Appendix P

Preliminary Engineering Report

HONUA'ULA

Preliminary Engineering Report

Wailea, Kīhei-Mākena, Maui

Prepared for:
Honua'ula Partners, LLC

Prepared by:
Wilson Okamoto Corporation
1907 S. Beretania Street, Suite 400
Honolulu, Hawaii 96826

March 2010

Preliminary Engineering Report

Honua‘ula

Wailea,Kīhei-Mākena, Maui

Prepared For:

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Engineers and Planners
1907 South Beretania Street, Suite 400
Honolulu, Hawaii 96826
WOA Job No. 7814-01

March 2010

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1. INTRODUCTION

1.1 Project Location

Honua'ula is located in Wailea, Kīhei-Mākena, Maui on the relatively gentle lower slopes of Haleakalā with Wailea Resort to the west (makai), Mākena Resort to the south, 'Ulupalakua Ranch to the east (mauka), and the Maui Meadows subdivision to the north (see Figure 1-1). Honua'ula consists of 670 acres, herein referred to as the "project site", and is further identified as 2-1-008: 056 and 071. The project site is bisected by a portion (TMK: 2-1-008: 999) of the Pi'ilani Highway right-of-way previously reserved for a planned extension leading to upcountry Maui. However, the State Department of Transportation (DOT) is no longer planning to use the right-of-way for the extension. Approximately 370 acres of the project site are mauka of the right-of-way and 300 acres are makai. Honua'ula is designated as Project District 9 in the *Kīhei – Mākena Community Plan* and is also zoned Project District 9 under Chapter 19.90A of the Maui County Code (MCC).

Primary access to the project site is from the intersection of Pi'ilani Highway and Wailea Ike Drive. A secondary access is provided from Kaukahi Street.

Elevations across the site range from approximately 300 – 700 feet above mean sea level. The project site is characterized by generally even slopes of 4 to 12 percent with some variation on some of the knolls and gullies in excess of 14 to 16 percent.

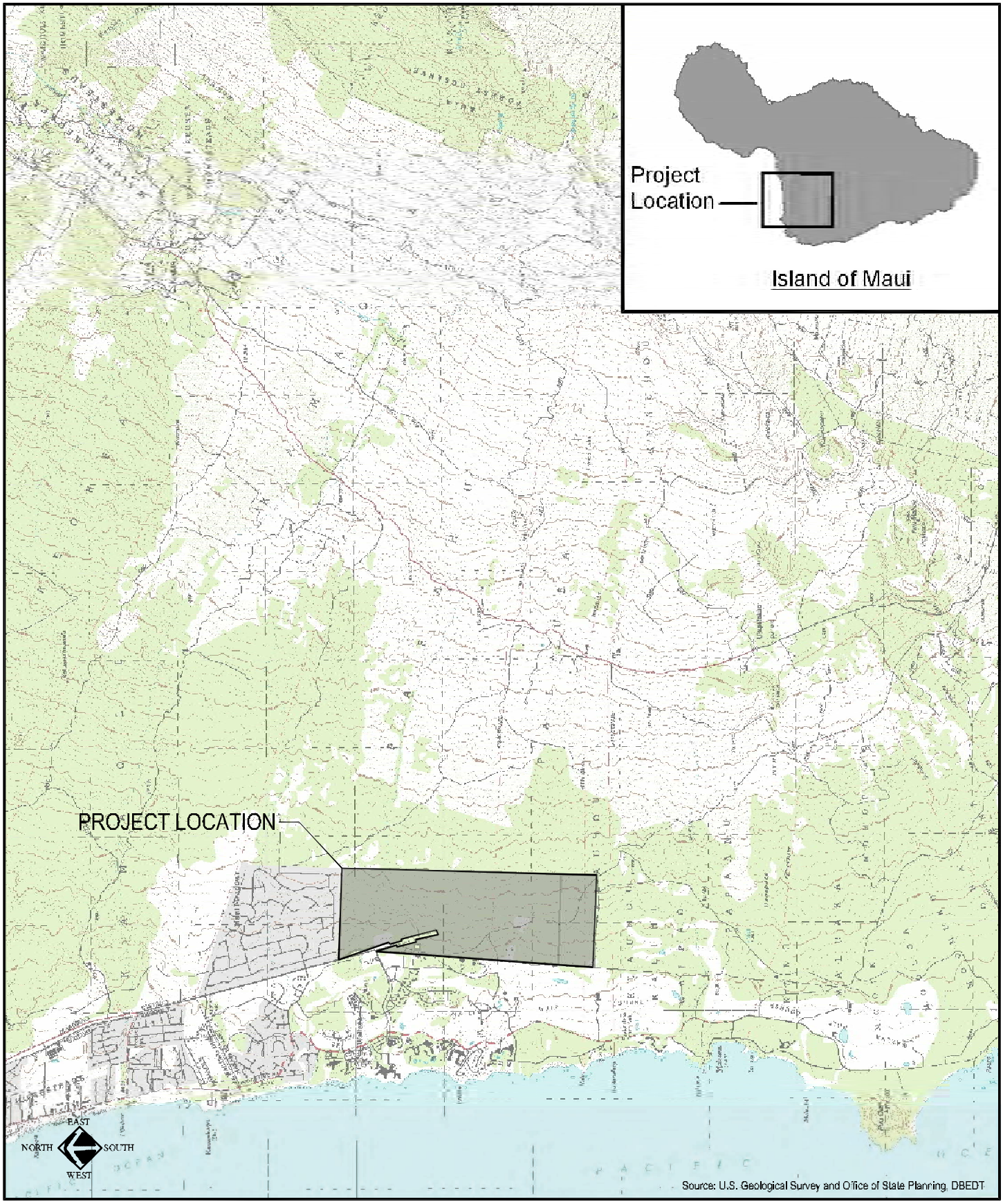
The northern 75 percent of the project site is characterized as a kiawe/buffel grass pastureland. The southern 25 percent of the parcel is 'a'ā land dissected by numerous gullies. The southern area is characterized as a mixed kiawe/wiliwili shrubland mixed with non-native kiawe trees, native wiliwili trees, and a dense understory of native 'ilima shrubs.

1.2 Project Description

Honua'ula will be a master-planned community embracing "smart growth" principles such as diverse residential opportunities, commercial mixed uses, on site recreational amenities, open space, and integrated bicycle and pedestrian networks. Honua'ula will also foster preservation of natural and cultural resources while contributing to Maui's social fabric and economic diversity.

In compliance with Chapter 19.90A MCC, Honua'ula will contain Single- and Multi- Family Residential, Village Mixed Use, and Recreation and Open Space/Utility sub-districts (see Figure 1-2).

Figure 1-1 Location Map



WILSON OKAMOTO CORPORATION

HONUA'ULA

Location Map

FIGURE 1-1

Single and Multi-family Residential Sub-districts: The Single- and Multi- Family Residential sub-districts will contain Honua'ula's residential neighborhoods. The number of residences that may be constructed on-site in Honua'ula, together with any associated off-site residential workforce housing units, will not exceed 1,400.

Approximately 35 percent of homes will be single-family. The average density of the Single-Family Residential sub-district will be 2.5 units per acre or less, and the minimum lot area will be 7,500 square feet. Approximately 65 percent of the homes will be multi-family. The average density of the Multi-Family Residential sub-district will be 10 units per acre or less, and the minimum lot area will be 10,000 square feet.

Village Mixed Use Sub-district The Village Mixed Use sub-district is envisioned as a community center comprised of a mix of residential, commercial, and recreational and community facilities serving the needs of Honua'ula residents and guests.

Permitted uses in the village mixed use district include: retail food and beverage establishments; grocery stores; retail shops; offices; business services; minor medical offices; religious institutions; and public facilities, as stated in Chapter 19.90A of the Maui County Code (MCC).

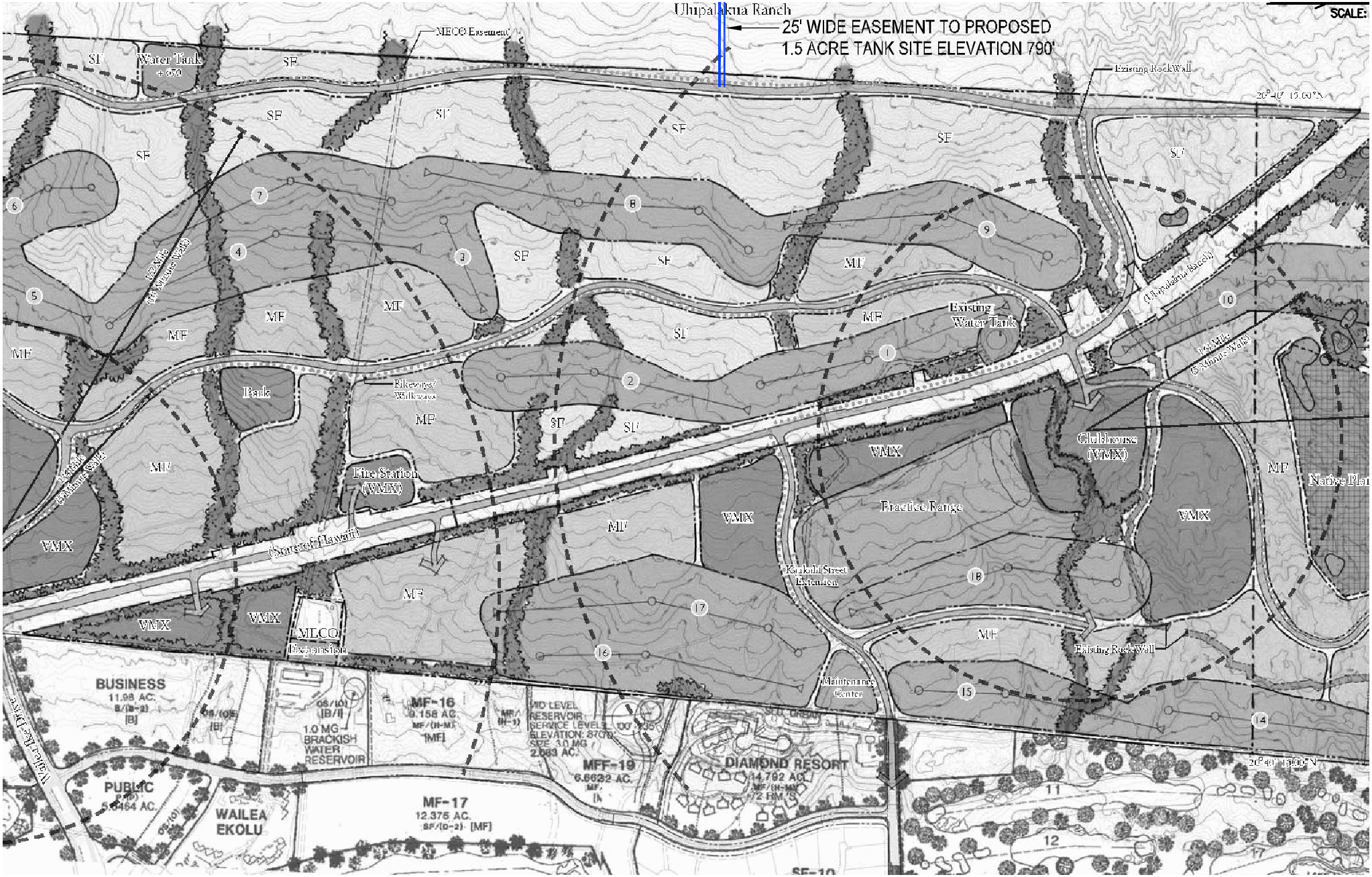
The total floor area of all structures commercial and retail structures within the village mixed use district will not exceed 100,000 square feet. The total land area of the Village Mixed Use sub-district will not exceed 53 acres.

Recreation and Open Space/Utility Sub-district: The Recreation and Open Space/Utility sub-district will include: the golf course and golf driving range; community and recreation centers; parks and playgrounds; native preservation and conservation areas; landscaped common or open space areas; trails and bike-pedestrian ways; drainage, utility, and erosion control systems; wells and reservoirs; and greenhouses and nurseries for the propagation of plants. The total land area of the Recreation and Open Space/Utility sub-district will not exceed 350 acres, including the golf course, as stated in Chapter 19.90A of the MCC.

Golf Course and Clubhouse: The 18-hole homeowner's golf course will include: a driving range; clubhouse facility with a restaurant; pro-shop; spa; and indoor and outdoor recreational amenities. The golf course and driving range will be part of the Recreation and Open Space/Utility sub-district, while the clubhouse and related facilities will be within the Village Mixed Use sub-district. Major portions of the golf course will be designed as an integral part of the community's drainage system.

Table 1-1 Land Use Summary		
Land Use Category	**Approximate Acreage**	**Approximate No. of Units**
Single-Family Residential	274.1	504
Multi-Family Residential	59.7	196
Multi-Family Affordable	41.7	450
Mixed Use Village	7	--
Golf Course and Clubhouse	182.1	--
Native Plant Preservation Area	22	--
Neighborhood Collector roads	49.6	--
Public Parks	6	--
Water Tank Sites	3.8	--
Fire Station	2	--
Wastewater Treatment Plant	2	--
MECO Expansion Area	1	--
Open Space/Buffer/Detention Basins	34	--
Total	685	1,150

Figure 1-2 Conceptual Site Plan
(11x17)


Uhipalakua Ranch
25' WIDE EASEMENT TO PROPOSED
1.5 ACRE TANK SITE ELEVATION 790'
SCALE:
MECO Easement
Water Tank
+650
Existing Rock Wall
20° 40' 15.00"N
SF
MF
SL
VMX
Existing Water Tank
Park
Bikeways/ Walkways
Fire Station (VMX)
Clubhouse (VMX)
Practice Range
Native Plan
Kaukahi Street Extension
Maintenance Center
Existing Rock Wall
MECO Expansion
BUSINESS
11.98 AC.
B-(B-2)
[B]
1.0 MG BRACKISH WATER RESERVOIR
MF-16
9.158 AC.
MF-(H-M)
[MF]
MID LEVEL RESERVOIR
SERVICE LEVEL
ELEVATION: 870'
SIZE: 3.0 MG
2.083 AC.
MFF-19
6.6632 AC.
DIAMOND RESORT
14.792 AC.
MF-(H-M)
72 RM'S
PUBLIC
5.6464 AC.
WAILEA EKOLU
MF-17
12.375 AC.
SF-(D-2) [MF]
Waialea Place
Honoapiilani Highway (Route 30)
1300'
1"=650'

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2. WASTEWATER

The Conditions of Zoning require that the project develop or participate in the operation of a private wastewater treatment facility and system. The following conditions are applicable to wastewater:

> *Condition 4: That Honua'ula Partners, LLC, its successors and permitted assigns, shall be responsible for all required infrastructural improvements for the project, including water source and system improvements for potable and non-potable use and fire protection, drainage improvements, traffic-related improvements, wastewater system improvements and utility upgrades, as determined by the appropriate governmental agencies and public utility companies. Except as otherwise provided by more specific conditions of zoning, said improvements shall be constructed and implemented concurrently with the development of each phase of Kīhei-Mākena Project District 9, and shall be completed prior to issuance of any certificate of occupancy or final subdivision approval, unless improvements are bonded by Honua'ula Partners, LLC, its successors and permitted assigns. Honua'ula Partners, LLC shall execute appropriate agreements with governmental agencies regarding participation in improvements of infrastructure and public facilities as determined by the agencies.*
>
> *Condition 14: That a nonpotable water supply system shall be utilized for all irrigation purposes.*
>
> *Condition 16: That Honuaula Partners, LLC, its successors and permitted assigns, shall provide a Sewage Disposal Analysis that has been reviewed and commented on by the State Department of Health, the State Department of Land and Natural Resources, the County Department of Environmental Management, and the County Department of Water Supply prior to Project District Phase II approval. The Sewage Disposal Analysis, along with reviews and comments, shall be submitted to the Maui County Council for review and the project shall be subject to additional conditions or amendments by the Maui County Council if warranted by the Sewage Disposal Analysis.*
>
> *Condition 17: The Honua'ula Partners LLC, its successors and permitted assigns, shall construct, maintain and/or participate in the operation of a private wastewater treatment facility and system that accommodate the needs of the entire Kīhei-Mākena Project District 9. All reclaimed water from the private wastewater treatment facility shall be utilized for irrigation, dust control, or other non-potable purposes, and none of the reclaimed water shall be placed into injection wells.*

The Wastewater Management Design Standards, Volume 1, City and County of Honolulu, July 1993 and Wastewater Flow Standards, County of Maui, February 2, 2006 were used to estimate wastewater flows.

This section reviews the existing wastewater system and describes proposed improvements to meet the demands of the project. The proposed improvements are subject to change based on the refinement of plans and availability of more detailed information.

2.1 Existing Conditions

2.1.1 County Wastewater System

The Wailea area is serviced by the Kīhei Wastewater Reclamation Facility (WWRF) located approximately 4 miles northwest of the project site (see Figure 2-1). Sewage from the Wailea area is conveyed to the Kīhei WWRF via the South Kīhei Collection System, which consists of trunk sewer mains running along South Kīhei Road and Wailea Alanui Drive. Other Kīhei communities along this route are also served by this system.

Several sewer pump stations along the route provide necessary lifts to convey flows by gravity to the Kīhei WWRF, as shown in Figure 2-1.

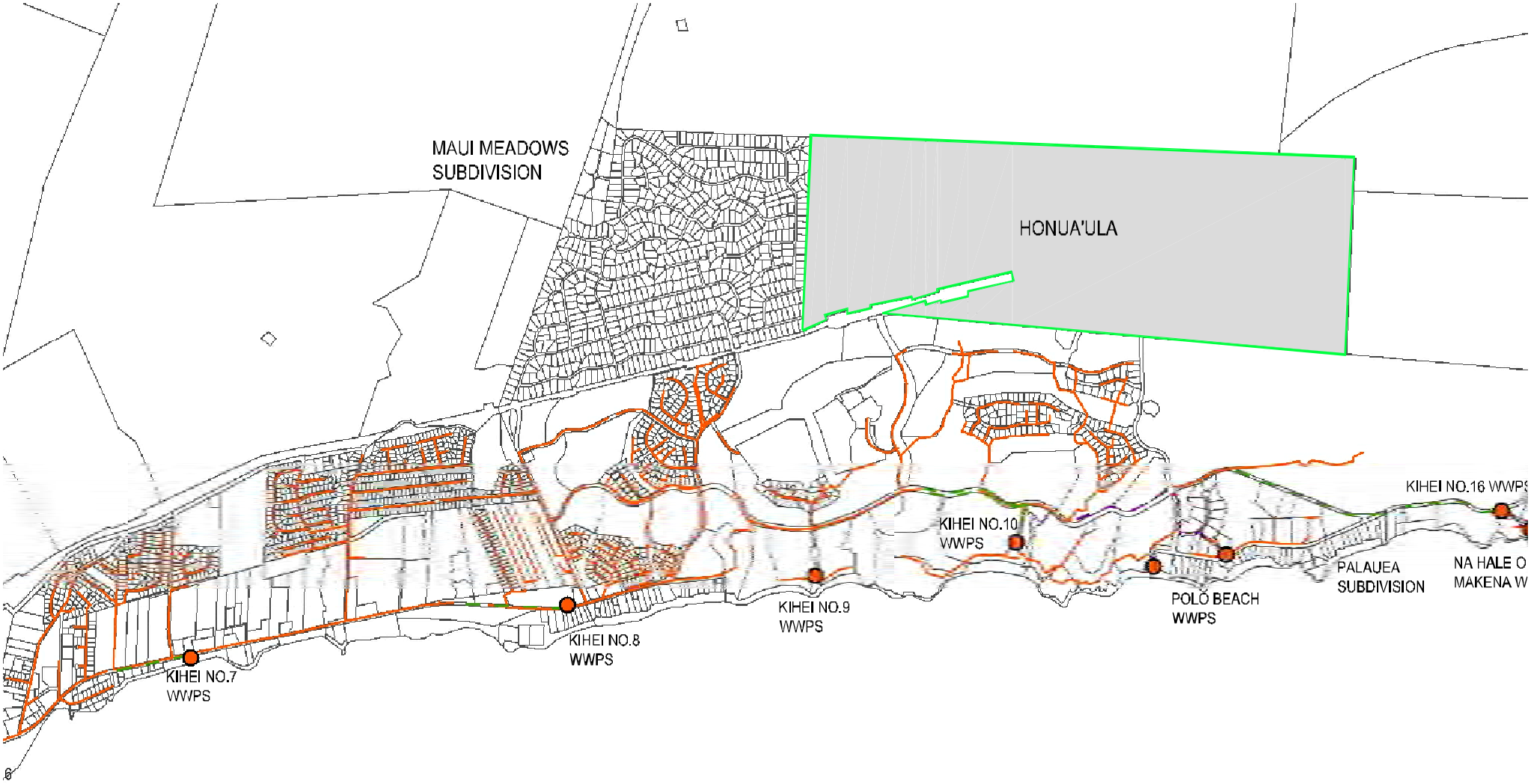
The project site is not served by a wastewater collection system.

The Kīhei WWRF is an activated sludge treatment facility that currently has a peak dry weather capacity of 8 million gallons per day (mgd). The facility has undergone major upgrades in its treatment capabilities with the addition of flocculation and chemical feed units, effluent filtration, ultraviolet disinfection, and renovations to the operations building. The plant is capable of producing R-1 effluent, which is the highest quality of reclaimed water, as established by Hawai'i State Department of Health (DOH) Standards. Because R-1 reclaimed water must undergo a high level of treatment, it has minimal restrictions for reuse.

The Kīhei WWRF currently reclaims between 40 and 50 percent of the wastewater it treats, typically between 1.6 and 2.0 mgd. The rest of the R-1 reclaimed water is discharged through injection wells located on the WWRF site. It is envisioned that the Kīhei WWRF will eventually reclaim 100 percent of its flow as public acceptance, demand for the high quality effluent increases in the future, and the distribution system is developed.

The Kīhei WWRF does have unused capacity, however the collection/transmission system may not be adequate to support the project. The County desires to reserve the remaining unused plant capacity to accommodate "infill" development in the existing service area, rather than to extend the service area. Additionally, the County desires to move toward a more sustainable

Figure 2-1 Existing Wastewater System
(11x17)



LEGEND

5000'

1" =2500'

COUNTY SEWERLINE

COUNTY FORCEMAIN

PRIVATE FORCEMAIN

PUMP STATION

PROJECT SITE

WWRF LOCATIONS

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approach to their operations. In regards to wastewater, this would mean more water reuse. The County's reuse system is much more limited in service area than their sewer system. Therefore, the reuse system would need to be extended much more to service the project site. From a sustainability perspective, it would be more desirable to have the reuse water source (treatment plant) closer to where the water will be used (project site). This would reduce pumping and energy costs.

2.1.2 Mākena Wastewater Reclamation Facility

The Mākena Wastewater Reclamation Facility (WWRF) is located approximately 1.5 miles south of Honua'ula and is owned and operated by Mākena Wastewater Corporation. The Mākena WWRF was constructed in 2001 to serve the Mākena Resort. The Mākena WWRF is presently sized to serve Increment 1 of the Mākena Resort. A portion of Increment 1 has been constructed. The current design capacity of the Mākena WWRF is 720,000 gallons per day (gpd), and was designed to be expandable to 1.54 mgd. Currently the Mākena WWRF has a wastewater flow of 391,413 gpd with an excess capacity of 328,587 gpd. Therefore, the wastewater volumes for which the reclamation facility was sized may not be achieved. Therefore the Mākena WWRF could provide wastewater treatment for the proposed Honua'ula Project.

