AC total			28.00/SF	64,400
			Page Total		159,130

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER — GFA 2300 SF

A3 Future Building — Cost/SF $232.61

Item	Description	Unit	Qty	Rate	$
FP	FIRE PROTECTION				
1	Fire sprinkler system throughout the building	SF	2,300	4.50	10,350
	Element FP total			4.50/SF	10,350
LP	ELECTRIC LIGHT AND POWER				
1	Light and power to the buildings	SF	2,300	18.00	41,400
	Element LP total			18.00/SF	41,400
CM	COMMUNICATIONS				
1	Data and communications	SF	2,300	2.50	5,750
	Element CM total			2.50/SF	5,750
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			96,940
	Element MA total			42.15/SF	96,940
PL	CONTINGENCY				
1	Design Contingency	Item			50,301
	Element PL total			21.87/SF	50,301
			Total		535,000

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER
A4 Site Utilities

Item	Description	Unit	Qty	Rate	$
XW	EXTERNAL WATER SUPPLY				
1	Furnish and install 16" pipe, in place complete	LF	1,950	95.00	185,250
2	Furnish and install 6" pipe, in place complete	LF	400	65.00	26,000
3	Fire hydrant	No	5	2500.00	12,500
4	Install 6" water meter, in place complete	No	1	7000.00	7,000
5	Chlorination and testing	Item			4,000
	Element XW total				234,750
XK	EXTERNAL STORMWATER DRAINAGE				
1	Furnish and install 24" drain pipe, in place complete	LF	400	65.00	26,000
2	Furnish and install 18" drain pipe, in place complete	LF	1,150	50.00	57,500
3	Drainage inlet	No	15	5000.00	75,000
	Element XK total				158,500
XD	EXTERNAL SEWER DRAINAGE				
1	Furnish and install 8" sewer pipe, in place complete	LF	650	41.00	26,650
2	Furnish and install 6" sewer pipe, in place complete	LF	65	36.00	2,340
3	Furnish and install 8" sewer force main, in place complete	LF	950	75.00	71,250
4	Sewer manhole	No	6	5000.00	30,000
5	Sewage lift station	No	1	40000.00	40,000
	Element XD total				170,240
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			140,872
	Element MA total				140,872
PL	CONTINGENCY				
1	Design contingency	Item			70,638
	Element PL total				70,638
			Total		775,000

ITEM DETAILS

A NEW VISITOR/INTERPRETIVE CENTER
A5 Landscape

Item	Description	Unit	Qty	Rate	$
XL	LANDSCAPING AND IMPROVEMENTS				
1	Large canopy shade trees	No	4	1200.00	4,800
2	Loulu palm	No	31	800.00	24,800
3	Medium canopy shade tree	No	49	400.00	19,600
4	Screen plantings	No	59	250.00	14,750
5	Accent shrubs and groundcovers	No	305	20.00	6,100
6	Native vines	No	14	20.00	280
7	Fountain shrub and groundcovers	SF	23,727	3.00	71,181
8	Tifon 419 bermuda grass	SF	92,327	0.20	18,465
9	Slim edge plastic header	LF	1,838	3.00	5,514
10	Imported/screen topsoil	CY	2,150	35.00	75,250
11	Automatic irrigation system	SF	116,054	1.00	116,054
12	90 Days formal maintenance period	SF	116,054	0.10	11,605
	Element XL total				368,399
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			92,099
	Element MA total				92,099
PL	CONTINGENCY				
1	Design contingency	Item			49,502
	Element PL total				49,502
				Total	510,000

VISITOR / INTERPRETIVE CENTER

(AUDITORIUM ONLY)

DIAMOND HEAD MASTER PLAN

TOTAL COST SUMMARY

GFA: Gross floor area

Zone Level	GFA SF	Cost /SF	Total Cost
A AUDITORIUM			
A1 Site Improvement			10,000
A2 Building Work	2,500	342.00	855,000
A3 Landscape			40,000
	2,500	**$362.00**	**$905,000**
Totals	**2,500**	**$362.00**	**$905,000**

ITEM DETAILS

A AUDITORIUM
A1 Site Improvement

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Clearing and grubbing	SF	2,500	2.80	7,000
	Element XP total				7,000
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			2,100
	Element MA total				2,100
PL	CONTINGENCY				
1	Design contingency	Item			900
	Element PL total				900
			Total		10,000