Wastewater received at the reclamation facility is treated using an activated sludge process with ultraviolet radiation disinfection. The wastewater influent is initially screened as it comes into the plant. The screened wastewater flows to aeration lagoons where micro-organisms (activated sludge) consume the organic material in the wastewater. The wastewater then flows to a clarifier where these micro-organisms settle out. The wastewater is then filtered and disinfected using ultraviolet light.

2.2 Design Wastewater Flows

The design peak flows were calculated for each of the Project's parcels using the average wastewater flows, maximum wastewater flows, dry weather infiltration/inflow ("I/I"), design maximum flows, and wet weather I/I.

The County of Maui design standards set forth the definitions to be used to estimate wastewater flows from developments, as shown below:

1. Average Wastewater Flow: The average wastewater flow is the sum of the products of wastewater flow rates multiply by the number of residential units or lot areas.

2. Peaking Factor: The peaking factor was determined by using the Babbit equation to determine the maximum hour wastewater flow.

$$MF = \frac{5}{p^{0.2}}$$

Where: MF = maximum flow peaking factor
p = population in thousands

3. Maximum Wastewater Flow: The maximum wastewater flows were determined by multiplying the average wastewater flow by a County adopted flow factor. A flow factor was determined using the cumulative total of average daily flows for each phase.

4. Dry Weather I/I: Assuming that the sewerlines will be laid above the normal groundwater table, an additional factor of 5 gallons per capita per day ("gpcd") was assumed to account for water entering the collection system through pipe and manhole joints.

5. Design Maximum Flow: The design maximum flow is the sum of the maximum wastewater flow and dry weather I/I.

6. Wet Weather I/I: Assuming that the sewerlines will be laid above the normal groundwater table, an additional factor of 1,250 gallons per acre per day ("gad") was assumed to account for water entering the collection system through pipe joints and sewer structures.

7. Design Peak Flow: The design peak flow is the sum of the design maximum flow and wet weather I/I.

The average dry weather wastewater flow was calculated to be 0.38 MGD, as summarized in Table 2-1 Wastewater Flow Analysis

Table 2-1
Wastewater Flow Analysis

Type	**Q_{avg} (MGD)**
Average Dry Weather	0.38
Maximum Day Dry Weather	0.91
Maximum Hour Dry Weather	1.37
Peak Wet Weather	2.19

2.3 Proposed Improvements

2.3.1 Collection System

2.3.2 Treatment System

The overarching consideration for the proposed improvements is to meet the Conditions of Zoning that the project is responsible for wastewater collection, treatment and disposal. Therefore, the County system serving the Wailea area cannot be used. As a result, connection to the Mākena WWRF or an on-site treatment plant were both considered as options:

1. Alternative 1 - On-Site Treatment Plant: The first alternative is to construct a facility that is capable of treating all of the flow to R-1 standards at the southwest corner of the project site on approximately 4 acres of land. The WWTP would first screen the wastewater for debris, then go through an equalization basin, next through a membrane bioreactor, and finally be disinfected using ultraviolet light. . The recycled water would be delivered to the Honua'ula golf course and other suitable users for irrigation reuse. Reverse Osmosis (RO) concentrate from an on-site desalination facility (see Section 3.2.2.5) would be blended with the R-1 water.

   A membrane bioreactor (MBR) wastewater treatment system is proposed for the on-site WWRF to produce R-1 quality water for non-potable use. The MBR process is a biological process (activated sludge process) combined with a separation process (membrane system). MBR systems are widely used throughout the world and are considered an industry standard for the production of reliable R-1 recycled water. In addition, MBR systems have the smallest footprint of the various biological treatment systems available and provide the highest quality recycled water.

   During the MBR process, wastewater is pumped into aeration basins, where a population of naturally-occurring microbes (activated sludge) treats the water by consuming organic matter. The activated sludge is separated from the water using membranes, located in the MBR basins. The activated sludge is pumped back to the head-end of the aeration basin to be used again.

   Periodically, excess activated sludge must be removed (wasted) from the treatment system. The activated sludge goes through a thickening process to form dewatered solids. The dewatered solids will be hauled to the County landfill for composting or disposal. At build-out the on-site WWRF is expected to produce approximately 17 wet tons of dewatered solids per week.

   The treated water will be disinfected using ultraviolet (UV) light. The treated water will flow through concrete channels containing banks of submerged UV light bulbs. The water will be disinfected as it passes by the bulbs and is

exposed to the UV light. The UV light penetrates the cells of pathogenic organisms, rendering them unable to replicate. The disinfected water exiting the channel will meet R-1 standards and will be suitable for reuse. A pump station located adjacent to the UV channel will deliver the R-1 water to the golf course.

Another potential approach to treating Honua'ula wastewater in lieu of the MBR is via an extended aeration activated sludge process, followed by addition of coagulant chemicals and granular media or cloth disk filtration. Additional land area within Honua'ula would have to be set aside for the WWRF if this approach is taken. The extended aeration activated sludge/coagulant/filtration approach is currently used at the Mākena Wastewater Reclamation Facility and the Kïhei Wastewater Reclamation Facility.

2. Alternative 2 - Mākena WWRF: The second alternative is to transport wastewater to the Mākena WWRF for treatment. Wastewater from Honua'ula would be conveyed to Mākena via a pump station and force main. R-1 recycled water would be pumped back to Honua'ula for use.

Either of the above options are feasible. Alternative 2 provides the benefit of consolidating wastewater services for both developments (Honua'ula and Mākena), allowing economies of scale in the treatment process and consolidated regulatory compliance. Sufficient irrigated golf course land is available within both developments to reuse 100 percent of the recycle water that will be produced.

Connection to the Mākena WWRF was chosen as the best option. Three alternative routes were considered to connect the project site to the Mākena WWRF. The most direct route was selected (R.M. Towill, Wailea 670 Wastewater Conveyance Alternatives: Analysis and Recommendations, April 16, 2008).

Wastewater will be treated at the Mākena WWRF (see Figure 2-2). It may be necessary to expand certain portions of the Mākena WWRF to provide a small amount of additional capacity to accommodate the total Honua'ula development wastewater flows along with the Mākena Resort flows (existing and proposed). As the developments will be phased, implementation of the improvements could be implemented at the appropriate phase.

2.3.2.1 Sewerlines

The proposed wastewater improvements consist of a gravity collection system to collect flows from varying areas within the development. Pump stations will be utilized where the topography requires flows to travel upslope. The on-site wastewater collection system will essentially follow the proposed roadway system (see Figure 2-3). The network of 8-inch gravity sewer lines will collect

wastewater from the residential lots and developments throughout the project site within four service areas. In each of these service areas, the sewer lines will follow the topography and will flow by gravity to each of the five respective wastewater pump stations.

2.3.2.2 Wastewater Pump Stations

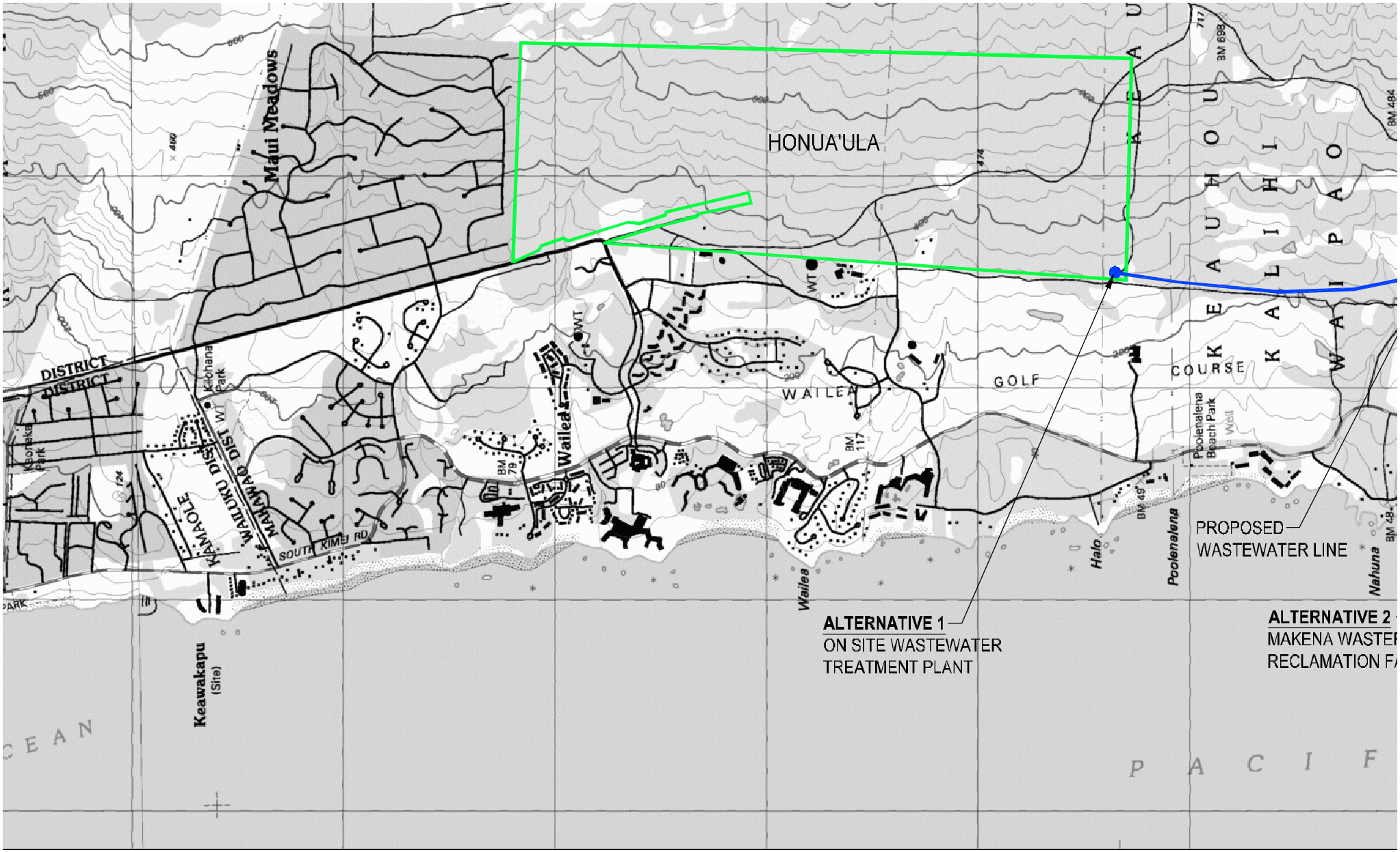
The existing drainageways provide an obstacle to the gravity system. Therefore, four (4) wastewater pump stations will be utilized to transport the wastewater under the drainageways. Sewerlines may be 3 – 15 feet deep, depending upon the installation method used. A fifth wastewater pump station will be built to transport the wastewater from the project site to the existing Mākena WWRF. The locations of the WWPSs were selected based on the layout of the gravity sewerlines, topography, surrounding land uses, and phasing schedule. A layout of the pump station service zones can be found in Figure 2-4.

All the wastewater flows will be collected at the southwest corner of the project site. From here the flows will be pumped to the Mākena WWRF.

2.4 Wastewater Reuse

Wastewater treated to an R-1 level will be pumped back to the project site and stored in water features located on the golf course. The brine water from the reverse osmosis (RO) facility (see Section 3.2.2.5) will be mixed with the R-1 and other non-potable reclaimed water (see Figure 2-5). Water stored on the golf course will then be distributed for irrigation purposes as needed.

To meet County's current standards and Conditions of the Zoning to reuse reclaimed water, it is proposed to use the R-1 reclaimed water to irrigate portions of the project area such as the golf course and golf course landscaping.



LEGEND

PROPOSED WASTEWATER LINE

4000'

1"=2000'

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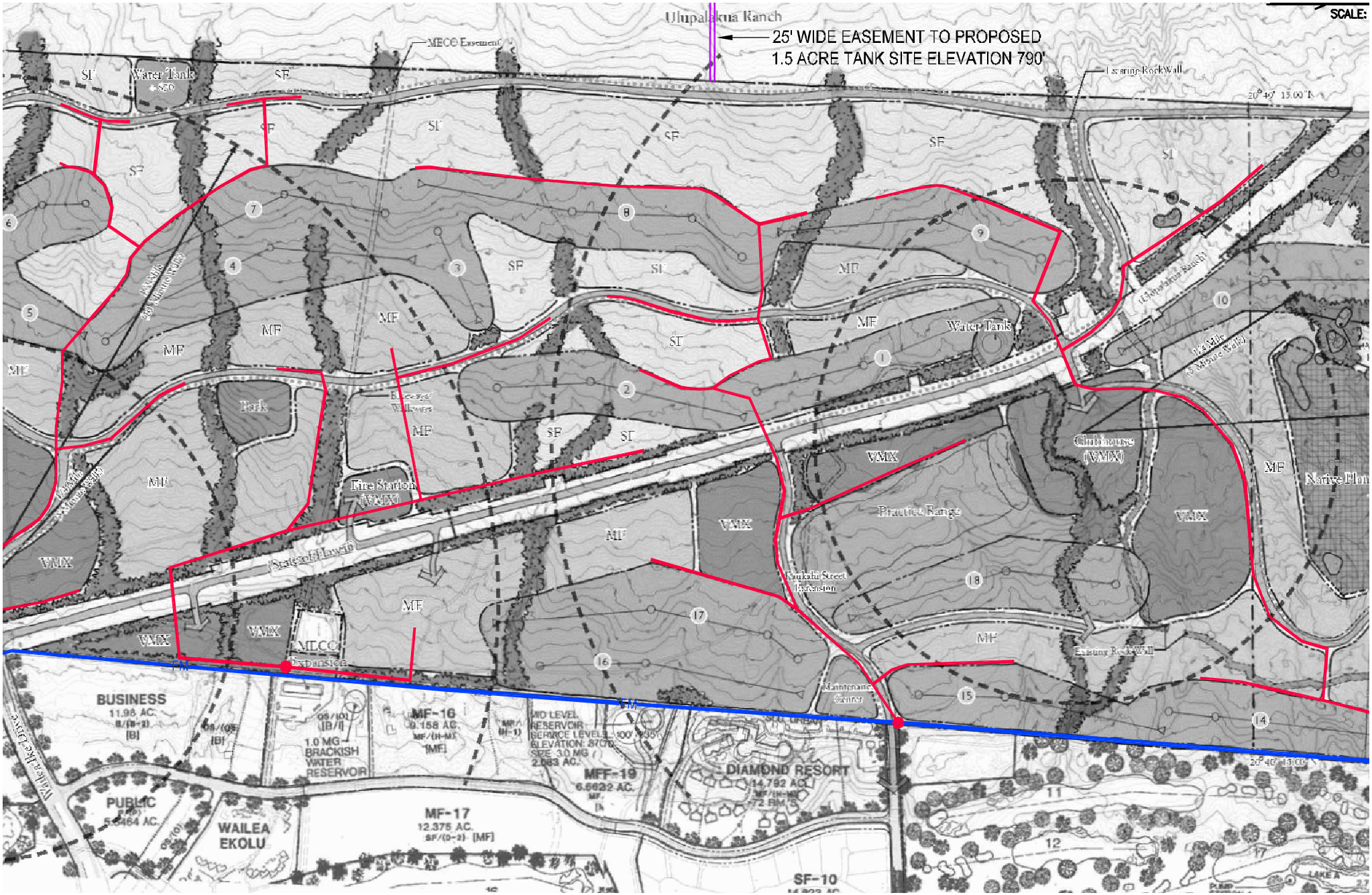

LEGEND

1300'

1"=650'

FM — SEWER FORCEMAIN

S8 — SEWERLINE

PUMP STATION

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SCALE:
25' WIDE EASEMENT FOR PROPOSED
1.5 ACRE TANK SITE ELEVATION 790'
Ulupalakua Ranch
MECO Easement
Lasang Rock Wall
20°42' 15.00"N
Water Tank
1
2
3
Park
Fire Station
(VMX)
Clubhouse
(VMX)
Practice Range
Water Tank
BUSINESS
11.98 AC.
MF-16
9.158 AC.
MF-17
12.375 AC.
SF/(D-2) [MF]
MFF-19
6.6922 AC.
1.0 MG
BRACKISH
WATER
RESERVOIR
MID LEVEL
RESERVOIR
DIAMOND RESORT
14.792 AC.
72 RM'S
PUBLIC
WAILEA
EKOLU
Wailea Alanui Drive
Existing Rock Wall
Maintenance
Center
Kaukahi Street
Extension
Native Plan
LEGEND
1300'
1"=650'
SERVICE AREA 1
SERVICE AREA 2
SERVICE AREA 3
SERVICE AREA 4

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R-1 reclaimed water will be mixed with the brine water to irrigate the golf course and golf course landscaping. The non-potable water will be used to irrigate the roadway landscaping, individual residential lots, and other common areas to be in compliance with the Conditions of Zoning.

As a backup to the reclaimed water system (during periods where reclaimed water maybe unavailable), if necessary, brackish water will be pumped to the golf course. Reclaimed water will not be placed in injection wells (see Condition 17).

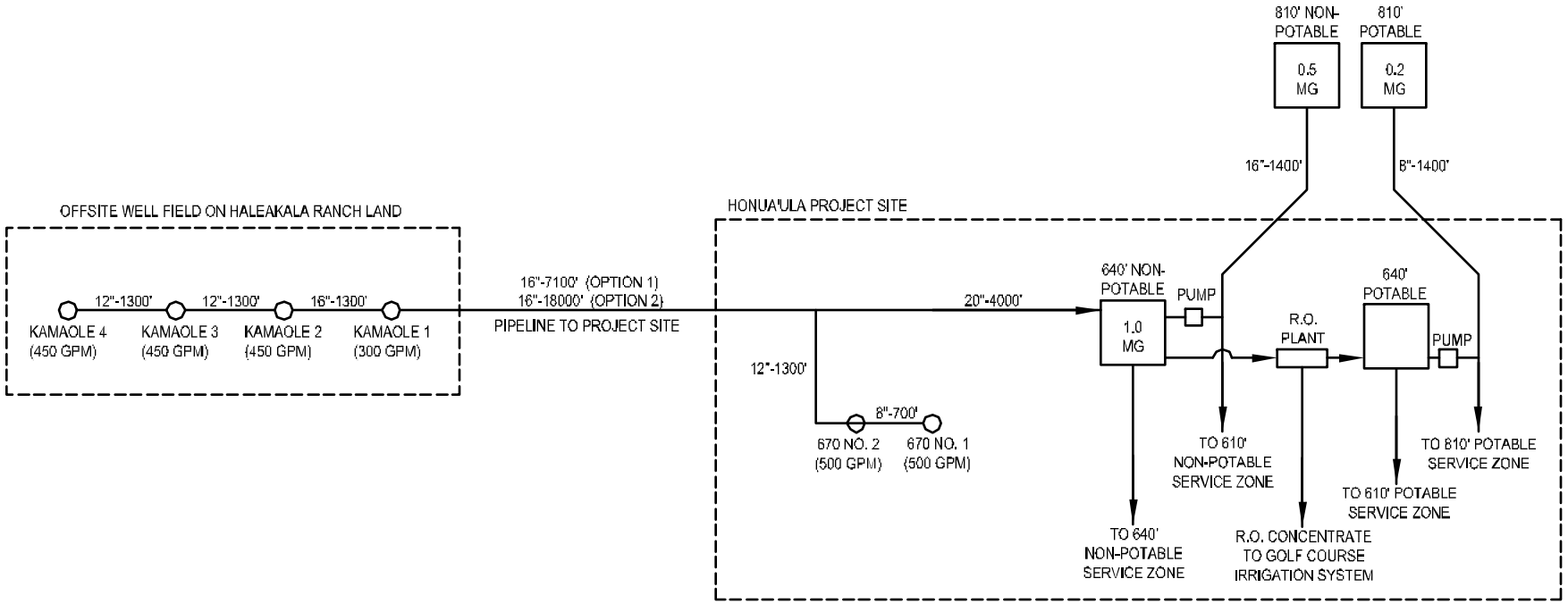
2.5 Summary

The overarching consideration for the proposed improvements is to meet the Conditions of Zoning that the project is responsible for wastewater collection, treatment and disposal. The County system serving the Wailea area cannot be used, therefore connection to the Mākena WWRF or an on-site treatment plant are potential options. Connection to the Mākena WWRF is the preferred option.

Both alternatives as discussed in the previous sections are feasible. However, Alternative 2 is recommended as it provides the benefit of consolidating wastewater services for both developments (Honua'ula and Mākena), allowing economies of scale in the treatment process and consolidated regulatory compliance.

The on-site wastewater collection system will essentially follow the proposed roadway systems. The network of 8-inch gravity sewer lines will collect wastewater from the residential lots and developments throughout the project site within four service areas. In each of these services areas, the sewer lines will flow to each of the four respective wastewater pump stations. The wastewater will be treated either on site or off site at the Mākena WWRF.

R-1 reclaimed water will be used to irrigate the golf course and golf course landscaping.



SCHEMATIC OF MAJOR COMPONENTS
OF THE HONUA'ULA POTABLE AND
NON-POTABLE SYSTEMS

WILSON OKAMOTO CORPORATION

HONUA'ULA

NON-POTABLE WATER PROCESS

FIGURE
2-5

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3. POTABLE AND NON-POTABLE WATER

The Conditions of Zoning require that the project develop a private water source, storage facilities, and transmission pipelines in accordance with Department of Water Supply standards:

> *Condition 1: That Honua'ula Partners, LLC, its successors and permitted assigns, shall, at their own cost and expense, develop, maintain, and operate, or cause to be developed, maintained, and operated, a private water source, storage facilities, and transmission lines for the Wailea 670 project in accordance with Department of Water Supply standards and all applicable community plans. Honua'ula Partners, LLC, its successors and permitted assigns, shall comply with all reporting requirements of the State Commission on Water Resource Management.*
>
> *In addition, Honua'ula Partners, LLC, its successors and permitted assigns, shall comply with applicable water ordinances that pertain to the supply and transmission of water from the island of Maui when such ordinances are enacted.*
>
> *At the time the project water system is completed, Honua'ula Partners, LLC, its successors and permitted assigns, shall offer to the County the right to purchase the project water system at the cost of development of such system.*
>
> *The water rates for the residential workforce housing units shall be no higher than the general water consumer rates set by the County in its annual budget, for as long as the units are subject to Chapter 2.96, Maui County Code.*
>
> *Condition 4: That Honua'ula Partners, LLC, its successors and permitted assigns, shall be responsible for all required infrastructural improvements for the project, including water source and system improvements for potable and non-potable use and fire protection, drainage improvements, traffic-related improvements, wastewater system improvements and utility upgrades, as determined by the appropriate governmental agencies and public utility companies. Except as otherwise provided by more specific conditions of zoning, said improvements shall be constructed and implemented concurrently with the development of each phase of Kīhei-Mākena Project District 9, and shall be completed prior to issuance of any certificate of occupancy or final subdivision approval, unless improvements are bonded by Honua'ula Partners, LLC, its successors and permitted assigns. Honua'ula Partners, LLC shall execute appropriate agreements with governmental agencies regarding participation in improvements of infrastructure and public facilities as determined by the agencies.*

> *Condition 14: That a non-potable water supply system shall be utilized for all irrigation purposes.*

*Water Systems Master Plan for the Honua'ula Project in Wailea, Maui (*TNWRE, December 2009) was used to estimate water demand.

This section documents the assumptions and process for designing the proposed potable and non-potable improvements to meet the demands of the project.

3.1 Existing Conditions

The project site falls within the Kamaole aquifer which extends west along Waiakoa Gulch to Kīhei; south to Cape Kina'u; Cape Kina'u northeast along crest of southwest rift of Haleakalā to Kolekole. The Kama'ole aquifer has a sustainable yield of 11 mgd and the total aquifer pumpage is on the order of 3.5 to 4.0 mgd at present (Mink and Lau, 1990). In 1990, the CWRM set the sustainable yield of the Kama'ole Aquifer at 11 million gallons per day (MGD). This was based on a computed groundwater recharge of 25 MGD and the assumption that 44 percent of the recharge could be withdrawn by wells without adversely impacting the integrity of aquifer. However, several far more detailed and sophisticated studies on the aquifer's recharge have been completed since then (USGS 1999; Waimea Water Services Inc. 2004; USGS 2007). These studies indicate that the recharge amount on which the CWRM's sustainable yield is based is substantially underestimated; the actual sustainable yield of the aquifer may be as much as 50 percent greater than the 1990 CWRM estimate. Current actual aquifer pumpage is estimated to be approximately 4.0 MGD (TNWRE 2010).

3.1.1 County System

The Kīhei-Wailea area is part of the Central Maui Water System. Potable water is supplied entirely by the Iao Aquifer, which also supplies the Wailuku-Kahului region. A 36-inch transmission main and an 18-inch main extending along Mokulele Highway delivers water to the Kīhei-Wailea area. Existing water systems in the vicinity of the project site include the Maui Meadows System to the north and Wailea Resort System to the west.

Although the project will not be served by the County Water System, adjacent developments are served by the County.

The County's Maui Meadows System consists of a 0.5 million gallon (MG) high-level tank located at the 799 foot elevation and a 1.0 MG mid-level tank located at the 563 foot elevation (see Figure 3-1). Both 0.5 MG and 1.0 MG tanks are fed by the Kilohana 1.0 MG low-level tank through a 12-inch transmission line.

There is also an existing 1.0 MG water tank that will be dedicated to the County of Maui located on the project site above Kaukahi Street. This tank provides service to developments below the project site.

The potable Wailea Resort System is a County system that consists of a low-level 2.0 MG tank south of Wailea Ike Drive at the 210 foot elevation and a 3.0 MG mid-level tank at the 374 foot elevation. The Wailea 3.0 MG tank is located to the west of the Honua'ula project and serves most of the subdivisions below the project site.

3.1.2 Private Water System

The Wailea Resort operates a private non potable system for golf course irrigation.

The project has four brackish wells. Two of these are on site (Wailea 670 Nos. 1 and 2). The other two are off site wells (Kama'ole 1 and 2) located on Haleakalā Ranch property north of Maui Meadows within a water source development area designated for well development for Honua'ula (see Figure 3-2). The total safe yield of the four wells, with one as standby, is 1.296 MGD (TNWRE 2009).

In compliance with Conditions 4 and 14, the project will develop and operate a private water system providing both potable and non-potable water for use within the project. The potable system will provide source and supply for all domestic needs through a series of wells, a delivery system, a reverse osmosis water treatment plant and storage tanks. The non-potable water system will utilize water from wells, reclaimed water from the wastewater treatment facility as well as all water/brine byproduct from the reverse osmosis treatment facility

The projected brackish supply needed to address both potable and non-potable water needs for the project at build-out is approximately 2.490 MGD. This demand will be served by the existing and proposed wells located within the Haleakala Ranch source development area (two more wells within this area will be developed as demand is projected within the project).

3.2 Potable Water System

3.2.1 Projected Potable Water Use

Based upon the *Water Systems Master Plan for the Honua'ula Project* (TNWRE, December 2009), the average daily potable water use for the project was estimated to be 0.342 MGD. The average use with the inclusion of the 10% allowance for leakage and unmetered use is estimated to be 0.3766 MGD.

3.2.2 Proposed Potable Water System Improvements

The proposed potable and non-potable water system will be part of a larger system integrating use of brackish well water and reclaimed water from the WWRF.

3.2.2.1 Pressure Zones

The elevation of the project site ranges from 320 to 710 feet. To provide service over this range of elevation, the project site was divided into two pressure zones, correlating with a high and low water storage system approximately divided by the 530-foot elevation.

The service pressure zones were established by storage reservoirs with spillway elevations of 640 and 810 feet. The 640-foot reservoirs will be on site and the 810-foot reservoirs will be mauka of the project site on land owned by Ulupalakua Ranch.

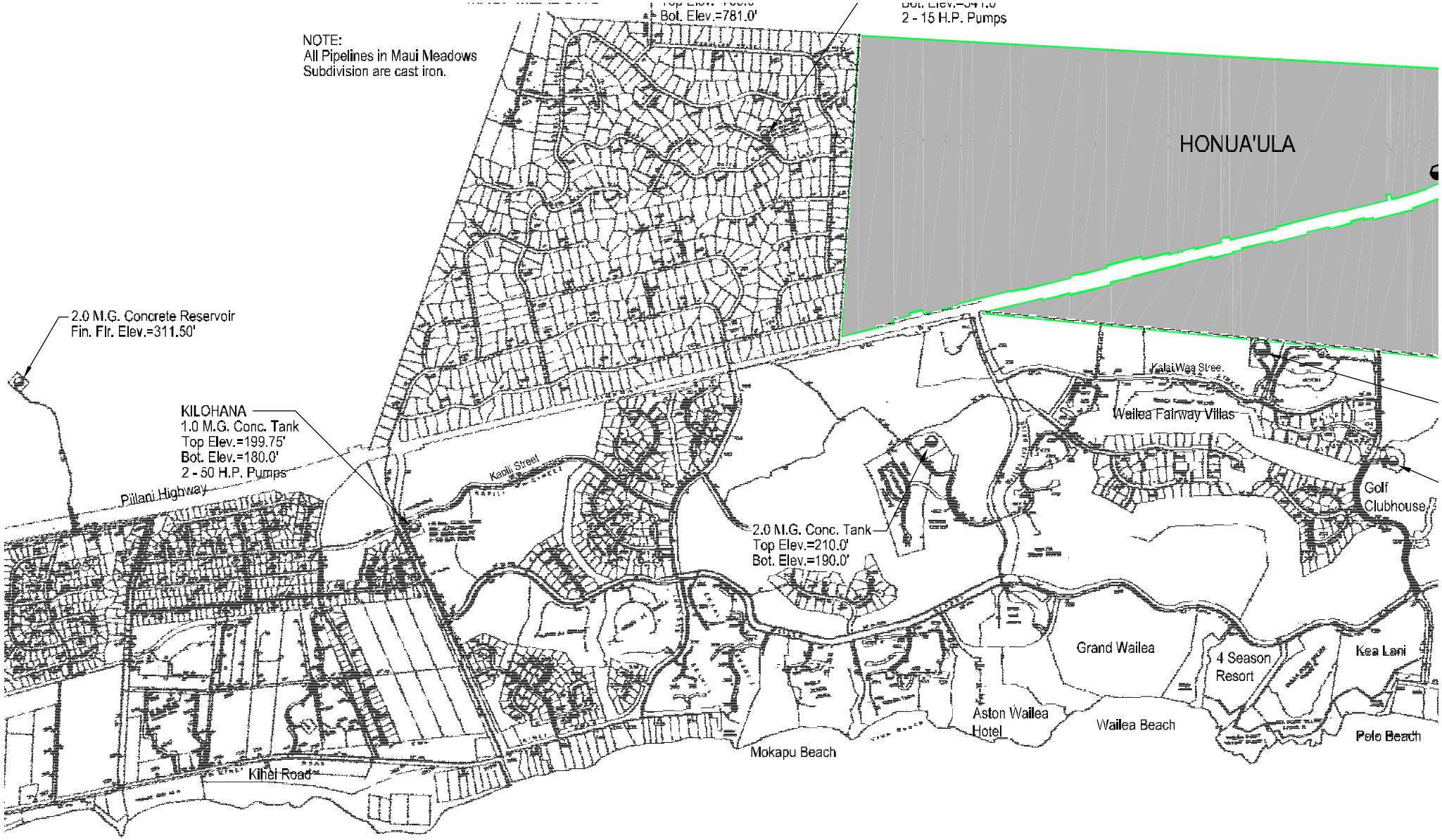
The overriding consideration for the potable water system is the condition of zoning requiring a system independent of the County water system.

3.2.2.2 Source and Transmission

Service from the County DWS is not available for the project, therefore the following three private water systems will be developed:

1. a non-potable system supplied by brackish wells will provide water for irrigation of common areas and within development parcels;
2. a potable system supplied by RO- treated water, using brackish groundwater as the feedwater supply, will provide drinking water and other, within building potable uses; and
3. a golf course irrigation system supplied by treated wastewater (R-1 quality), concentrate from the RO treatment of the potable supply, and brackish groundwater from the non-potable irrigation system.

To provide potable and non-potable water service to the project, two new brackish water wells (Kama'ole 3 and 4) will be developed in a well field to the north of Maui Meadows which is approximately 2.5 miles away at an elevation of 600 feet (in Haleakalā Ranch property) (see Figure 3-2). A well field is an area designated for well development. Depending on actual water use rates that materialize, an additional well may be required with the well field (in Haleakalā Ranch property). The new wells will all be within the Kamaole aquifer and within the Kīhei-Mākena Community Plan area. The brackish water will be pumped through a 12" – 20" pipeline to the project site. A total supply of 2.49- MGD would be provided at full build-out.


Bot. Elev.=781.0'
2 - 15 H.P. Pumps
NOTE:
All Pipelines in Maui Meadows
Subdivision are cast iron.
HONUA'ULA
2.0 M.G. Concrete Reservoir
Fin. Flr. Elev.=311.50'
KILOHANA
1.0 M.G. Conc. Tank
Top Elev.=199.75'
Bot. Elev.=180.0'
2 - 50 H.P. Pumps
Piilani Highway
Kaoli Street
2.0 M.G. Conc. Tank
Top Elev.=210.0'
Bot. Elev.=190.0'
Kalai Waa Stree.
Wailea Fairway Villas
Golf
Clubhouse
Grand Wailea
4 Season
Resort
Kea Lani
Aston Wailea
Hotel
Wailea Beach
Polo Beach
Mokapu Beach
Kihei Road
3000'
1"=1500'

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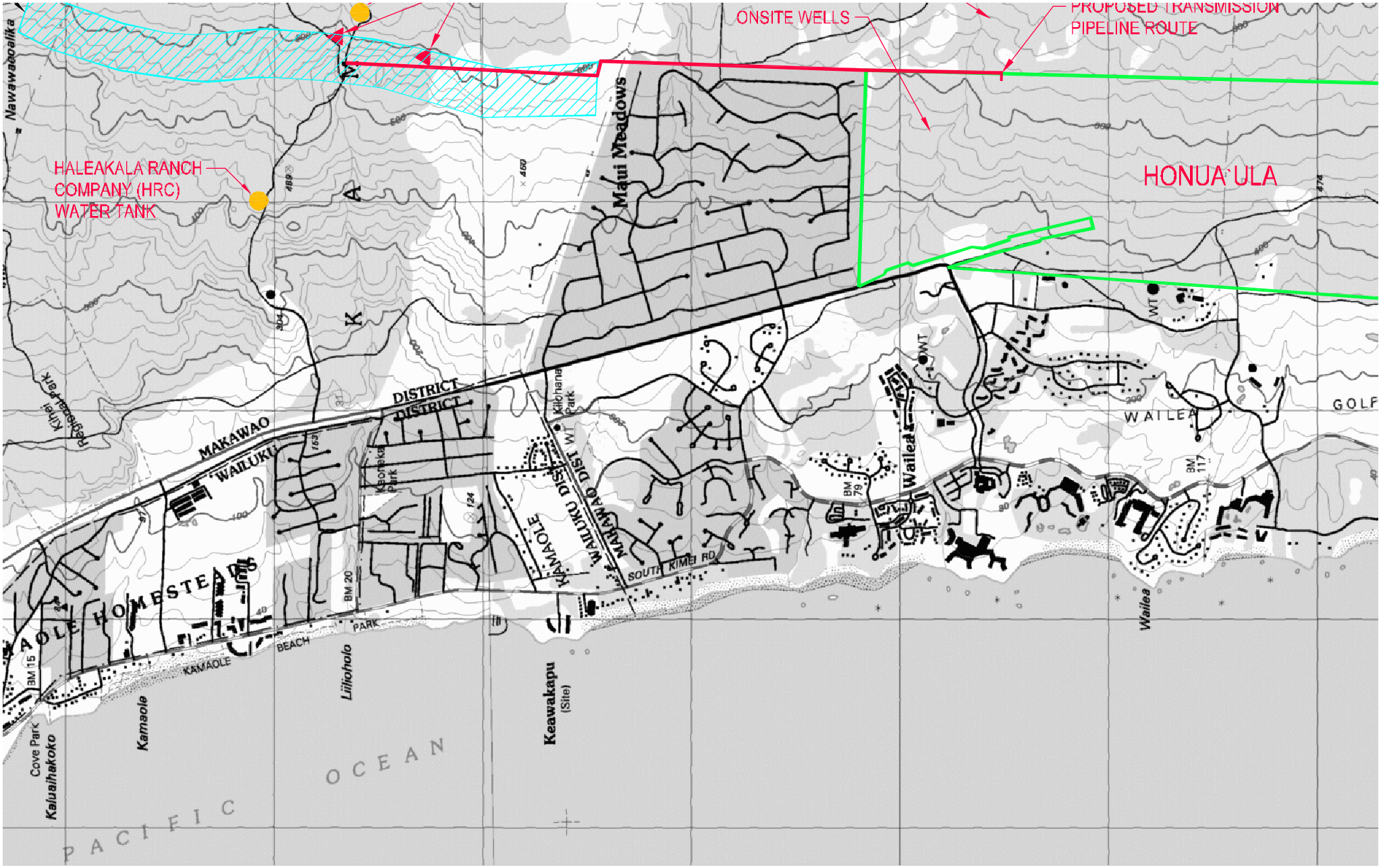
ONSITE WELLS
PROPOSED TRANSMISSION PIPELINE ROUTE
HALEAKALA RANCH COMPANY (HRC) WATER TANK
HONUA ULA
Maui Meadows
MAKAWAO
WAILUKU
DISTRICT
DISTRICT
MAKAWAO DIST
WAILUKU DIST
KAMAOLE
SOUTH KIHEI RD
KAMAOLE HOMESTEADS
KAMAOLE BEACH PARK
Kamaole
Liliioholo
Keawakapu
(Site)
Kalualhakoko
Cove Park
OCEAN
PACIFIC
WAILEA
GOLF
Wailea
Kihei Boat Ramp
Kalepolepo Park
Kihohana Park
Kaonoeka Park
BM 15
BM 20
BM 79
BM 117
WT
LEGEND
WELL FIELD
KAMAOLE WELL SITES
HRC WATER TANKS
PROPOSED WATERLINE
4000'
1"=2000'

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The alignment will route brackish water from Kama'ole Wells 3 and 4 through the well field directly to the water treatment and storage facilities located within and outside the project area. This system will require pumping to deliver the water to the treatment facility. The alignment and these facilities fall along the eastern (mauka) boundary of Meadow Meadows and Honua'ula.

3.2.2.3 Storage

Water storage will be required for each of the pressure zones. According to the report by TNWRE (2009), the lower tank (at approximate elevation 640-foot), servicing the lower portion of the site, will be located along the eastern border of the project adjacent to a reverse osmosis plant (see Figure 3-2). The lower tank will be a 0.5 MG tank. The high tank (at approximate elevation 810-foot), located off-site and east (mauka) of the project site, will service the upper portion of the project site. The upper tank will be a 0.2 MG tank. Both tanks were sized to provide the projected maximum day use including the 10% allowance for leakage and unmetered use with no credit for source inflow.

As described above in section 3.2.2.2, storage for the upper delivery system will be established through a pressurized system using storage tanks for supply and the lower level system using storage and gravity for service.

3.2.2.4 Distribution

The on-site upper level and lower level potable water distribution system, respectively will largely follow the proposed roadway system providing water to irrigate the golf course, individual residential lots, roadway landscaping, and other common areas (see Figure 3-3). An 8" potable waterline and a 16" non-potable waterline will be used for water distribution. Waterline sizes were determined from the tables provided in the Sizing Water Service Lines and Meters of the American Water Works Association. Tables can be found in Appendix A. Some assumptions were noted to determine the size of the waterlines:

1. Pipe material will be Class 150 PVC 1120 Pressure Pipe for non-potable water
2. Pipe material will be Ductile Iron Pressure Pipe for potable water
3. A Flow of 2,000 GPM is used for the non-potable water

Pressure reducing valves are used to regulate excessive pressures within the pressure zones.

3.2.2.5 Treatment – Reverse Osmosis

The brackish well water will be treated by reverse osmosis to produce potable water for the project. The reverse osmosis process involves initially passing the raw brackish water through a filter to remove particulate matter. The filtered water is then forced through a membrane under pressure. The membrane acts

as a barrier to salts and other constituents. The water that passes through the membrane may be further chemically treated and disinfected prior to use. The reverse osmosis plant will be located at the eastern border of the project site next to the lower distribution tanks (see Figure 3-3). A portion of the brackish water will bypass the reverse osmosis plant, to be used as non-potable water for irrigation. The brine effluent produced by the plant will also be diluted and reused as non-potable water for irrigation. The non-potable water system is discussed subsequently.

The RO facility generates brine in the process of producing potable water. The Conditions of Zoning prohibit the use of injection wells to dispose of the brine. However, by diluting it with other non-potable water (such as R-1), its salt content can be reduced to a degree that it will be used for irrigation.

3.3 Non-Potable Water System

3.3.1 Projected Non-Potable Water Use

Non-potable water will be used to irrigate the golf course, individual residential lots, roadway landscaping, and other common areas. The Conditions of Zoning require that irrigation be done using non-potable water. The projected average daily non-potable water use is 0.810 MGD through Phase 3. The estimated golf course irrigation requirement is 0.717 MGD for 110 acres (TNWRE, 2009).

Development of the non-potable water system will be concurrent with the phasing of major backbone infrastructure and the individual residential subdivisions.

3.3.2 Proposed Non-Potable Improvements

3.3.2.1 Pressure Zones

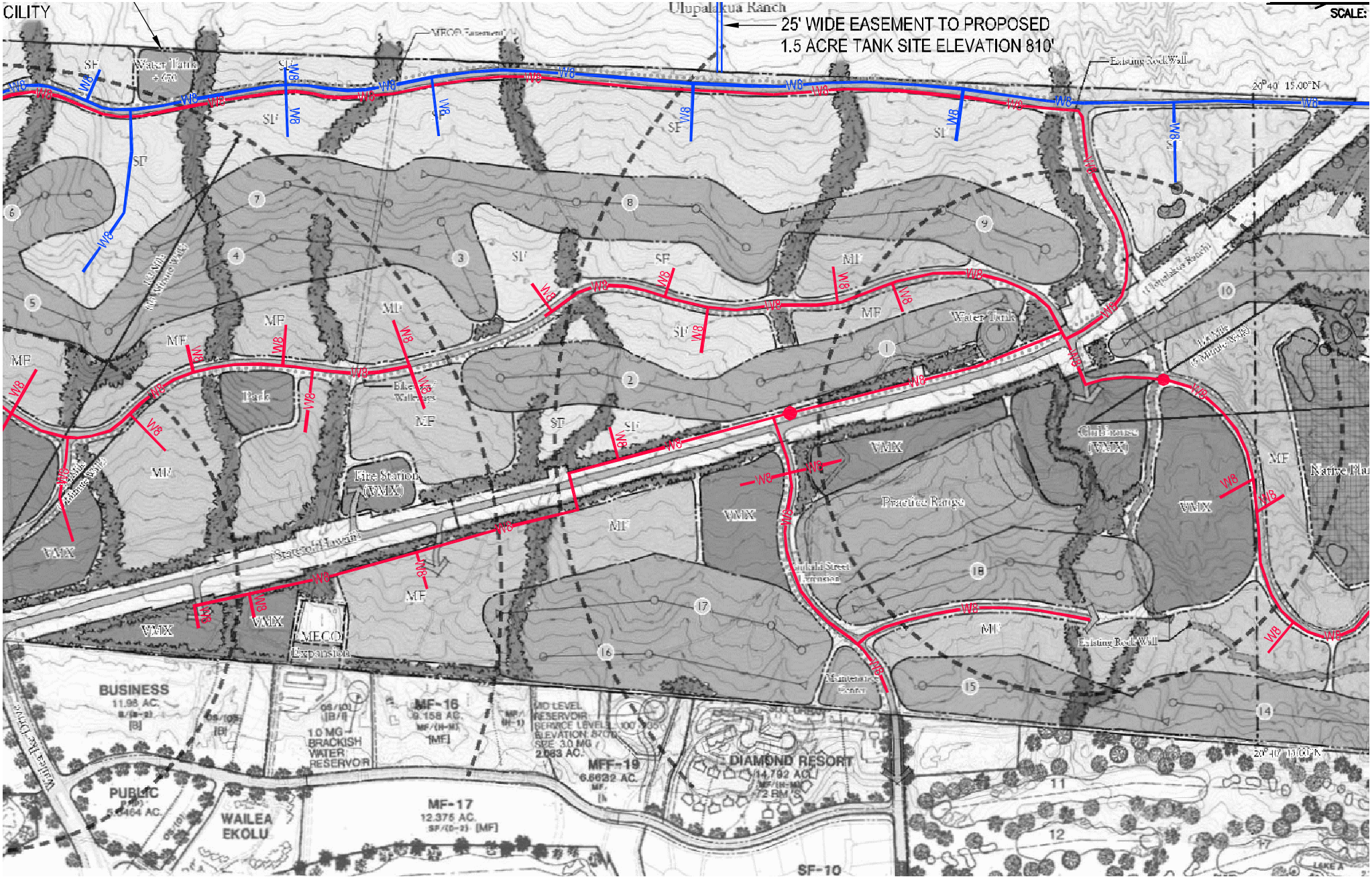
Comparable to the potable water system, the site is separated into two pressure zones due to the elevation difference across the site.

3.3.2.2 Source

There are three sources of non-potable water: the R-1 reclaimed water returned from the Wastewater Reclamation Facility, the brine water being wasted from the RO facility, and well water.

3.3.2.3 Storage

Similar to the potable water system, storage tanks will be provided for each pressure zone. According to the report by TNWRE (2009), a 1.0 MG lower non-potable water tank will be located at the 640' elevation adjacent the RO plant.


CILITY
Ulupalakua Ranch
25' WIDE EASEMENT TO PROPOSED
1.5 ACRE TANK SITE ELEVATION 810'
SCALE:
MECO Easement
Existing Rock Wall
20°40' 15.00"N
Water Tank
+470
Water Tank
Park
Bike Walkways
Fire Station
(VMX)
Practice Range
Clubhouse
(VMX)
Native Plan
Existing Rock Wall
MECO
Expansion
BUSINESS
11.98 AC.
1.0 MG
BRACKISH
WATER
RESERVOIR
MF-16
9.158 AC.
MID LEVEL
RESERVOIR
SERVICE LEVEL
ELEVATION 870'
SIZE 3.0 MG
2.083 AC.
MFF-19
6.6632 AC.
DIAMOND RESORT
14.792 AC.
72 RM'S
PUBLIC
5.6464 AC.
WAILEA
EKOLU
MF-17
12.375 AC.
SF-10
20°40' 10.00"N
LEGEND
1300'
1"=650'
W8
UPPER WATERLINE
W8
LOWER WATERLINE
PRESSURE RELIEF VALVE

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A 0.5 MG upper non-potable water tank will be located at the 810' elevation. The golf course irrigation water will be stored in water features located on the golf course.