ITEM DETAILS

A AUDITORIUM — **GFA 2500 SF**

A2 Building Work — **Cost/SF** — **$342.00**

Item	Description	Unit	Qty	Rate	$
XP	SITE PREPARATION				
1	Site fencing to protect existing structures during construction	Item			25,000
	Element XP total			10.00/SF	25,000
SB	SUBSTRUCTURE				
1	Slab preparation	SF	2,500	1.10	2,750
2	4" Slab on grade including sub base material	SF	2,500	10.00	25,000
3	Foundation system	SF	2,500	6.10	15,250
4	Reinforced concrete slab on grade to ADA ramp	SF	2,500	9.85	24,625
	Element SB total			27.05/SF	67,625
CL	COLUMNS				
1	Reinforced concrete columns, complete incl rebar and formwork	LF	72	84.00	6,048
2	Wooden columns, complete	LF	36	17.50	630
	Element CL total			2.67/SF	6,678
RF	ROOF				
1	Roof structue complete	SF	3,960	19.50	77,220
2	Copper roof covering system	SF	4,428	16.10	71,291
3	Copper guttering and dounspouts, incl specialty fittings	LF	326	28.00	9,128
	Element RF total			63.06/SF	157,639
EW	EXTERNAL WALLS				
1	CMU exterior walls, complete	SF	1,250	15.50	19,375
2	Lava rock veneer to exterior walls	SF	1,250	27.50	34,375
3	Lava rock walls through the site	SF	500	32.00	16,000
	Element EW total			27.90/SF	69,750
WW	WINDOWS				
1	Windows including frame and hardware	SF	600	43.00	25,800
	Element WW total			10.32/SF	25,800
	Page Total				352,492

ITEM DETAILS

A AUDITORIUM — GFA 2500 SF
A2 Building Work — Cost/SF $342.00

Item	Description	Unit	Qty	Rate	$
ED	EXTERNAL DOORS				
1	Single external doors, incl glazing, frame and hardware	No	2	1450.00	2,900
2	Double external doors, incl glazing, frame and hardware	Pr	7	2250.00	15,750
	Element ED total			7.46/SF	18,650
NW	INTERNAL WALLS				
1	Internal walls throughout the buildings	SF	800	13.00	10,400
2	Furring to internal face of external walls	SF	1,250	4.50	5,625
	Element NW total			6.41/SF	16,025
ND	INTERNAL DOORS				
1	Single internal doors, incl frame and hardware	No	2	1150.00	2,300
2	Double internal doors incl, frame and hardware	Pr	2	1950.00	3,900
	Element ND total			2.48/SF	6,200
WF	WALL FINISHES				
1	Internal wall finish throughout the buildings	SF	2,850	7.10	20,235
	Element WF total			8.09/SF	20,235
FF	FLOOR FINISHES				
1	Floor finish to auditorium	SY	250	42.00	10,500
2	Floor finish to covered walkway	SF	250	4.00	1,000
	Element FF total			4.60/SF	11,500
CF	CEILING FINISHES				
1	Ceiling finishes auditorium	SF	2,250	9.00	20,250
	Element CF total			8.10/SF	20,250
FT	FITMENTS				
1	Allowance for fitments to auditorium	SF	2,250	5.20	11,700
	Page Total				104,560

ITEM DETAILS

A AUDITORIUM — GFA 2500 SF
A2 Building Work — Cost/SF $342.00

Item	Description	Unit	Qty	Rate	$
2	Allowance for theater seating	No	120	250.00	30,000
3	Audio visual equipment	Item			Excl.
	Element FT total			16.68/SF	41,700
AC	AIR CONDITIONING				
1	Air conditioning throughout the buildings	SF	2,250	28.00	63,000
	Element AC total			25.20/SF	63,000
FP	FIRE PROTECTION				
1	Fire sprinkler system throughout the building	SF	2,500	5.50	13,750
	Element FP total			5.50/SF	13,750
LP	ELECTRIC LIGHT AND POWER				
1	Light and power	SF	2,500	19.50	48,750
	Element LP total			19.50/SF	48,750
CM	COMMUNICATIONS				
1	Data and communications	SF	2,500	3.50	8,750
	Element CM total			3.50/SF	8,750
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			155,325
	Element MA total			62.13/SF	155,325
PL	CONTINGENCY				
1	Design Contingency	Item			78,373
	Element PL total			31.35/SF	78,373
			Total		855,000

ITEM DETAILS

A AUDITORIUM
A3 Landscape

Item	Description	Unit	Qty	Rate	$
XL	LANDSCAPING AND IMPROVEMENTS				
1	Loulu palm	No	9	800.00	7,200
2	Medium canopy shade tree	No	4	400.00	1,600
3	Accent shrubs and groundcovers	No	60	20.00	1,200
4	Fountain shrub and groundcovers	SF	2,300	3.00	6,900
5	Tifon 419 bermuda grass	SF	2,250	0.20	450
6	Imported/screen topsoil	CY	84	35.00	2,940
7	Automatic irrigation system	SF	4,550	1.50	6,825
8	90 Days formal maintenance period	SF	4,550	0.40	1,820
	Element XL total				28,935
MA	CONTRACTORS MARGIN				
1	Contractors overhead and profit	Item			7,449
	Element MA total				7,449
PL	CONTINGENCY				
1	Design contingency	Item			3,616
	Element PL total				3,616
	Total				40,000