3.3.2.4 Distribution

The on-site upper level and lower level non-potable water distribution system respectively will largely follow the proposed roadway system providing water to irrigate individual residential lots, roadway landscaping, and other common areas (see Figure 3-4). A separate distribution system will be used to irrigate the golf course. Pressure reducing valves will be used to regulate excessive pressures within the pressure zones.

3.4 Summary

At full build-out, the proposed project is estimated to have a daily potable water use of 0.342 MGD, and an average use with 10% allowance for leakage and unmetered use of 0.3766 MGD. The daily non-potable water use is 0.810 MGD, and an average use with 10% allowance for leakage and unmetered use of 0.890 MGD. Due to the elevation range of the project site, the site was divided into two zones, correlating with high-level and low-level water storage water systems approximately divided by the 530-foot elevation.

To provide potable and non-potable water demand, two new brackish water wells will be developed to meet the demands of the proposed project. Depending on actual water use rates that materialize, an additional well may be required. The project is estimated to have a 0.5 MG lower-level tank and a 0.2 MG higher-level tank to store potable water. A 1.0 MG lower-level tank and 0.5 MG higher-level tank to store non-potable water. The potable tanks were sized to meet the estimated maximum day rate plus the 10% allowance for leakage and unmetered use, in storage volume with no credit for source inflow. The non-potable tanks were sized to provide fire protection, providing a fire flowrate with coincident maximum day demand for the duration of the fire, with the reservoir ¾ full at the start of the fire.

Waterline sizes will vary in size from 8 inch to 20 inch lines and follow the proposed roadway systems.

Non-potable water will be used to irrigate the golf course, individual residential lots, roadway landscaping, and other common areas in compliance with the Conditions of Zoning.

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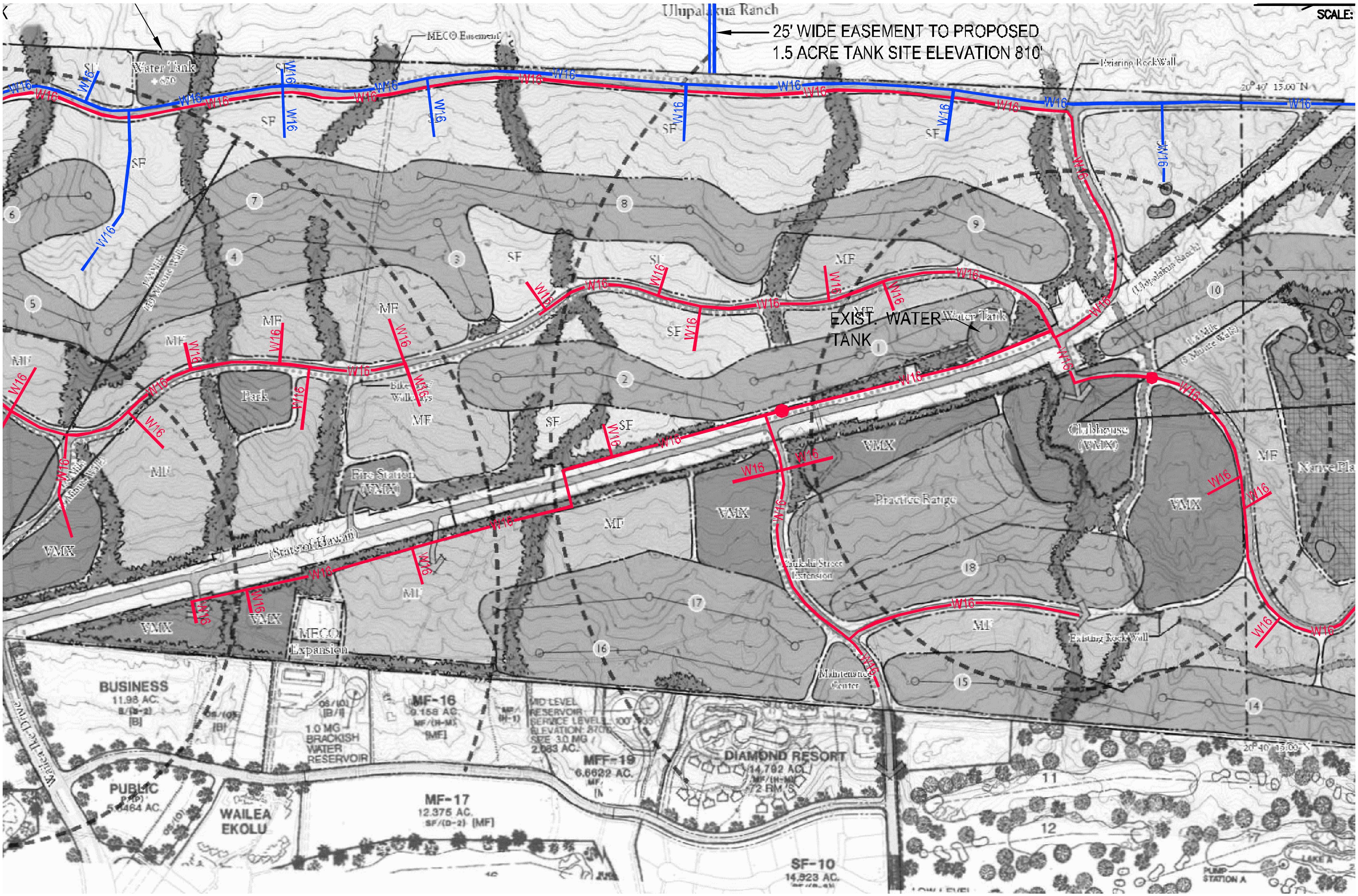

LEGEND

WX (blue line)	UPPER IRRIGATION
WX (red line)	LOWER IRRIGATION
Red / blue dots	PRESSURE RELIEF VALVES
Purple line	RECLAIMED WATER

1300'

1"=650'

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4. DRAINAGE

The Conditions of Zoning require that the project develop infrastructure improvements:

> *Condition 4: The Honua'ula Partners LLC, its successors and permitted assigns, shall be responsible for all required infrastructural improvements for the project, including water source and system improvements for potable and non-potable use and fire protection, drainage improvements, traffic-related improvements, wastewater system improvements and utility upgrades…….*

This section reviews the existing topography and drainage conditions and describes proposed improvements to meet the demands of the project. The proposed improvements are subject to change based on the refinement of plans and availability of more detailed information.

4.1 Existing Conditions

For the purpose of the drainage assessment the drainage area (herein referred to as "project area") to be assessed encompasses approximately 687 acres, including the project site (TMK: 2-1-008: 056 and 071), TMK 2-1-008: 043, and the Pi'ilani Highway right-of-way within the property (TMK 2-1-008:999(portion)).

In addition to the on-site drainage areas, the "project area" also consists of off-site drainage areas. Approximately 3,989 acres of land mauka of the project area is taken into consideration as off-site drainage. The area mauka of the project site consists of undeveloped land, dirt roads and minor natural drainage channels. Generally, the drainage will flow in a westerly direction from Haleakalā toward the ocean.

Wailea Resort and Golf Course is located makai of Honua'ula.

4.1.1 Climate

The project area generally experiences warm, dry weather except during occasional trade wind showers and during the major storm periods in the winter months. Kona storms usually produce high surface water runoff. Average annual rainfall is approximately 18 inches in the project area.

4.1.2 Topography and Soil Conditions

On site soils are largely comprised of four soil types designated by the U.S. Department of Agriculture, Soil Conservation Service (see Figure 4-1):

- The majority of the project site is classified as Keawakapu Extremely Stony Silty Clay Loam (KNXD). The soil consists of a 2-inch thick dark reddish-brown stony silt loam. The subsoil has a 16-inch thick dark reddish-brown

silty clay loam. Permeability is moderate, runoff is slow to medium, and the erosion hazard is slight to moderate. The slopes generally range from 3 to 17 percent with elevations ranging from 320 feet on the makai (west) end to 720 feet on the mauka (east) end.

- The lower, western portion of the project site is classified as Makena Loam, Stony Complex (MXC). It consists of Makena loam and Stony land. The permeability is moderately rapid, runoff is slow to medium and the erosion hazard is slight to moderate. The slopes generally range from 3 to 5 percent.

- The southern third of the project site is classified as Very Stony Land (rVS), with slopes ranging from 7 to 13 percent. Permeability is moderate, runoff is slow to medium and the erosion hazard is slight to moderate.

- Oanapuka (OAD), Very Stony Silt Loam is found in the southeast corner of the project site. This soil type has been used to support pasture land and wildlife habitat with its exotic grasses and trees. Permeability is moderately rapid, runoff is slow and erosion hazard is slight to moderate.

4.1.3 Hydrology

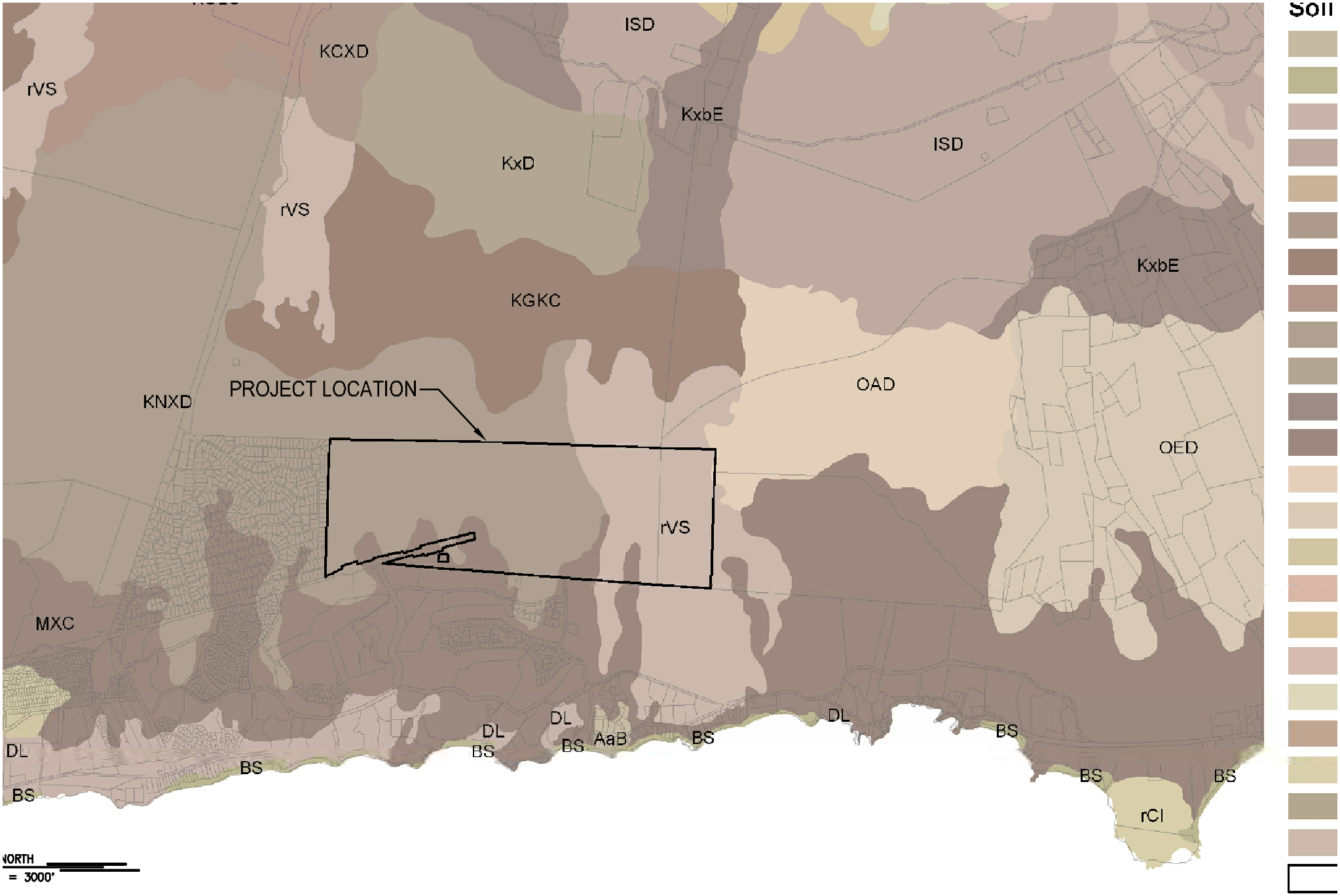
Surface runoff mauka of the project sheetflows over the project site toward the ocean or through natural drainage paths before discharging into the ocean. There are approximately 8 well-defined natural drainage paths in which runoff flows through the site.

The existing project area consists of about 4,692 acres of off site and on site drainage. The existing area can be categorized into twelve (12) distinct drainage basins, based on approximate ridgelines and natural topography (see Figure 4-2).

1. **Drainage Basin A**. This drainage basin has an area of approximately 1,500 acres. Surface flow from Haleakalā travels in a westerly direction over the natural terrain toward the ocean. Currently, most of the basin is covered with slight to moderate vegetation. Most of the drainage flow can be considered off site. Ultimately, the runoff flows west through the Wailea development and into the ocean.

2. **Drainage Basin B**. Surface flow from this drainage basin encompasses approximately 446 acres. This surface flow starts from Haleakalā and travels in a westerly direction toward the ocean through the natural terrain.

   Most of this terrain is made up of slight to moderate vegetation. Ultimately, this drainage flow will reach the ocean though the lower Wailea development.


Soil
ISD
KCXD
rVS
KxbE
ISD
KxD
rVS
KxbE
KGKC
PROJECT LOCATION
KNXD
OAD
OED
rVS
MXC
DL
BS
DL
BS
DL
BS
AaB
BS
DL
BS
BS
BS
rCl
NORTH
= 3000'
6000'
1"=3000'

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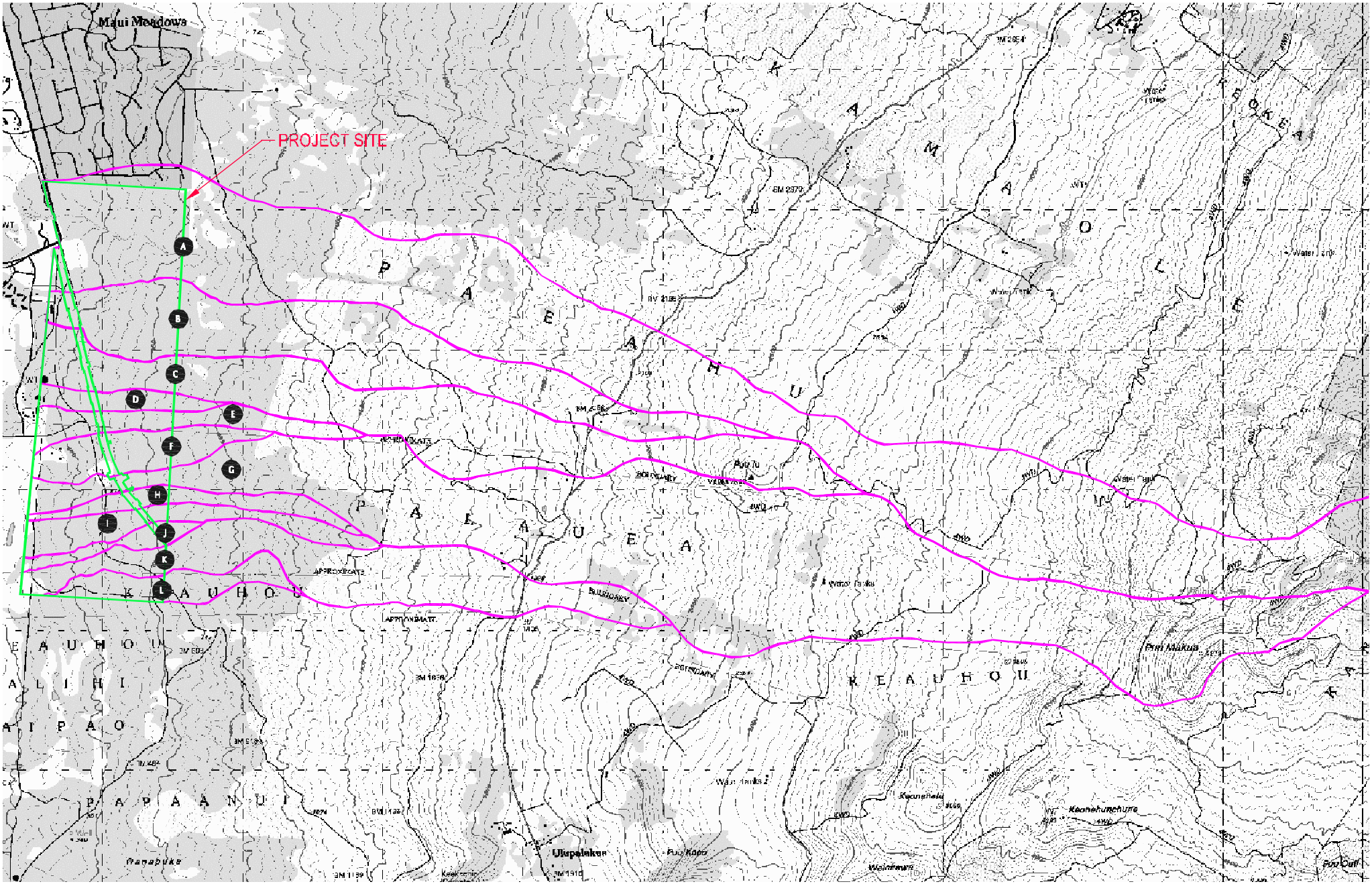
Maui Meadows
PROJECT SITE
A
B
C
D
E
F
G
H
I
J
K
L
LEGEND
6000'
1"=3000'
EXISTING DRAINAGE AREA
PROJECT SITE

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3. **Drainage Basin C**. Approximately 494 acres of light brush makes up this drainage basin. Starting from Haleakalā, runoff surface flows in a westerly direction toward the ocean through the natural terrain. Most of this drainage basin can be considered off site drainage. Ultimately, the drainage flow will pass through the neighboring Wailea development and into the ocean.

4. **Drainage Basin D**. Most of the 41 acres of this drainage basin is considered on site. Runoff in this basin surface flows through the natural terrain of slight to moderate vegetation in a westerly direction toward the ocean through the Wailea development.

5. **Drainage Basin E**. About half of the 84 acres from this drainage basin can be considered off site while the other half is considered on site. The drainage flow from the upper off site area flows in a westerly direction toward the project site through the natural terrain of slight to moderate vegetation. Moving through the Wailea development, the drainage flow from this drainage basin will ultimately discharge into the ocean.

6. **Drainage Basin F**. This drainage basin has a total area of about 100 acres. Surface runoff from this drainage basin generally flows in a westerly direction toward the ocean. Slight to moderate vegetation covers the existing basin. Most of this basin can be considered on site. Ultimately, the flow from this basin will pass through the Wailea development and into the ocean.

7. **Drainage Basin G**. Reaching up into Haleakalā, this drainage basin is about 1,430 acres. The runoff from this basin surface flows in a westerly direction toward the ocean through the natural terrain of aa basalt. Most of this basin can be considered off site. Ultimately, the surface runoff will pass through Wailea development and discharge into the ocean.

8. **Drainage Basin H**. The natural terrain of this drainage basin consists of about 61 acres of slight to moderate vegetation. About half of this basin can be considered on site. Moving in a westerly direction, runoff surface flows from Haleakalā toward the ocean through the Wailea development.

9. **Drainage Basin I**. This drainage basin has an area of about 92 acres, mostly consisting of ā'a basalt. Surface flow will travel westerly through about half the basin over natural terrain. Then, through the other half of the basin, the project site. Ultimately, this flow will travel through the Wailea development and into the ocean.

10. **Drainage Basin J**. Over half of the 31 acres in this basin can be considered on site. Slight to moderate vegetation covers the existing

natural terrain. Surface flow travels in a westerly direction toward the ocean through the Wailea development.

11. **Drainage Basin K**. About 325 acres make up this drainage basin. Mostly covered in slight to moderate vegetation and natural terrain, surface flow moves in a westerly direction toward the ocean. Most of this drainage basin can be considered off site. Ultimately, the runoff will flow through the Wailea development and into the ocean.

12. **Drainage Basin L**. This basin has an approximate area of 80 acres. Runoff surface flows in a westerly direction through the slight to moderate vegetation that covers most of the natural terrain. About half of this basin can be considered off site. Ultimately, the runoff will discharge into the ocean through the Wailea development.

Table 4-1 provides a summary of the twelve existing drainage basins that are shown in Figure 4-2.

4.1.4 Flood Zone

According to the Flood Insurance Rate Map (FIRM), Community-Panel Number 150003 0330 B, dated June 1, 1981, the project area is located in Zone C, an area of minimal flooding (see Figure 4-3). The project is not located in a flood zone.

4.2 Demand Analysis

As Honua'ula is developed, the nature of the land will be altered. The rate at which surface runoff flows (usually measured in cubic feet per second, cfs) will change and the quantity of runoff (usually measured in acre-feet, ac-ft) will also change resulting from the altered nature of the land. The off site runoff entering the Project Site is assumed to remain unchanged. The change in runoff from the Project Site was determined as described in the following sections.

First, the peak runoff rates for a 100 year – 24 hour event for the existing, pre-development, and post-development conditions were calculated. The existing conditions are considered to be the overall watershed, including areas mauka of the project site. Portions of the existing areas within the project site area are further broken down into pre-development conditions. This more defined pre-development condition allows comparison to post- development conditions. The drainage area off site remains the same for pre- and post-development conditions.

Second, using the calculated peak runoff rates, the runoff volumes for a 100 year – 24 hour event for both the pre-development and post-development conditions were calculated. The difference between pre-development and post-development runoff volumes will be used to size detention basins such that the future runoff volume will not exceed the existing volume.

Table 4-1
Existing Off Site/On Site Drainage
100 Year - 24 Hour Event

Basin	Analysis Method	Area (ft^2)	Area (acres)	Length (ft)	Slope (%)	Velocity (ft/s)	Tc (hr)	Weighted CN	Rainfall Type	$I_{100\ year}$ (in.)	C	Q (ft^3/s)
A	SCS	65,728,478	1508.93	37,430	16.5	6.5	1.6	71	I	10.5	-	2,383.52
B	SCS	19,432,400	446.11	17,884	13.2	5.8	0.86	71	I	10.5	-	1,017.56
C	SCS	21,511,502	493.84	20,496	13.3	5.8	0.99	71	I	10.5	-	1,036.78
D	Rational	1,799,885	41.32	-	-	-	-	-	-	10.5	0.3	130.16
E	Rational	3,637,667	83.51	-	-	-	-	-	-	10.5	0.3	263.06
F	Rational	4,298,467	98.68	6,015	7.3	4.2	0.4	-	-	10.5	0.3	310.84
G	SCS	62,289,878	1429.99	32,826	15.6	6.3	1.46	67	I	10.5	-	2,157.95
H	Rational	2,672,385	61.35	-	-	-	-	-	-	10.5	0.3	193.25
I	Rational	4,005,311	91.95	-	-	-	-	-	-	10.5	0.3	289.64
J	Rational	1,368,209	31.41	-	-	-	-	-	-	10.5	0.3	98.94
K	SCS	14,186,510	325.68	15252	13.2	6	0.71	66	I	10.5	-	733.41
L	Rational	3,442,956	79.04	-	-	-	-	-	-	10.5	0.3	248.98
	Total	204,373,648	4,691.81									8,864.09

*The SCS method was used for drainage areas greater than 100 acres

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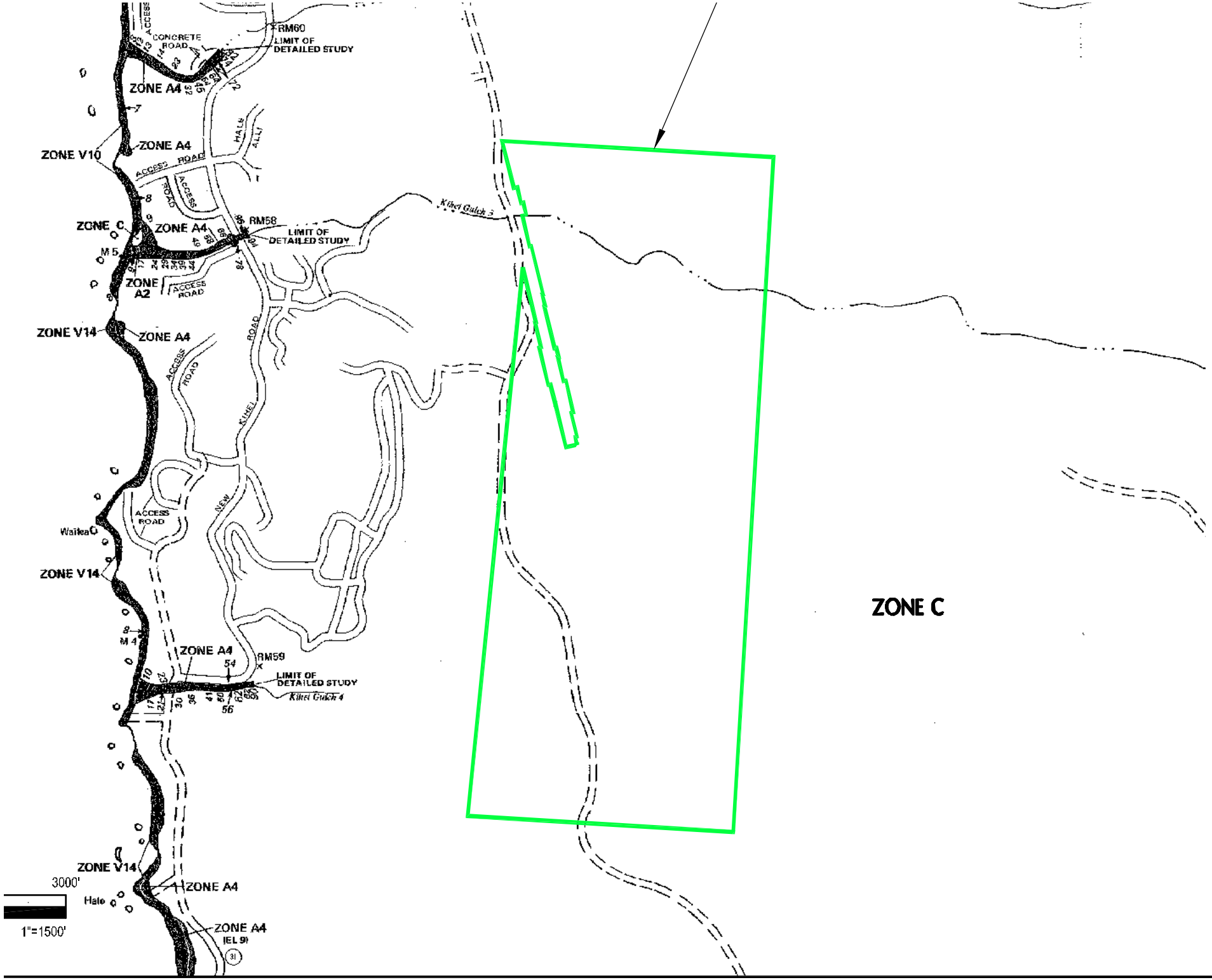
ZONE A4
RM60
LIMIT OF DETAILED STUDY
CONCRETE ROAD
ZONE V10
ZONE A4
ACCESS ROAD
HALE ALLY
ZONE C
ZONE A4
RM58
LIMIT OF DETAILED STUDY
Kihei Gulch 3
M 5
ZONE A2
ACCESS ROAD
ZONE V14
ZONE A4
ACCESS ROAD
KIHEI ROAD
NEW
Wailea
ACCESS ROAD
ZONE V14
M 4
ZONE A4
RM59
LIMIT OF DETAILED STUDY
Kihei Gulch 4
ZONE C
ZONE V14
ZONE A4
3000'
Hale
1"=1500'
ZONE A4
(EL 9)
500-Year Flo
100-Year Flo
Zone Design
Date of Iden
e.g., 12/2/74
100-Year Flo
500-Year Flo
Base Flood E
With Elevati
Base Flood
Where Unifo
Elevation Re
Coastline Mi
**Reference
*EXPL
ZONE
A
A0
AH
A1-A30
A99
B
C
D
V
V1-V30

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Third, the peak runoff rates for a 50 year – 1 hour event for the post-development condition was calculated and used to size the drainage piping systems.

4.2.1 Peak Runoff Rates

The peak runoff rates for the drainage area were calculated in conformance with the County of Maui Department of Public Works Rules for the Design of Storm Drainage Facilities in the County of Maui dated July 1995 (County Standards). The two methods of calculating peak runoff rates are:

- Rational Method is used for watersheds with areas less than 100 acres. A design storm with a recurrence interval of 50 years and duration of 1 hour is used for storm water calculations.

- SCS Method is used for watersheds with areas greater than 100 acres. A design storm with a recurrence interval of 100 years and duration of 24 hours is used for storm water calculations.

Peak runoff rates for the existing twelve (A – L) drainage basins were calculated to establish the existing runoff through the existing gulches and gullies, and is summarized in Table 4-1.

Increases in storm water runoff are generally related to the type of development or improvements undertaken to previously undeveloped areas. This increase of storm water runoff is created by changes in a number of factors including soil infiltration characteristics (soil permeability), relief (slope of ground), vegetation cover (percentage of vegetation cover over the drainage area), and development type (industrial, hotel, residential, agriculture, others). Of these factors, development type is the most significant characteristic that affects storm water runoff.

As the project area is developed, the runoff pattern defining the existing twelve drainage basins will be modified by the construction of the related roads and drainage facilities. In order to calculate the peak runoff rates for the project area in the future (post-development), the existing twelve drainage areas were further divided into 27 drainage areas (further discussed in Section 4.3.1).

The pre-development peak runoff rates were used as a base, from which to calculate the storage volume required to maintain existing conditions after the project area is developed.

Table 4-2 indicates the calculations of the pre-development peak runoff rates for the 27 drainage basins.

4.3 Post-development Improvements

4.3.1 Hydrology

In general, storm runoff will continue to travel from the upper mauka lands through the project to the ocean. Runoff from the off site mauka areas is not expected to increase as it enters the property. On site development, including roadways, residential lots, and commercial areas, will cause an increase in storm runoff due to the increase in impervious surfaces. However, the drainage scheme and the proposed drainage system improvements will maintain or reduce the rate of runoff discharged to the ocean to equal or less than pre-development rates, in compliance with County Standards. In addition, the use of detention basins, debris basins, and natural swales or channels will store and filter the stormwater, removing pollutants (via percolation) prior to exiting the project site (see Figure 4-4).

The future development will consist of about 697 acres of on site drainage that includes a portion of Pi'ilani Highway entering into the site. It also includes roughly 3,989 acres of off site drainage that will remain the same as existing. On site drainage basins were created for both pre-development conditions and post-development conditions. Runoff will be redirected into natural open drainage channels, detention basins, and series of drain lines. The proposed development was further divided into 27 drainage basin areas (see Figure 4-5).

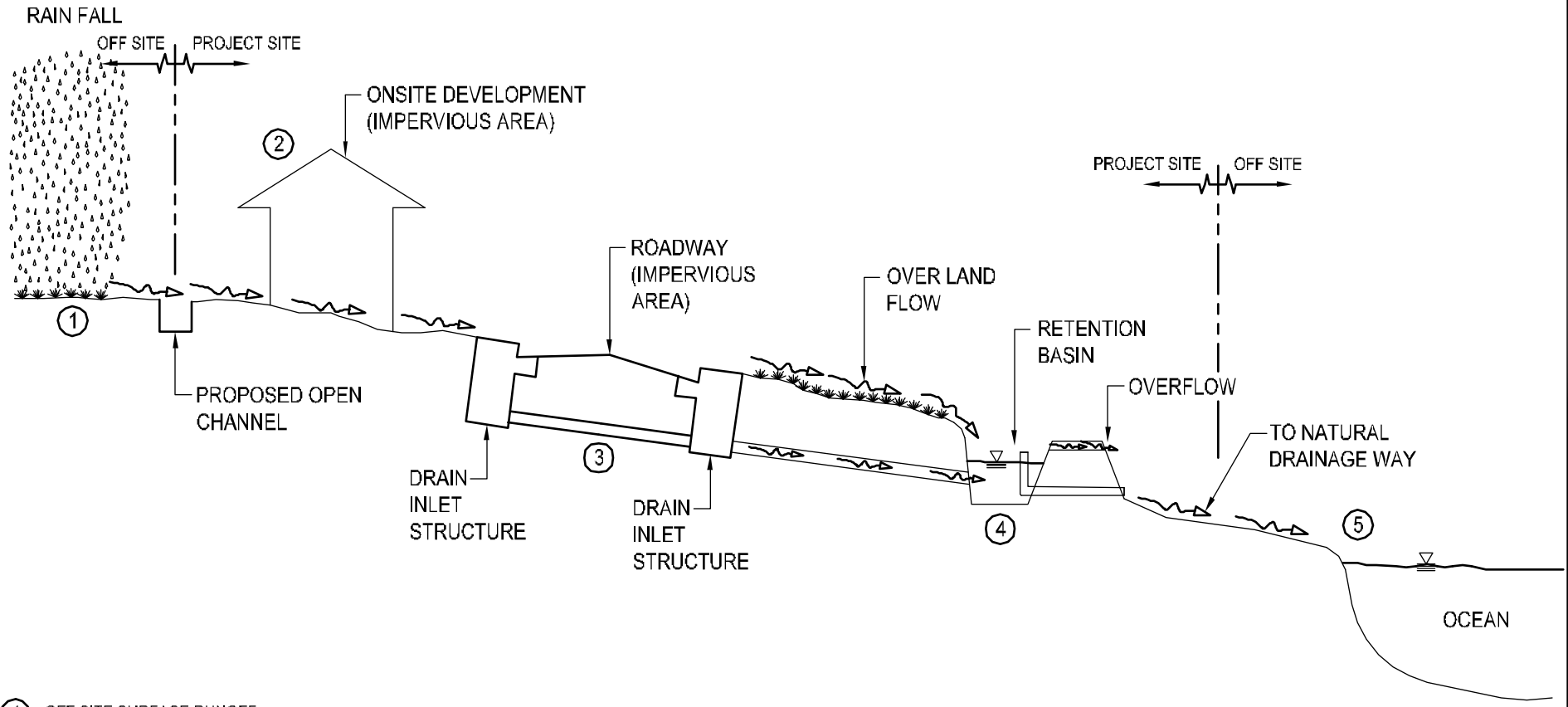
1. **Drainage Basin 1.** Located on the north side of the Project Site, this drainage basin includes multi family lots, a natural open channel, and a detention basin. Approximately 30 acres of this drainage basin will be diverted into a natural open drainage channel which flows through the northern portion of this basin. This channel diverts runoff in a westerly direction toward Detention Basin 1, within the area.

2. **Drainage Basin 2.** This drainage basin is roughly 30 acres and is located toward the northeast corner of the project. Single and multi family lots make up this basin along with roads, a natural open drainage channel, and detention basins. Most of the runoff will move through the natural open channel and eventually end up in Detention Basin 2 on the west side of the area.

3. **Drainage Basin 3.** About 39 acres make up this drainage basin on the northeast side of the project site. Single and multi family lots are planned for much of this area. Holes 5 and 6 of the golf course also occupy a portion of this basin. A natural open drainage channel will run though the middle of this basin with runoff flowing in a westerly direction. This channel will divert most of the runoff into Detention Basins 3 and 4 in the western portion of this area.

Table 4-2
On Site Predevelopment Peak Runoff Rates
100 Year - 24 Hour Event

Basin	Analysis Method	Area (acres)	Length (ft)	Slope (%)	Velocity (ft/s)	Tc (min)	Tc (hr)	$I_{100\ year}$ (in.)	C	Q (ft^3/s)
1	Rational	29.88	3,240	10.06	1.86	29	0.48	10.5	0.30	94.12
2	Rational	29.94	1,834	9.81	1.80	17	0.28	10.5	0.30	94.31
3	Rational	38.47	1,769	9.84	1.73	17	0.28	10.5	0.30	121.18
4	Rational	27.61	1274	10.20	1.52	14	0.23	10.5	0.30	86.98
5	Rational	11.90	1315	13.38	1.69	13	0.22	10.5	0.30	37.48
6	Rational	11.40	714	12.61	1.13	10.5	0.18	10.5	0.30	35.92
7	Rational	24.19	1,691	11.35	1.88	15	0.25	10.5	0.30	76.19
8	Rational	10.53	920	13.04	1.33	11.5	0.19	10.5	0.30	33.16
9	Rational	27.38	1620	9.75	1.69	16	0.27	10.5	0.30	86.23
10	Rational	12.66	724	15.19	1.12	10.75	0.18	10.5	0.30	39.89
11	Rational	47.65	1108	10.83	1.54	12	0.20	10.5	0.30	150.09
12	Rational	28.24	942	8.49	1.21	13	0.22	10.5	0.30	88.97
13	Rational	18.65	1156	10.38	1.48	13	0.22	10.5	0.30	58.75
14	Rational	13.65	474	10.55	0.81	9.75	0.16	10.5	0.30	43.00
15	Rational	27.20	1028	8.75	1.14	15	0.25	10.5	0.30	85.68
16	Rational	3.61	550	3.64	0.71	13	0.22	10.5	0.30	11.37
17	Rational	8.68	1175	6.81	2.45	8	0.13	10.5	0.30	27.33
18	Rational	5.87	270	1.85	0.41	11	0.18	10.5	0.30	18.48
19	Rational	17.88	765	10.46	1.28	10	0.17	10.5	0.30	56.32
20	Rational	14.24	1048	11.93	1.16	15	0.25	10.5	0.30	44.85
21	Rational	23.53	1070	9.35	1.27	14	0.23	10.5	0.30	74.13
22	Rational	16.63	1038	9.63	1.12	15.5	0.26	10.5	0.30	52.37
23	Rational	73.37	1248	11.22	1.54	13.5	0.23	10.5	0.30	231.13
24	Rational	25.60	594	11.78	0.97	10.25	0.17	10.5	0.30	80.63
25	Rational	99.63	3130	9.27	1.49	35	0.58	10.5	0.30	313.83
26	Rational	21.00	783	12.13	1.13	11.5	0.19	10.5	0.30	66.14
27	Rational	27.57	1925	5.19	1.69	19	0.32	10.5	0.30	86.85
	Total	696.95								2,195.39



(1) OFF SITE SURFACE RUNOFF
OFF SITE DRAINAGE AREAS MAUKA OF THE SITE WILL REMAIN UNDEVELOPED. DRAINAGE RUNOFF WILL BE DIVERTED TO NATURAL DRAINAGE PATH.

(2) ON SITE RUNOFF
THE PROPOSED DEVELOPMENT OF THE SITE WILL INCREASE THE STORM WATER RUNOFF VOLUME DUE TO THE ADDITIONAL IMPERVIOUS AREAS.

(3) DRAINAGE PIPE SYSTEM
ON SITE RUNOFF WILL BE DIVERTED TO DRAIN INLET STRUCTURES AND PIPED THROUGH A SERIES OF DRAINLINES THROUGHOUT THE PROJECT SITE TO PROPOSED BASINS.

(4) RETENTION BASINS
BASINS WILL BE PROVIDED TO CAPTURE THE ADDITIONAL RUNOFF VOLUME CREATED BY THE NEW DEVELOPMENT. THE BASINS WILL "RETAIN" THE INCREASED RUNOFF VOLUME.

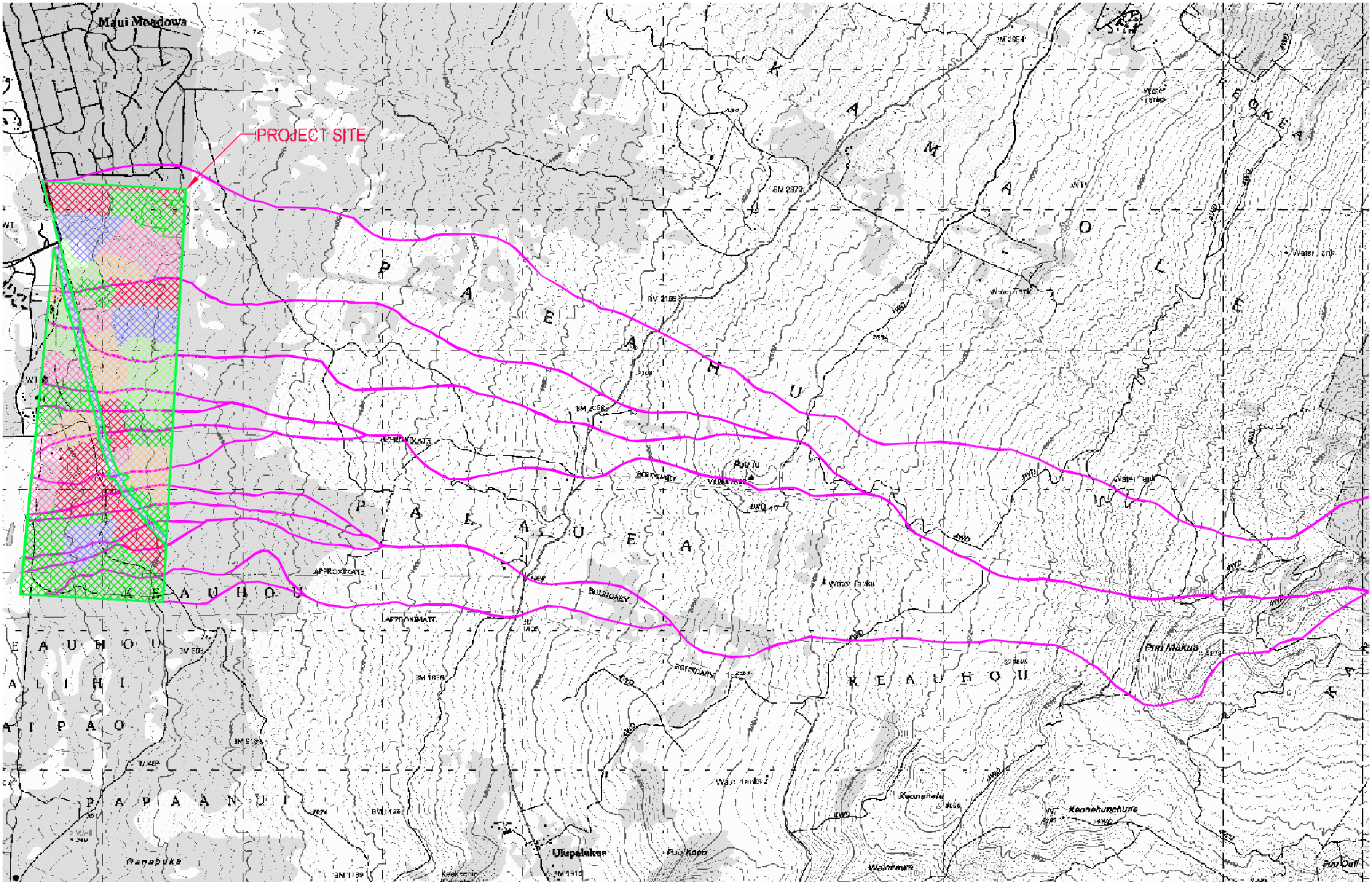
(5) DOWNSTREAM PROPERTIES
THE RUNOFF VOLUME LEAVING THE PROJECTS SITE WILL BE REDUCED, DUE TO THE ON SITE PROPOSED IMPROVEMENTS. THE PROPOSED HONUA'ULA DEVELOPMENT WILL NOT ADVERSELY AFFECT THE EXISTING RUNOFF CONDITIONS AND THE ADJACENT DOWNSTREAM PROPERTIES.

WILSON OKAMOTO CORPORATION

HONUA'ULA

Drainage Diagram

FIGURE 4-4



LEGEND

6000'

1"=3000'

EXISTING DRAINAGE AREA

PROJECT SITE

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4. **Drainage Basin 4.** Multi family lots and village mix use lots will make up most of approximately 28 acres of this drainage basin. It is located toward the northeast side of the project site. A natural open drainage channel diverts runoff through the middle of this basin, in a westerly direction, toward Detention Basin 1.

5. **Drainage Basin 5.** Located on the north side of the project, approximately 12 acres make up this basin. Most of this basin is to be single and multi family lots. A natural open drainage channel is located in the middle of this basin and diverts runoff westerly toward Detention Basin 5 on the west side of this area.

6. **Drainage Basin 6.** This drainage basin of about 11 acres is located in the north western portion of the project site. It includes multi family lots and village mixed use lots. Runoff in this area will surface flow through a natural drainage channel to Detention Basin 6 to the west.

7. **Drainage Basin 7.** Single and multi family lots, golf course holes 4, 5, and 7, a natural open drainage channel, and a detention basin will make up approximately 24 acres of this basin. The natural open drainage channel runs through the middle of this basin. Most of the runoff will surface flow to the open channel then flow in a westerly direction toward Detention Basin 7 along the west side of golf course.

8. **Drainage Basin 8.** Approximately 11 acres of this drainage basin are proposed to have multi family lots and a park. This basin is located in the western portion of the project site. Some runoff will be captured by Detention Basin 8 and the rest will continue to flow in a western direction.

9. **Drainage Basin 9.** Single and multi family lots and golf course holes 4 and 7, are within approximately 27 acres of this basin. Most of the surface runoff in this area will go into Detention Basin 9 around the golf course holes.

10. **Drainage Basin 10.** Approximately 13 acres make up this drainage basin located in the middle portion of the project site. It includes multi family lots, an open natural drainage channel, as well as the fire station. Most of the runoff flows toward Detention Basin 10 and the rest will continue to surface flow in a westerly direction.

11. **Drainage Basin 11.** This drainage basin of approximately 48 acres is in the middle portion of the project site. This area includes single family units, holes 3 and 8, and a detention basin. Runoff will flow toward a natural open channel that runs through the middle of this area. The runoff

will flow to Detention Basin 11 in the western portion of this area along the golf course.

12. **Drainage Basin 12.** Approximately 28 acres make up this drainage basin. Single and multi family lots, a couple of detention basins, and hole 2 of the golf course make up this basin. Runoff will surface flow in a westerly direction toward Detention Basins 12 and 13.

13. **Drainage Basin 13.** This drainage basin is approximately 19 acres. It contains single and multi family lots, a natural open channel, and a detention basin. Runoff is directed to the natural open channel in the northern portion of this basin. Ultimately, runoff will flow to Detention Basin 14 in the western portion of this area.

14. **Drainage Basin 14.** Single and multi family lots, a natural open drainage channel, hole 1 or the golf course, and a detention basins make up this basin which is located in the central portion of the project site. The natural open drainage channel runs through the middle of approximately 14 acres in this basin. Runoff surface flows toward the open channel and to Detention Basin15 in the western portion of this area.

15. **Drainage Basin 15.** Located in toward the south east portion of the project site, this drainage basin is about 27 acres. It will include single and multi family lots, a natural open drainage channel, a portion of hole 9 of the golf course, and a detention basin. The natural drainage channels divert the runoff in this basin toward Detention Basin 16 in the western portion of this area.

16. **Drainage Basin 16.** This drainage basin is approximately 4 acres located in the northwest portion of the project site. It is proposed to have multi-family lots and the water tank. Runoff will surface flow in a western direction toward Pi'ilani Highway.

17. **Drainage Basin 17.** Single family units are proposed for roughly 9 acres of this drainage basin. This drainage basin is located to the east of Pi'ilani highway in the southern portion of the site. Runoff in this basin will go to Pi'ilani Highway.

18. **Drainage Basin 18.** Located in the western portion of the project site, this drainage basin has an area of about 6 acres. Village mixed use units and a natural open drainage channel are proposed for this area. The runoff in this basin will surface flow in a westerly direction toward the Wailea development.

19. **Drainage Basin 19.** This drainage basin is about 18 acres and is located in the western portion of the project site. It includes an area for MECO

expansion, multi family lots, and some village mixed use lots. The runoff in this area will flow in a westerly direction toward the Wailea development.

20. **Drainage Basin 20.** This basin is approximately 14 acres and is located in the western portion of the project site. It includes holes 16 and 17 of the golf course, natural open drainage channel and multi family lots. The runoff in this basin will flow in a western direction toward Detention Basin 17.

21. **Drainage Basin 21.** This drainage basin is located on the middle portion of the project site, and is about 24 acres. This basin includes golf course holes 16 and 17, a maintenance center, multi family lots, and village mixed use lots. Most of the runoff in this area will flow toward the golf course and Detention Basin 18.

22. **Drainage Basin 22.** Multi family lots, a portion of the driving range, and hole 18 of the golf course make up the approximate 17 acres in this area. Most of the runoff in this area will flow in southern direction toward Drainage Basin 23 where it will be handled by Detention basin 19.

23. **Drainage Basin 23.** This drainage basin is about 73 acres. It includes, Single and multi family lots, village mixed use lots, the golf club house, holes, 10 and 18, a natural open drainage channel, and a couple detention basins. The runoff in this area will surface flow to Detention Basins 19 and 20 through the natural open channels.

24. **Drainage Basin 24.** This basin of about 26 acres is located on the south western side of the project. Multi family lots, holes 14 and 15, a natural drainage channel, and a detention basin are contained in this area. Runoff in this area will flow to the natural drainage channels and eventually into the Detention Basin 21.

25. **Drainage Basin 25.** Single and multi family lots, holes 11 through 14 of the golf course, several detention basins, and the wastewater treatment plant, make up about 100 acres of this drainage basin. Runoff in this area will surface flow toward one of five detention basins, Detention Basin 22 through 26, in this area.

26. **Drainage Basin 26.** The Native Plant Preservation Area makes up this drainage basin. It is about 21 acres and is located in the southern portion of the Project Site. Most of the runoff is expected to stay within this basin.

27. **Drainage Basin 27.** This Basin takes into account the portion of Pi'ilani Highway that runs within the project area. The runoff in this basin will

surface flow in a westerly direction and will be handled by basins to the west of the road right-of-way.

The post-development peak runoff rates were calculated for the drainage basins within the project site to determine the drainage facilities within the proposed roadways. Table 4-3 illustrates the calculations for the post-development runoff rates for the 27 drainage areas.

See Figure 4-6 for Post-Development and Off-Site Drainage Basins. The off site peak runoff rate were also calculated for the drainage basins mauka of the project site. Table 4-4 illustrates these calculations.

4.3.2 Future Runoff Volume Calculations

With the development of the Honua'ula project, the storm water runoff volume is expected to increase. The drainage system will be designed to retain the increased storm water runoff volume created by site improvements and development. The higher volume of runoff will require a comparable increase in storage to maintain existing conditions.

In order to accommodate the additional flow, detention basins will be provided to retain the increased drainage runoff volume. The Area-Duration method was used with a 100 year, 24-hour storm event to determine the required capacity of the detention basins. This calculation method uses the differences of runoff coefficient (C) of pre-development and post-development to determine the increase of storm water runoff volumes. Basin volume is measured in acre-feet. Table 4-5 illustrates the volumes of pre-development and post-development areas.

For the purposes of this Report, it is assumed that off site drainage areas mauka of the Honua'ula remain undeveloped. If development should occur in these off site areas in the future, it will be necessary for such developments to incorporate drainage facilities to retain any increase in runoff volumes within the development.

4.4 Proposed Improvements

Construction of the golf courses will improve drainage over the existing topography. Golf course design features and use of plant materials will reduce storm runoff and improve drainage control. With the creation of detention basins travel time of flows crossing the property will be lengthened thus reducing the peak discharges.

Construction of the housing units, other buildings and roads will increase impervious areas and speed surface runoff thus increasing the flow rates and volumes. This increase will be handled through the addition of detention basins throughout the site.

Table 4-3
On Site Post Development Peak Runoff Rates
100 yr., 24 hr Event

Basin	Analysis Method	Area (acres)	Length (ft)	Slope (%)	Velocity (ft/s)	Tc (min)	Tc (hr)	$I_{100\ year}$ (in.)	C	Q (ft^3/s)
1	Rational	29.88	3,240	10.06	1.86	29	0.48	10.5	0.44	137.26
2	Rational	29.94	1,834	9.81	1.80	17	0.28	10.5	0.51	161.12
3	Rational	38.47	1,769	9.84	1.73	17	0.28	10.5	0.38	151.48
4	Rational	27.61	1274	10.20	1.52	14	0.23	10.5	0.33	94.95
5	Rational	11.90	1315	13.38	1.69	13	0.22	10.5	0.31	39.04
6	Rational	11.40	714	12.61	1.13	10.5	0.18	10.5	0.34	41.01
7	Rational	24.19	1,691	11.35	1.88	15	0.25	10.5	0.37	94.61
8	Rational	10.53	920	13.04	1.33	11.5	0.19	10.5	0.42	46.14
9	Rational	27.38	1620	9.75	1.69	16	0.27	10.5	0.42	120.01
10	Rational	12.66	724	15.19	1.12	10.75	0.18	10.5	0.39	51.53
11	Rational	47.65	1108	10.83	1.54	12	0.20	10.5	0.48	240.14
12	Rational	28.24	942	8.49	1.21	13	0.22	10.5	0.43	128.26
13	Rational	18.65	1156	10.38	1.48	13	0.22	10.5	0.43	84.70
14	Rational	13.65	474	10.55	0.81	9.75	0.16	10.5	0.42	59.84
15	Rational	27.20	1028	8.75	1.14	15	0.25	10.5	0.42	119.95
16	Rational	3.61	550	3.64	0.71	13	0.22	10.5	0.45	16.96
17	Rational	8.68	1175	6.81	2.45	8	0.13	10.5	0.53	47.83
18	Rational	5.87	270	1.85	0.41	11	0.18	10.5	0.25	15.40
19	Rational	17.88	765	10.46	1.28	10	0.17	10.5	0.59	110.29
20	Rational	14.24	1048	11.93	1.16	15	0.25	10.5	0.25	37.38
21	Rational	23.53	1070	9.35	1.27	14	0.23	10.5	0.25	61.78
22	Rational	16.63	1038	9.63	1.12	15.5	0.26	10.5	0.25	43.64
23	Rational	73.37	1248	11.22	1.54	13.5	0.23	10.5	0.35	267.73
24	Rational	25.60	594	11.78	0.97	10.25	0.17	10.5	0.42	112.21
25	Rational	99.63	3130	9.27	1.49	35	0.58	10.5	0.49	515.20
26	Rational	21.00	783	12.13	1.13	11.5	0.19	10.5	0.25	55.12
27	Rational	27.57	1925	5.19	1.69	19	0.32	10.5	0.90	260.55
	Total	696.95								3,114.12

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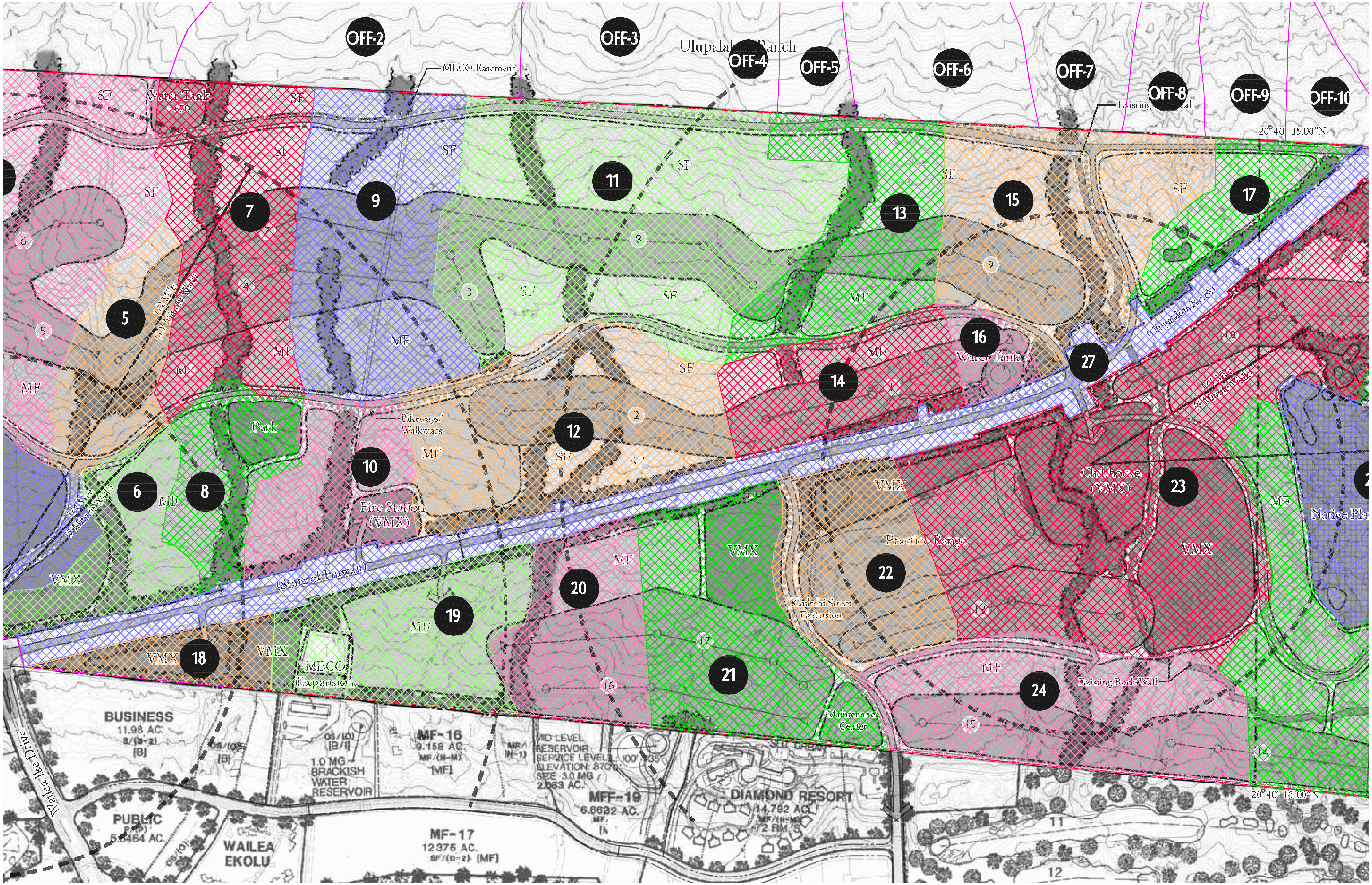
OFF-2
OFF-3
OFF-4
OFF-5
OFF-6
OFF-7
OFF-8
OFF-9
OFF-10
MECO Easement
Water Tank
9
11
13
15
17
7
5
12
14
16
27
10
6
8
Park
Bikeways/ Walkways
Fire Station (VMX)
18
19
20
21
22
23
24
VMX
MF
SF
MECO Expansion
Practice Range
Clubhouse (VMX)
Existing Rock Wall
Maintenance Center
Native Plant
BUSINESS
11.98 AC.
PUBLIC
5.6464 AC.
WAILEA EKOLU
MF-16
9.158 AC.
MF-17
12.375 AC.
MFF-19
6.6622 AC.
1.0 MG BRACKISH WATER RESERVOIR
DIAMOND RESORT
14.792 AC.
Wailea Ike Drive
20°40' 15.00"N

1300'

1" =650'

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Table 4-4
Off Site Peak Runoff Rates
100 Year - 24 Hour Event

Basin	Analysis Method	Area (acres)	Length (ft)	Slope (%)	Velocity (ft/s)	Tc (hr)	Weighted CN	Rainfall Type	$I_{100\ year}$ (in.)	C	Q (ft^3/s)
OFF-A	SCS	1345.74	37,430	16.5	6.5	1.6	71	I	10.5	-	2,125.75
OFF-B	SCS	344.88	17,884	13.2	5.8	0.86	71	I	10.5	-	786.66
OFF-C	SCS	422.34	20,496	13.3	5.8	0.99	71	I	10.5	-	866.68
OFF-D	Rational	7.22	4460	11.1	5.1	0.24	-	I	10.5	0.3	22.75
OFF-E	Rational	40.01	7713	11.7	5.7	0.38	-	I	10.5	0.3	126.03
OFF-F	Rational	28.65	6,015	7.3	4.2	0.4	-	I	10.5	0.3	90.26
OFF-G	SCS	1390.84	32,826	15.6	6.3	1.46	67	I	10.5	-	2,098.87
OFF-H	Rational	36.64	7823	11.6	5.6	0.39	-	I	10.5	0.3	115.42
OFF-I	Rational	41.24	8324	11.5	5.5	0.42	-	I	10.5	0.3	129.91
OFF-J	Rational	5.98	4346	10.6	5	0.24	-	I	10.5	0.3	18.84
OFF-K	SCS	282.06	15252	13.2	6	0.71	66	I	10.5	-	635.18
OFF-L	Rational	43.52	6553	11.3	5.3	0.34	-	I	10.5	0.3	137.08
	Total	3,989.13									7,153.43

4.4.1 Detention Basins

With the development of the proposed Honua'ula project, storm water runoff volumes in this area will increase. Twenty-six (26) detention basins throughout the site will be provided to handle this increase of about 76.56 ac-ft (see Figure 4-7). This increase of runoff volume is due to the increase of impervious areas throughout the site. The development of the golf course will control runoff. The detention basins will keep the post-development runoff on site so as to not adversely affect properties downstream to the west. Overall, the increase in runoff volume for the entire site will be handled by the detention basins. Table 4-6 shows the required runoff volume and the capacities of the proposed detention basins.

Detention basins will be located in low lying areas, within the golf course, or along the makai project boundary. All detention basins, except for Detention Basin #2 (located in Phase 2), will be constructed during Phase 1. Detention Basin #2 will be constructed during Phase 2.

4.4.2 Drainage Pipe System

Runoff from the residential, commercial, road and other paved areas will be graded to drain inlet structures and piped through a series of drain lines in the roadways throughout the project site (see Figure 4-8). These drain lines will allow runoff to be kept on site by diverting drainage flows to the detention basins.

The Rational Method was used to determine the peak runoff rates for the 50 year 1 hour storm event (see Table 4-7). These peak runoff rates were used to determine the sizes of the drain structures throughout the roadways. The majority of the drain lines will be 18 inch diameter and the remaining will be 24 inch diameter. In the final design, further analysis on inlet and outlet structures, junction-structures, slope of pipes, and open channel sections will be performed to enhance engineering efficiency.

The drainage pipe system will be constructed within their respective phases.

4.4.3 Open Channels

Proposed natural open drainage channels will be provided throughout the site to divert runoff toward the detention basins. Open channels will be provided at the upper limits of the project site to direct mauka off site runoff entering the project site to the natural drainage paths flowing through the project. These channels will remain natural and unlined. Open channel plans will be finalized during the final design of the project.

4.4.4 Roadway Culverts

Proposed roadway culverts will be provided throughout the site to divert runoff under roadways, which will prevent flooding on the roadways. Roadway culvert plans will be finalized during the final design of the project.

In addition, bioswales, landscape elements designed to remove silt, along roadways may be an option where appropriate.

4.5 Summary

Peak existing, pre-development, and post-development flow rates for the Honua'ula project were determined using the Rational Method and SCS Method for the 100 year 24 hour storm. The total runoff generated for existing, pre-development, post-development, and off site conditions are 8,864 cfs, 2,195 cfs, 3,114 cfs, and 7,153 cfs, respectively.

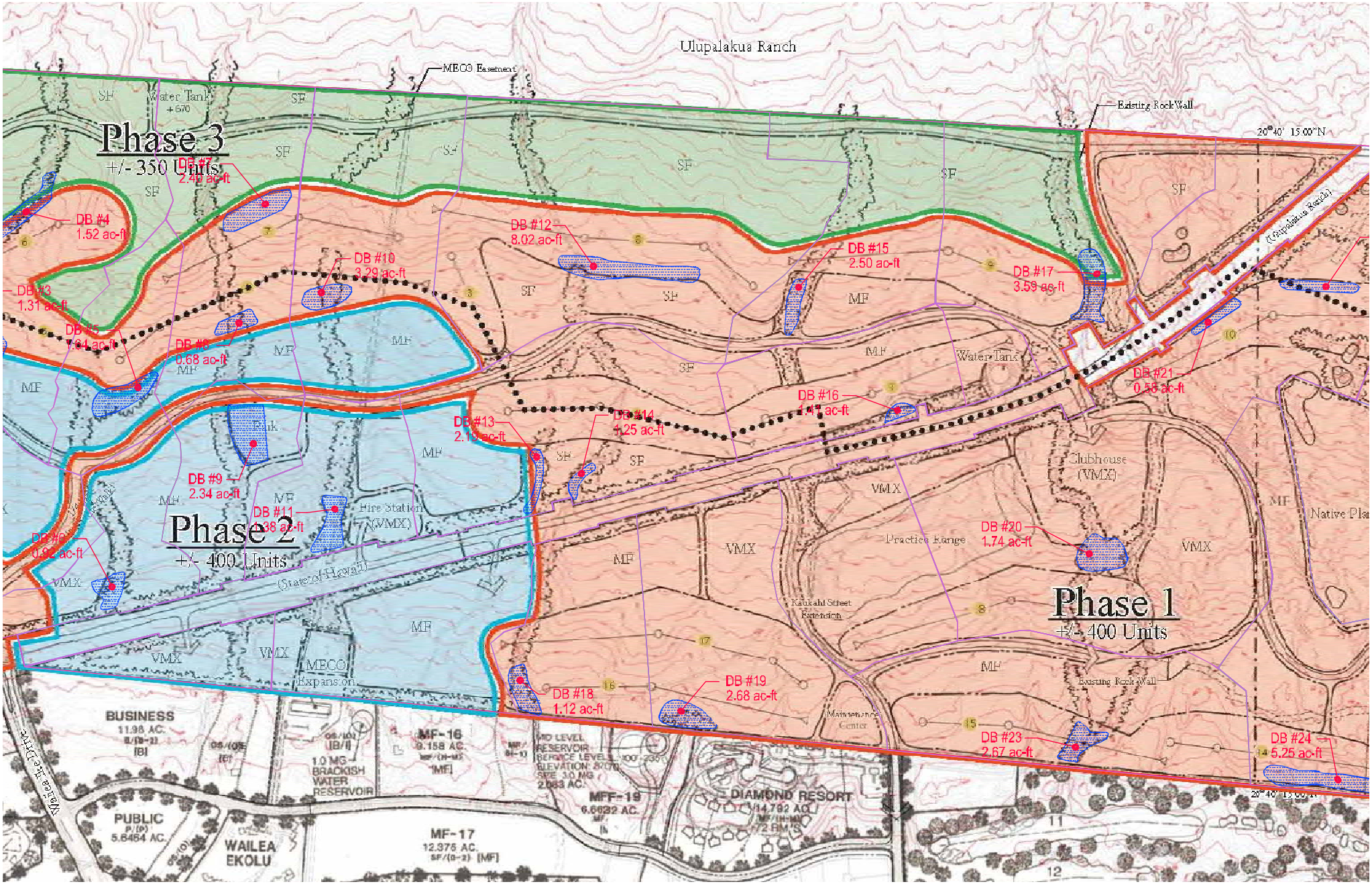
Runoff volumes of 182.95 ac-ft and 259.51 ac-ft were also determined for the pre-development and post-development drainage conditions, respectively. Due to the addition of more impervious area from the project site, there is an increase of 76.56 ac-ft from pre-development conditions to post-development conditions. This additional volume will be handled by the 26 detention basins located throughout the project site, which provide a total volume of 81.62 ac-ft. These basins provide an excess runoff capacity of 5.06 ac-ft. Natural open channels and drain pipe system will divert runoff toward these detention basins.

The proposed Honua'ula development will not adversely affect the existing runoff conditions and the adjacent downstream properties.

Table 4-5
On Site Predevelopment and Post Development Volumes
Area-Duration Method
100 Year - 24 Hour Event

Basin	Analysis Method	Area (acres)	$I_{100\ year}$ (in.)	Pre C	Post C	Pre V (ac-ft)	Post V (ac-ft)	Net V (ac-ft)
1	Rational	29.88	10.5	0.30	0.44	7.84	11.44	3.59
2	Rational	29.94	10.5	0.30	0.51	7.86	13.43	5.57
3	Rational	38.47	10.5	0.30	0.38	10.10	12.62	2.52
4	Rational	27.61	10.5	0.30	0.33	7.25	7.91	0.66
5	Rational	11.90	10.5	0.30	0.31	3.12	3.25	0.13
6	Rational	11.40	10.5	0.30	0.34	2.99	3.42	0.42
7	Rational	24.19	10.5	0.30	0.37	6.35	7.88	1.53
8	Rational	10.53	10.5	0.30	0.42	2.76	3.85	1.08
9	Rational	27.38	10.5	0.30	0.42	7.19	10.00	2.81
10	Rational	12.66	10.5	0.30	0.39	3.32	4.29	0.97
11	Rational	47.65	10.5	0.30	0.48	12.51	20.01	7.50
12	Rational	28.24	10.5	0.30	0.43	7.41	10.69	3.27
13	Rational	18.65	10.5	0.30	0.43	4.90	7.06	2.16
14	Rational	13.65	10.5	0.30	0.42	3.58	4.99	1.40
15	Rational	27.20	10.5	0.30	0.42	7.14	10.00	2.86
16	Rational	3.61	10.5	0.30	0.45	0.95	1.41	0.47
17	Rational	8.68	10.5	0.30	0.53	2.28	3.99	1.71
18	Rational	5.87	10.5	0.30	0.25	1.54	1.28	-0.26
19	Rational	17.88	10.5	0.30	0.59	4.69	9.19	4.50
20	Rational	14.24	10.5	0.30	0.25	3.74	3.11	-0.62
21	Rational	23.53	10.5	0.30	0.25	6.18	5.15	-1.03
22	Rational	16.63	10.5	0.30	0.25	4.36	3.64	-0.73
23	Rational	73.37	10.5	0.30	0.35	19.26	22.31	3.05
24	Rational	25.60	10.5	0.30	0.42	6.72	9.35	2.63
25	Rational	99.63	10.5	0.30	0.49	26.15	42.93	16.78
26	Rational	21.00	10.5	0.30	0.25	5.51	4.59	-0.92
27	Rational	27.57	10.5	0.30	0.90	7.24	21.71	14.47
	Total	696.95				182.95	259.51	76.56

Area Duration Method: Volume = Area x I / 12 x C
Off site drainage will not change. No increase in runoff volume.



LEGEND

1300'

1"=650'

DB #XX — DETENTION BASIN

BASIN

DRAINAGE AREA

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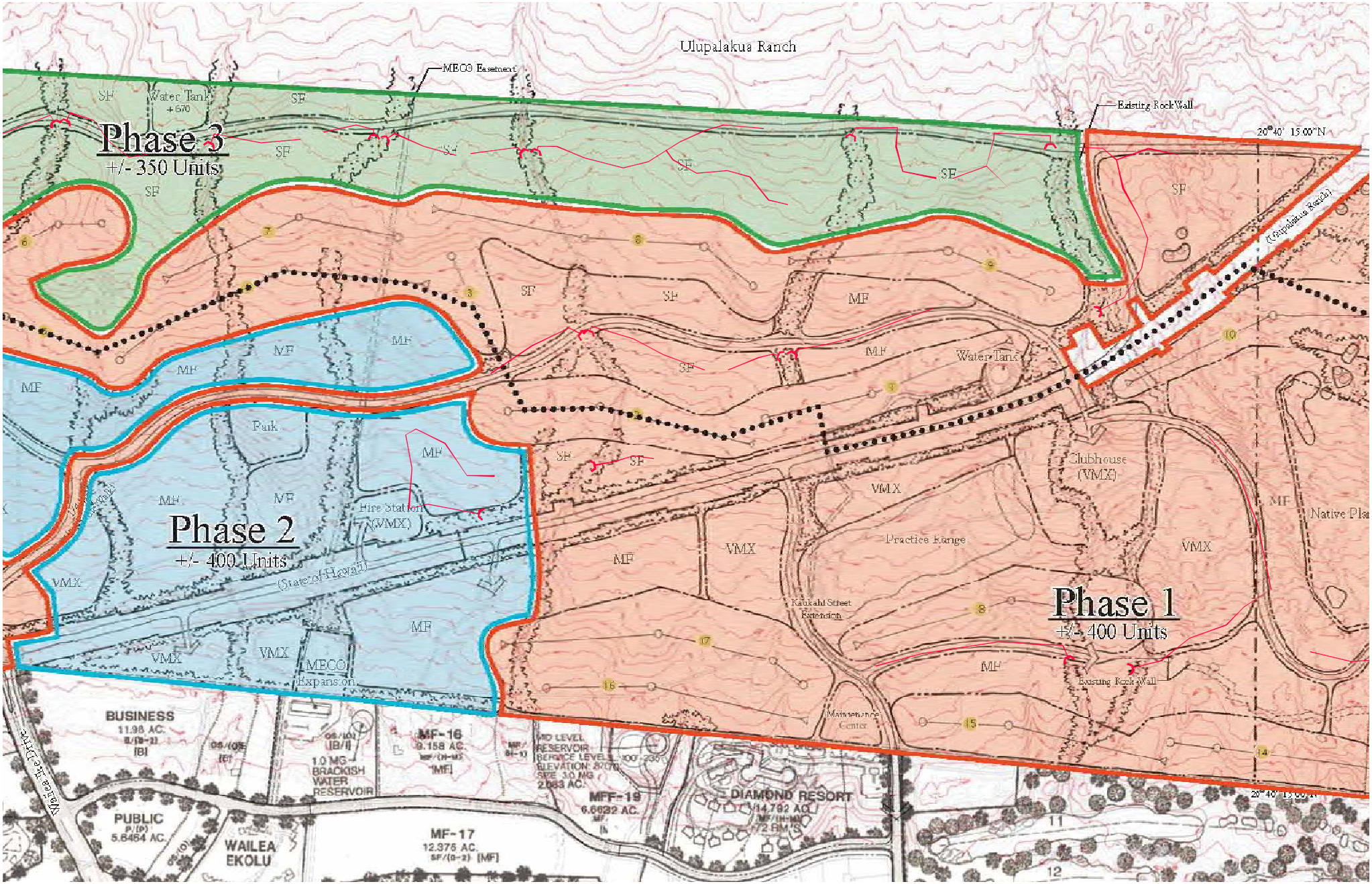

LEGEND

1300'

1" =650'

DRAIN OUTLET

DRAINLINE

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Table 4-6
Detention Basins

Basin #	Required Runoff Volume (ac-ft)	Detention Basin #	Depth (ft)	Provided Runoff Volume (ac-ft)	Total Provided Runoff Volume (ac-ft)	Excess Runoff Volume (ac-ft)	Meet Required?
1	3.59	1	4	4.15	4.15	0.55	YES
2	5.57	2	3	7.04	7.04	1.47	YES
3	2.52	3	2	1.05	2.57	0.04	YES
		4	2	1.52			
4	0.66	1	4	4.15	4.15	3.48	YES
5	0.13	5	2	1.64	1.64	1.51	YES
6	0.42	6	3	1.38	1.38	0.95	YES
7	1.53	7	3	2.41	2.41	0.88	YES
8	1.08	8	1	2.23	2.23	1.15	YES
9	2.81	9	6	3.29	3.29	0.48	YES
10	0.97	10	3	1.62	1.62	0.65	YES
11	7.50	11	6	8.02	8.02	0.52	YES
12	3.27	12	7	2.19	3.45	0.17	YES
		13	6	1.25			
13	2.16	14	6	2.50	2.50	0.34	YES
14	1.40	15	7	1.41	1.41	0.00	YES
15	2.86	16	4	3.59	3.59	0.73	YES
16	0.47					-0.47	NO*
17	1.71					-1.71	NO*
18	-0.26					0.26	YES
19	4.50					-4.50	NO*
20	-0.62	17	2	1.12	1.12	1.74	YES
21	-1.03	18	4	2.68	2.68	3.71	YES
22	-0.73					0.73	YES
23	3.05	19	4	1.74	6.53	3.48	YES
		20	4	4.79			YES
24	2.63	21	5	2.67	2.67	0.04	YES
25	16.78	22	5	7.00	19.18	2.40	YES
		23	5	5.25			
		24	5	1.93			
		25	5	2.81			
		26	5	2.20			
26	-0.92					0.92	YES
27	14.47					-14.47	NO*
Totals	**76.56**			**81.62**	**81.62**	**5.06**	**YES**

* Excess runoff to be handled by other detention basins on site.

Table 4-7
Post Development Runoff Rates (Rational)
Pipe System
50 Year - 1 Hour Event

Basin	Basin Area (ft^2)	Pipe Area (ft^2)	Area (acres)	Tc (min)	$I_{50\ year}$ (in.)	C	Q (ft^3/s)
1	1,301,545	--	29.88	10	2.5	0.44	32.68
2	1,304,185	--	29.94	6.75	2.5	0.51	38.36
2-1	--	188,730					5.55
2-2	--	355,220					10.45
2-3	--	149,066					4.38
		693,016					**20.38**
3	1,675,751	--	38.47	7.5	2.5	0.38	36.07
3-1	--	268,010					5.77
3-2	--	223,166					4.80
		491,176					**10.57**
4	1,202,822	--	27.61	7.75	2.5	0.33	22.61
5	518,241	--	11.90	6.75	2.5	0.31	9.29
6	496,687	--	11.40	9	2.5	0.34	9.76
7	1,053,636	--	24.19	13.5	2.5	0.37	22.53
7-1	--	250,920					5.36
		250,920					**27.89**
8	458,524	--	10.53	8.5	2.5	0.42	10.99
9	1,192,495	--	27.38	17	2.5	0.42	28.57
9-1	--	131,975					3.16
9-2	--	192,489					4.61
		324,464					**7.77**
10	551,652	--	12.66	10	2.5	0.39	12.27
11	2,075,474	--	47.65	18.5	2.5	0.48	57.18
11-1	--	140,406					3.87
11-2	--	375,130					10.33
11-3	--	362,086					9.97
		877,622					**24.18**
12	1,230,271	--	28.24	9.25	2.5	0.43	30.54
12-1	--	338,499					8.40
12-2	--	108,123					2.68
12-3	--	376,563					9.35
12-4	--	85,427					2.12
		908,612					**22.55**

Table 4-7 (Continued)
Post Development Runoff Rates (Rational)
Pipe System
50 Year - 1 Hour Event

Basin	Basin Area (ft^2)	Pipe Area (ft^2)	Area (acres)	Tc (min)	$I_{50\ year}$ (in.)	C	Q (ft^3/s)
13	812,400	--	18.65	8.25	2.5	0.43	20.17
13-1	--	215,099					5.34
		215,099					**5.34**
14	594,619	--	13.65	7.5	2.5	0.42	14.25
14-1	--	108,825					2.61
14-2	--	303,563					7.27
		412,388					**9.88**
15	1,184,779	--	27.20	9.25	2.5	0.42	28.56
15-1	--	117,954					2.84
		117,954					**2.84**
16	157,220	--	3.61	8	2.5	0.45	4.04
17	377,935	--	8.68	11.5	2.5	0.53	11.39
18	255,598	--	5.87	19.25	2.5	0.25	3.67
19	778,811	--	17.88	24.5	2.5	0.59	26.26
20	620,262	--	14.24	21	2.5	0.25	8.90
21	1,025,170	--	23.53	19.5	2.5	0.25	14.71
22	724,222	--	16.63	25	2.5	0.25	10.39
23	3,196,190	--	73.37	13.5	2.5	0.35	63.74
23-1	--	557,968					11.13
		557,968					**11.13**
24	1,115,022	--	25.60	10.25	2.5	0.42	26.72
24-1	--	259,977					6.23
24-2	--	141,501					3.39
		401,478					**9.62**
25	4,339,778	--	99.63	35	2.5	0.49	122.67
25-1	--	207,459					5.86
25-2	--	1,307,561					36.96
25-3	--	183,647					5.19
25-4	--	455,095					12.86
25-5	--	130,796					3.70
25-6	--	297,117					8.40
		2,581,675					**72.97**
26	914,627	--	21.00	11.5	2.5	0.25	13.12
27	1,200,993	--	27.57	19	2.5	0.90	62.04
27-1	--	28,174,801	449.78				1,455.32
		28,174,801					**1,455.32**

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5. ROADWAY SYSTEM

A traffic study for the Honua'ula development was prepared by Austin, Tsutsumi & Associates in November 2009. Relevant portions of the study are summarized below.

5.1 Project Site Access

The intersection of Pi'ilani Highway and Wailea Ike Drive provides the primary roadway access to the project site. Pi'ilani Highway is a four-lane, undivided, north/south State arterial highway that connects central Maui to the Kīhei-Wailea-Mākena areas. It is a four-lane highway from Mokulele Highway to Kilohana Drive and reduces to a two-lane from Kilohana Drive to Wailea Ike Drive. Wailea Ike Drive is a four-lane, divided, east/west County collector roadway that narrows to a two-lane roadway just before its connection to Piilani Highway. Wailea Ike Drive is the main entrance to the Wailea Resort and connects to Pi'ilani Highway with Wailea Alanui Drive. Wailea Ike's vertical alignment is a relatively steep grade.

A second access point to the project site is located on Kaukahi Street which runs parallel to Wailea Ike Drive further south. Kaukahi Street is a two-way, two-lane street. Kaukahi Street is east/west roadway between Wailea Alanui Drive/Mākena Alanui Drive and Kalai Waa Street. Kaukahi Street intersects Wailea Alanui Drive/Makena Alanui Drive on the west end and terminates at the Wailea Resort property line on the east end. Kaukahi Street will be extended to intersect with the future extension of Piilani Highway. The extension of Pi'ilani Highway is discussed below as part of the third access point for the project. Because Kaukahi Street is a private road, the extension of Kaukahi Street into the project is planned to be a gated access to address the concerns of current landowners along Kaukahi Street.

The third access point to the project site will be from the extension of Pi'ilani Highway into the site. The extension will be constructed when the project is 50% complete and will extend south from the Wailea Ike intersection beyond Kaukahi Street into the project site.

5.2 Roadway Types

There will be six (6) major types of roadways within the project site as described below (see Figures 5-1 to 5-4).

1. Parkway: The parkway will consist of a 102-foot right-of-way which includes an 8-foot median, two 12-foot travel lanes in the eastbound direction, three 12-foot travel lanes in the westbound direction. There will be curb and gutter, and a 6-foot landscape strip on each side. There will be a 10-foot combined sidewalk/bikeway on the westbound direction and a 4 to 6-foot wide sidewalk on the eastbound direction. The parkway will

utilize concrete for the roadway and sidewalk due to the steepness of the area.

2. Pi'ilani Highway Extension: The Pi'ilani Highway extension is separated into three segments. Two portions of the extension will be State-owned and privately maintained (within State right-of-way) while the third will be privately owned and maintained.

    a. Wailea Ike Drive Intersection: The first segment of the Pi'ilani Highway extension will consist of a 105-foot right-of-way with two 12-foot thru lanes, one 12-foot right turn lane and one 11-foot left turn lane for northbound traffic. There will be a median with one 12-foot southbound lane and curb, gutter, and a 4 to 6-foot wide meandering sidewalk on the makai side of the street.

    b. South of the Wailea Ike Drive Intersection (within State right-of-way): This segment of the Pi'ilani Highway extension will consist of one 12-foot lane in each direction with an 11-foot middle turning lane. There will be curb, gutter and 4 to 6-foot wide meandering sidewalk on the makai side of the street. The right-of-way width varies from 140 to 202 feet.

    c. South of the Wailea Ike Drive Intersection (Private): The last segment of the Pi'ilani Highway extension will consist of a 54-foot right-of-way with a 11-foot lane with 2-foot paved shoulders and an 8-foot bioswale in each direction. A 6-foot landscape strip and 6-foot wide sidewalk will be located on one side of the road. This segment will connect with Kaukahi Street and will not extend to the mauka boundary of the project site. The roadway sections will be widened to accommodate an exclusive left turn lane at the intersections located along the extension.

3. Collector Roads: There will be two alternate roadway sections for the collector roads for the development. Both sections will consist of a 60-foot right-of-way with two 11-foot travel lanes.

    a. Option 1: The first option will include an 8-foot wide bioswale and 10-foot wide meandering sidewalk/bikeway on one side of the road and a 15-foot bioswale/landscape strip on the other side.

    b. Option 2: The second option will include a 4-foot wide paved bike lane in each direction adjacent to the travel lanes. One side of the road will contain a 4 to 6-foot wide meandering sidewalk with a variable bioswale/landscape strip. The other side will contain a 15-foot bioswale/landscape strip.

4. Minor Streets: Minor streets for the development will consist of a 52-foot right-of-way, widening to 58-feet in areas where a 4 to 6-foot wide sidewalk will be provided. There will be two 11-foot travel lanes and a 15-foot wide bioswale/landscape strip on each side. An 8-foot wide paved parking lane will be provided at designated locations.

5. Cul De Sacs: Cul de sacs for the development will consist of a 52-foot right-of-way with two 11-foot travel lanes and a 15-foot wide bioswale/landscape strip on each side. An 8-foot wide paved parking lane will be provided at designated locations.

6. Village Streets: There are two Village Street roadway sections for the development - one for parking on one side of the street and the other for parking on both sides:

    a. Parking on One Side of the Street: This section will consist of a 56-foot right-of-way with two 11-foot travel lanes, curb, gutter, a 6-foot landscape strip and a 4 to 6-foot wide sidewalk on both sides of the street. An 8-foot parking lane (6-foot paved and 2-foot gutter) will be provided on one side of the street.

    b. Parking on Two Sides of the Street: This section will consist of a 62-foot right-of-way with two 11-foot travel lanes, curb, gutter, a 6-foot landscape strip and 4 to 6-foot wide sidewalk on both sides of the street. An 8-foot parking lane (6-foot paved and 2-foot gutter) will be provided on both sides of the street.

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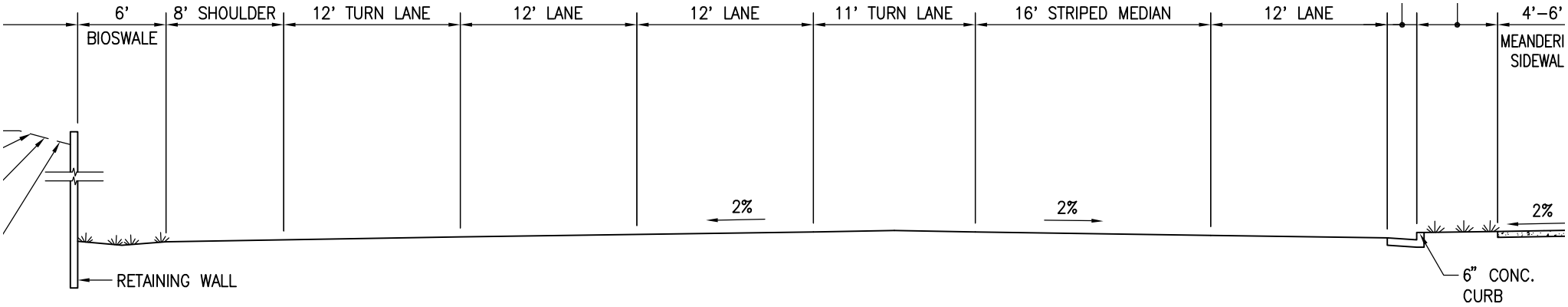
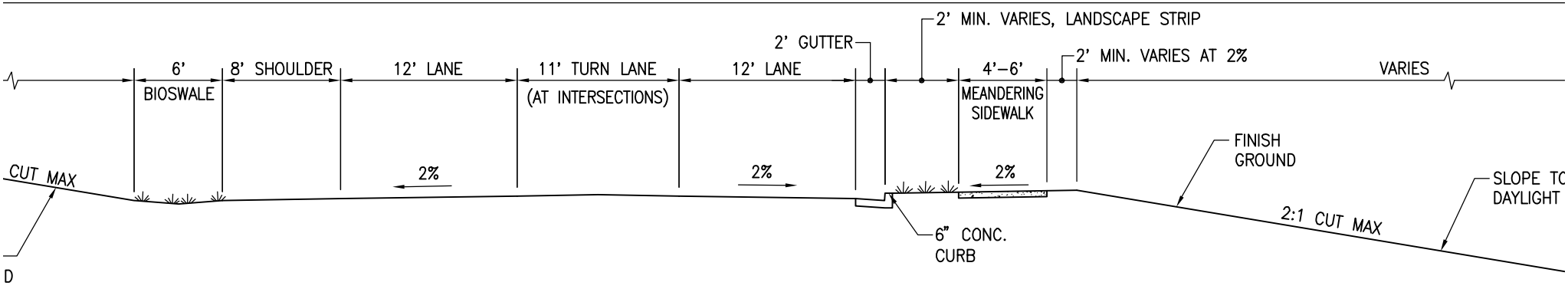


PIILANI HIGHWAY EXTENSION AT WAILEA IKE INTERSECTION (STATE)

SCALE: 1"=10'



PIILANI HIGHWAY EXTENSION (STATE)

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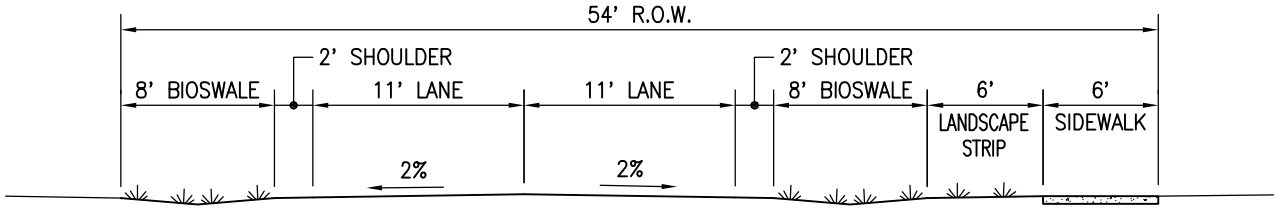

PIILANI HIGHWAY EXTENSION (PRIVATE)

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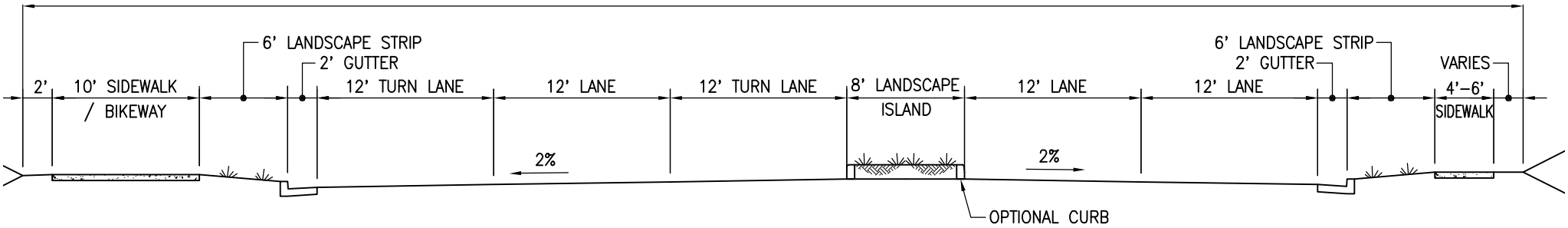

PARKWAY

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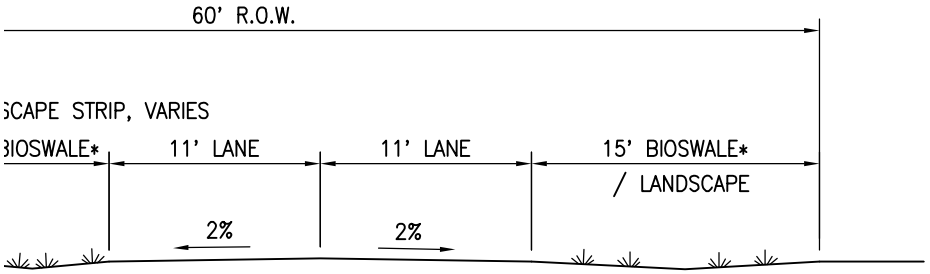
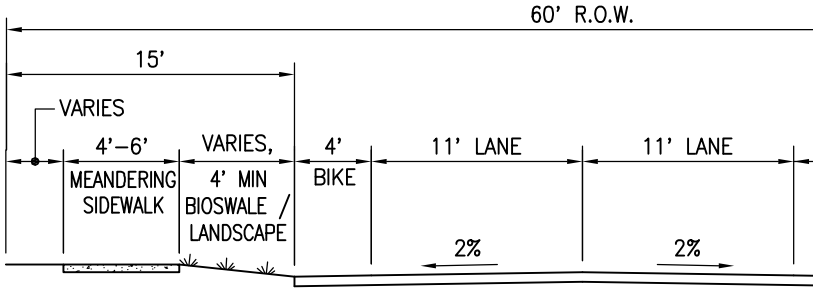


OLLECTOR ROAD - OPTION 1

SCALE: 1"=10'

(*) REINFORCED SWALE AT STEEP GRADE



COLLECTOR ROAD - OPTION

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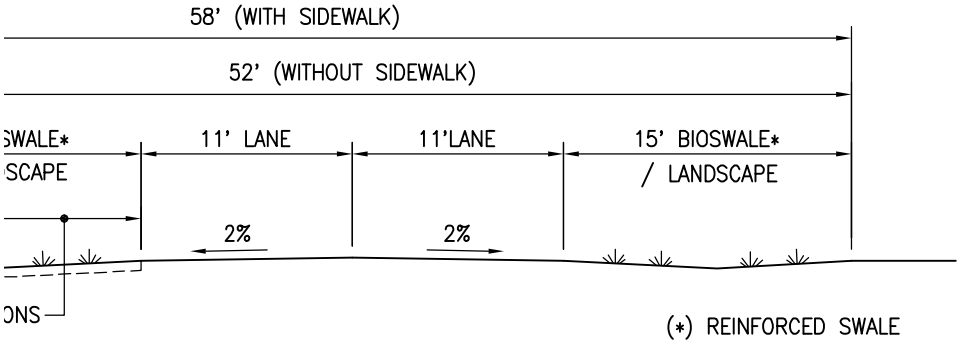
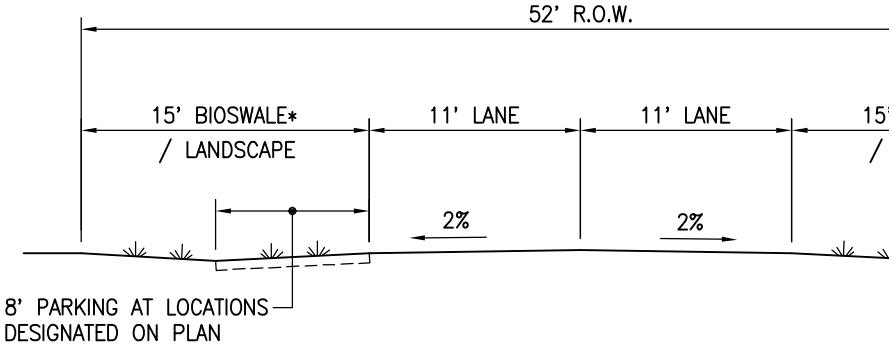


(*) REINFORCED SWALE AT STEEP GRADE

MINOR STREET

SCALE: 1"=10'



CUL DE SAC

SCALE: 1"=10'

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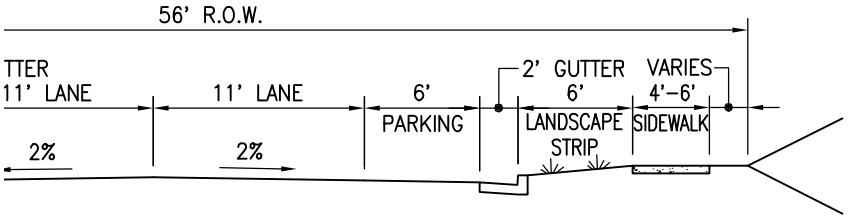
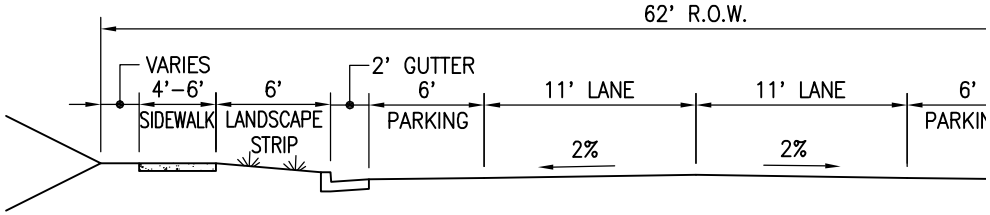


AGE STREET (PARKING 1 SIDE)

SCALE: 1"=10'



VILLAGE STREET (PARKING 2 SI

SCALE: 1"=10'

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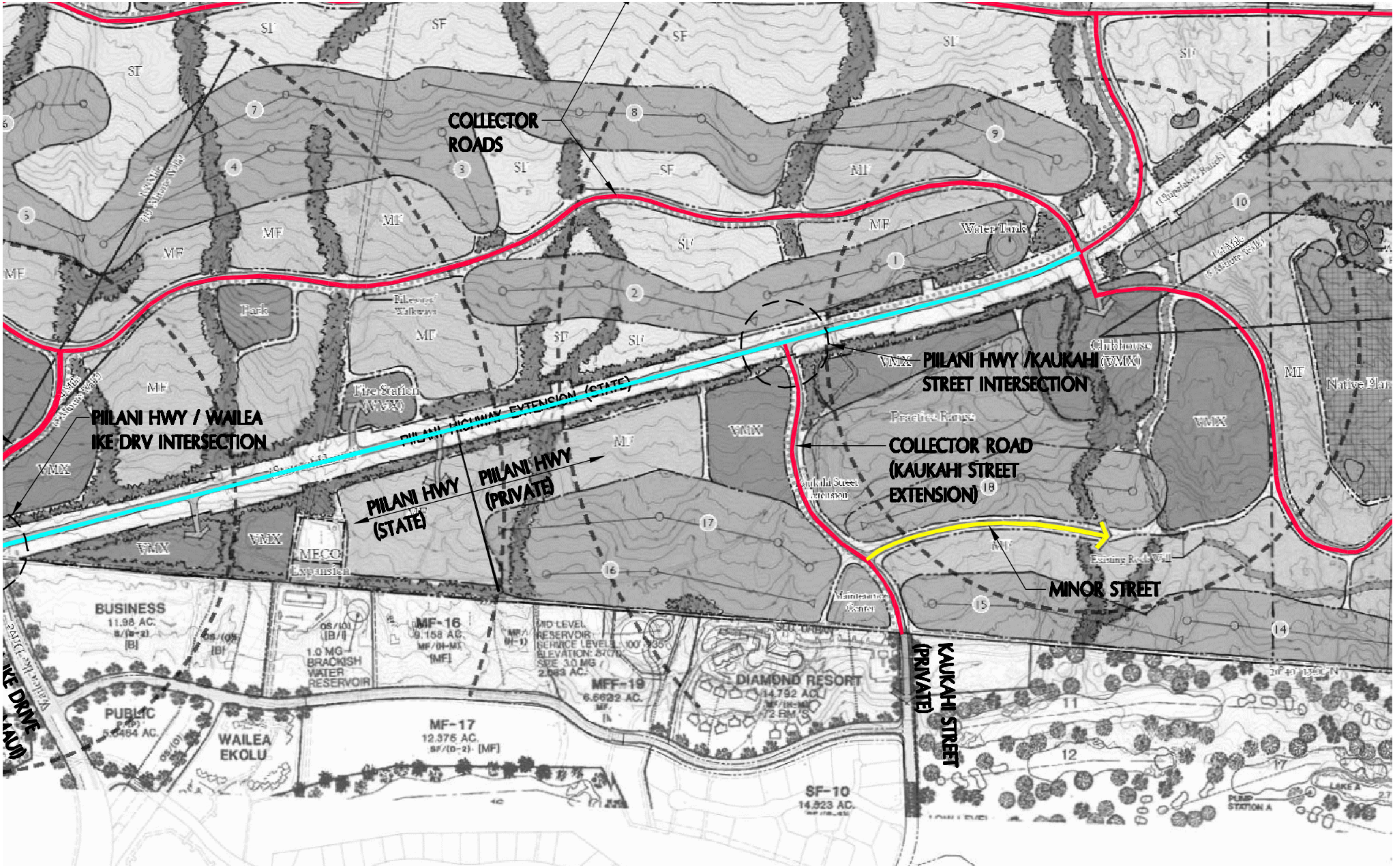
Figure 5-4 Roadway Site Layout Plan
(11x17)



LEGEND

1300'

1"=650'

- PIILANI HWY EXTENSION (R.O.W. VARIES)
- PARKWAY (100' R.O.W.)
- COLLECTOR ROAD (R.O.W. VARIES)
- MINOR STREET (52' R.O.W.)

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6. OTHER UTILITIES

6.1 Electrical

The Kīhei – Mākena region is serviced by a 69 kV (kilovolt) power line that runs from the 'Ulupalakua Ranch, mauka of Honua'ula, to the Maui Electric Company (MECO) substation located on a separate parcel (TMK (2)2-1-08: 043) near the western boundary of the makai portion of the property. The Wailea Substation is currently being fed by transmission lines from the Maalaea Power Plant, northwest of the property and from Kealahou Switchyard, mauka of the property. The substation converts the 69 kV power to 12.47 kV for distribution to the Wailea area. The converted 12.47 kV lines run within a 12-foot wide easement along the makai boundary of the property. The Wailea Substation is nearly filled to capacity.

When fully built-out, the peak forecasted electrical demand for Honua'ula is estimated to be 9,467 kilowatts (kW) per month. Based on the forecasted Honua'ula electrical demand and use, MECO anticipates additional transformer units or new substation development may be necessary. The current plans for the project include an area for the expansion of the substation.

In addition to the substation improvements, the project proposes to underground existing overhead power lines that run through the property in the mauka-makai direction and also along the makai boundary.

The projected electrical demand is approximately 9,467.0 KW (kilowatt). We will coordinate with MECO to ensure service is provided.

6.2 Communication

Hawaiian Telecom provides telephone service in the Kīhei – Mākena region, and Oceanic Time Warner cable provides cable service. The telephone system servicing the area consists of overhead and underground facilities.

The project proposes to place existing overhead lines along the makai boundary underground.

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7. REFERENCES

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Appendix A

Water Pipe Size Chart

TABLE 5.41

Friction Loss in Pipe–C = 130–6-in. PVC 1120 Pressure Pipe (ASTM-D2241)

Flow	Class 100 SDR 25* 6.35 ID		Class 150 SDR 18 6.134 ID		Class 200 SDR 14 5.914 ID	
US gpm	Velocity *fps*	Head Loss *psi/100 ft*	Velocity *fps*	Head Loss *psi/100 ft*	Velocity *fps*	Head Loss *psi/100 ft*
50	0.51	0.01	0.54	0.01	0.58	0.01
60	0.61	0.01	0.65	0.02	0.70	0.02
70	0.71	0.02	0.76	0.02	0.82	0.03
80	0.81	0.02	0.87	0.03	0.93	0.03
90	0.91	0.03	0.98	0.03	1.05	0.04
100	1.01	0.03	1.09	0.04	1.17	0.05
120	1.22	0.05	1.30	0.06	1.40	0.07
140	1.42	0.06	1.52	0.08	1.64	0.09
160	1.62	0.08	1.74	0.10	1.87	0.12
180	1.82	0.10	1.95	0.12	2.10	0.14
200	2.03	0.12	2.17	0.15	2.34	0.18
220	2.23	0.15	2.39	0.18	2.57	0.21
240	2.43	0.17	2.61	0.21	2.80	0.25
260	2.63	0.20	2.82	0.24	3.04	0.29
280	2.84	0.23	3.04	0.27	3.27	0.33
300	3.04	0.26	3.26	0.31	3.50	0.37
320	3.24	0.30	3.47	0.35	3.74	0.42
340	3.44	0.33	3.69	0.39	3.97	0.47
360	3.65	0.37	3.91	0.44	4.20	0.52
380	3.85	0.41	4.13	0.48	4.44	0.58
400	4.05	0.45	4.34	0.53	4.67	0.63
450	4.56	0.56	4.89	0.66	5.26	0.79
500	5.07	0.68	5.43	0.80	5.84	0.96
550	5.57	0.81	5.97	0.96	6.42	1.14
600	6.08	0.95	6.51	1.13	7.01	1.34
650	6.59	1.10	7.06	1.30	7.59	1.56
700	7.09	1.26	7.60	1.50	8.18	1.79
750	7.60	1.44	8.14	1.70	8.76	2.03
800	8.11	1.62	8.69	1.92	9.34	2.29
850	8.61	1.81	9.23	2.14	9.93	2.56
900	9.12	2.01	9.77	2.38	10.51	2.85
950	9.62	2.22	10.31	2.63	11.10	3.14
1 000	10.13	2.45	10.86	2.89	11.68	3.46
1 100	11.14	2.92	11.94	3.45	12.85	4.12
1 200	12.16	3.43	13.03	4.06	14.02	4.84
1 300	13.17	3.97	14.11	4.70	15.18	5.62
1 400	14.18	4.56	15.20	5.39	16.35	6.44
1 500	15.20	5.18	16.29	6.13	17.52	7.32
1 600	16.21	5.84	17.37	6.91	18.69	8.25
1 700	17.22	6.53	18.46	7.73	19.86	9.23
1 800	18.24	7.26	19.54	8.59	21.02	10.26
1 900	19.25	8.02	20.63	9.49	22.19	11.34
2 000	20.26	8.82	21.72	10.44	23.36	12.46
2 200	22.29	10.52	23.89	12.45	25.70	14.87
2 400	24.32	12.36	26.06	14.62	28.03	17.46

*(SDR) Standard Dimension Ratio (OD/T) with OD s of Cast Iron Pipe; Factor of Safety of 2.5 Less Surge; Pressure Class at 73 F, psi.

TABLE 5.42

Friction Loss in Pipe–C = 130–8–in. PVC 1120 Pressure Pipe (ASTM-D2241)

Flow *US gpm*	Class 100 SDR 25* 8.326 ID		Class 150 SDR 18 8.044 ID		Class 200 SDR 14 7.758 ID	
	Velocity *fps*	Head Loss *psi/100 ft*	Velocity *fps*	Head Loss *psi/100 ft*	Velocity *fps*	Head Loss *psi/100 ft*
130	0.77	0.02	0.82	0.02	0.88	0.02
140	0.83	0.02	0.88	0.02	0.95	0.02
150	0.88	0.02	0.95	0.02	1.02	0.03
160	0.94	0.02	1.01	0.03	1.09	0.03
170	1.00	0.02	1.07	0.03	1.15	0.03
180	1.06	0.03	1.14	0.03	1.22	0.04
190	1.12	0.03	1.20	0.04	1.29	0.04
200	1.18	0.03	1.26	0.04	1.36	0.05
220	1.30	0.04	1.39	0.05	1.49	0.06
240	1.41	0.05	1.52	0.06	1.63	0.07
260	1.53	0.05	1.64	0.06	1.76	0.08
280	1.65	0.06	1.77	0.07	1.90	0.09
300	1.77	0.07	1.89	0.08	2.04	0.10
350	2.06	0.09	2.21	0.11	2.38	0.13
400	2.36	0.12	2.53	0.14	2.72	0.17
450	2.65	0.15	2.84	0.18	3.05	0.21
500	2.95	0.18	3.16	0.21	3.39	0.26
550	3.24	0.22	3.47	0.26	3.73	0.31
600	3.54	0.25	3.79	0.30	4.07	0.36
650	3.83	0.29	4.10	0.35	4.41	0.42
700	4.13	0.34	4.42	0.40	4.75	0.48
750	4.42	0.38	4.74	0.45	5.09	0.54
800	4.71	0.43	5.05	0.51	5.43	0.61
850	5.01	0.48	5.37	0.57	5.77	0.68
900	5.30	0.54	5.68	0.64	6.11	0.76
950	5.60	0.60	6.00	0.70	6.45	0.84
1 000	5.89	0.65	6.31	0.77	6.79	0.92
1 100	6.48	0.78	6.94	0.92	7.47	1.10
1 200	7.07	0.92	7.58	1.08	8.15	1.29
1 300	7.66	1.06	8.21	1.26	8.82	1.50
1 400	8.25	1.22	8.84	1.44	9.50	1.72
1 500	8.84	1.39	9.47	1.64	10.18	1.95
1 600	9.43	1.56	10.10	1.85	10.86	2.20
1 800	10.61	1.94	11.36	2.30	12.22	2.74
2 000	11.79	2.36	12.63	2.79	13.58	3.33
2 200	12.96	2.81	13.89	3.33	14.93	3.97
2 400	14.14	3.31	15.15	3.91	16.29	4.66
2 600	15.32	3.83	16.42	4.53	17.65	5.41
2 800	16.50	4.40	17.68	5.20	19.01	6.20
3 000	17.68	5.00	18.94	5.91	20.36	7.05
3 500	20.63	6.64	22.10	7.86	23.76	9.37
4 000	23.57	8.51	25.25	10.06	27.15	12.00
4 500	26.52	10.58	28.41	12.51	30.54	14.92
5 000	29.47	12.85	31.57	15.20	33.94	18.13
5 500	32.41	15.33	34.72	18.13	37.33	21.62

*(SDR) Standard Dimension Ratio (OD/T) with OD s of Cast Iron Pipe; Factor of Safety of 2.5 Less Surge; Pressure Class at 73 F, psi.

TABLE 5.43

Friction Loss in Pipe–C = 130–10-in. PVC 1120 Pressure Pipe (ASTM-D2241)

Flow	Class 100 SDR 25* 10.212 ID		Class 150 SDR 18 9.866 ID		Class 200 SDR 14 9.514 ID	
US gpm	Velocity *fps*	Head Loss *psi/100 ft*	Velocity *fps*	Head Loss *psi/100 ft*	Velocity *fps*	Head Loss *psi/100 ft*
180	0.71	0.01	0.76	0.01	0.81	0.01
200	0.78	0.01	0.84	0.01	0.90	0.02
220	0.86	0.01	0.92	0.02	0.99	0.02
240	0.94	0.02	1.01	0.02	1.08	0.02
260	1.02	0.02	1.09	0.02	1.17	0.03
280	1.10	0.02	1.18	0.03	1.26	0.03
300	1.18	0.03	1.26	0.03	1.35	0.04
350	1.37	0.03	1.47	0.04	1.58	0.05
400	1.57	0.04	1.68	0.05	1.81	0.06
450	1.76	0.06	1.89	0.07	2.03	0.08
500	1.96	0.07	2.10	0.08	2.26	0.09
550	2.15	0.08	2.31	0.09	2.48	0.11
600	2.35	0.09	2.52	0.11	2.71	0.13
650	2.55	0.11	2.73	0.13	2.93	0.15
700	2.74	0.13	2.94	0.15	3.16	0.18
800	3.13	0.16	3.36	0.19	3.61	0.23
900	3.53	0.20	3.78	0.24	4.06	0.28
1 000	3.92	0.24	4.20	0.29	4.51	0.34
1 100	4.31	0.29	4.62	0.34	4.96	0.41
1 200	4.70	0.34	5.04	0.40	5.42	0.48
1 300	5.09	0.39	5.46	0.47	5.87	0.56
1 400	5.48	0.45	5.88	0.53	6.32	0.64
1 500	5.88	0.51	6.30	0.61	6.77	0.72
1 600	6.27	0.58	6.72	0.68	7.22	0.82
1 700	6.66	0.65	7.13	0.77	7.67	0.91
1 800	7.05	0.72	7.55	0.85	8.12	1.01
1 900	7.44	0.79	7.97	0.94	8.58	1.12
2 000	7.83	0.87	8.39	1.03	9.03	1.23
2 200	8.62	1.04	9.23	1.23	9.93	1.47
2 400	9.40	1.22	10.07	1.45	10.83	1.73
2 600	10.19	1.42	10.91	1.68	11.73	2.00
2 800	10.97	1.63	11.75	1.93	12.64	2.30
3 000	11.75	1.85	12.59	2.19	13.54	2.61
3 200	12.54	2.08	13.43	2.47	14.44	2.94
3 400	13.32	2.33	14.27	2.76	15.35	3.29
3 600	14.10	2.59	15.11	3.07	16.25	3.66
3 800	14.89	2.86	15.95	3.39	17.15	4.04
4 000	15.67	3.15	16.79	3.73	18.05	4.45
4 500	17.63	3.92	18.89	4.63	20.31	5.53
5 000	19.59	4.76	20.98	5.63	22.57	6.72
5 500	21.55	5.68	23.08	6.71	24.82	8.01
6 000	23.50	6.67	25.18	7.89	27.08	9.41
6 500	25.46	7.73	27.28	9.15	29.34	10.91
7 000	27.42	8.87	29.38	10.49	31.59	12.52
7 500	29.38	10.08	31.48	11.92	33.85	14.22

*(SDR) Standard Dimension Ratio (OD/T) with OD s of Cast Iron Pipe; Factor of Safety of 2.5 Less Surge; Pressure Class at 73 F, psi.

TABLE 5.44

Friction Loss in Pipe–C = 130–12-in. PVC 1120 Pressure Pipe (ASTM-D2241)

Flow	Class 100 SDR 25* 12.144 ID		Class 150 SDR 18 11.734 ID		Class 200 SDR 14 11.314 ID	
US gpm	Velocity *fps*	Head Loss *psi/100 ft*	Velocity *fps*	Head Loss *psi/100 ft*	Velocity *fps*	Head Loss *psi/100 ft*
200	0.55	0.01	0.59	0.01	0.64	0.01
250	0.69	0.01	0.74	0.01	0.80	0.01
300	0.83	0.01	0.89	0.01	0.96	0.02
350	0.97	0.01	1.04	0.02	1.12	0.02
400	1.11	0.02	1.19	0.02	1.28	0.03
450	1.25	0.02	1.34	0.03	1.44	0.03
500	1.39	0.03	1.48	0.03	1.60	0.04
550	1.52	0.03	1.63	0.04	1.76	0.05
600	1.66	0.04	1.78	0.05	1.91	0.06
700	1.94	0.05	2.08	0.06	2.23	0.08
800	2.22	0.07	2.37	0.08	2.55	0.10
900	2.49	0.09	2.67	0.10	2.87	0.12
1 000	2.77	0.10	2.97	0.12	3.19	0.15
1 100	3.05	0.12	3.26	0.15	3.51	0.18
1 200	3.32	0.15	3.56	0.17	3.83	0.21
1 300	3.60	0.17	3.86	0.20	4.15	0.24
1 400	3.88	0.19	4.15	0.23	4.47	0.27
1 500	4.16	0.22	4.45	0.26	4.79	0.31
1 600	4.43	0.25	4.75	0.29	5.11	0.35
1 800	4.99	0.31	5.34	0.37	5.74	0.44
2 000	5.54	0.38	5.93	0.44	6.38	0.53
2 200	6.09	0.45	6.53	0.53	7.02	0.63
2 400	6.65	0.53	7.12	0.62	7.66	0.74
2 600	7.20	0.61	7.71	0.72	8.30	0.86
2 800	7.76	0.70	8.31	0.83	8.94	0.99
3 000	8.31	0.80	8.90	0.94	9.57	1.12
3 500	9.70	1.06	10.38	1.25	11.17	1.49
4 000	11.08	1.36	11.87	1.60	12.77	1.91
4 500	12.47	1.69	13.35	1.99	14.36	2.38
5 000	13.85	2.05	14.84	2.42	15.96	2.89
5 500	15.24	2.44	16.32	2.89	17.55	3.45
6 000	16.62	2.87	17.80	3.39	19.15	4.05
6 500	18.01	3.33	19.29	3.93	20.74	4.70
7 000	19.39	3.82	20.77	4.51	22.34	5.39
7 500	20.78	4.34	22.25	5.13	23.94	6.12
8 000	22.16	4.89	23.74	5.78	25.53	6.90
8 500	23.55	5.47	25.22	6.46	27.13	7.72
9 000	24.93	6.08	26.70	7.18	28.72	8.58
9 500	26.32	6.72	28.19	7.94	30.32	9.48
10 000	27.70	7.39	29.67	8.73	31.91	10.42
11 000	30.47	8.81	32.64	10.41	35.11	12.43
12 000	33.24	10.35	35.60	12.23	38.30	14.60
13 000	36.01	12.00	38.57	14.18	41.49	16.93
14 000	38.78	13.76	41.54	16.27	44.68	19.42
15 000	41.55	15.64	44.51	18.48	47.87	22.07

(SDR) Standard Dimension Ratio (OD/T) with OD s of Cast Iron Pipe; Factor of Safety of 2.5 Less

* Surge; Pressure Class at 73 F, psi.