Appendix B

Groundwater Resources Assessment

Assessment of the Potential Impact on Water Resources of the Honua'ula Project in Wailea, Maui

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February 2010

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Introduction

This report presents an assessment of the potential impact on water resources of the Honua'ula project which will be located on approximately 670 acres on TMK 2-1-08:56 and 71 in Wailea, Maui (its location is shown on Figure 1). Figure 2 illustrates the development plan and Exhibit 1 provides a detailed land use summary by its three phases of development. The land uses include 1150 residential units, a golf course, commercial and community facilities, parks, and preservation-conservation areas. The projected is bisected by a right-of-way (ROW) for the proposed extension of Piilani Highway.

Aspects of the Project That Will Impact Water Resources

Four aspects of the project have the potential to impact water resources. These are: use of groundwater for potable consumption and landscape irrigation; generation, treatment, and reuse of domestic wastewater; increase of surface water runoff; and percolation to groundwater of excess landscape irrigation. Each of these is described and quantified in the sections below.

Use of Groundwater. The project's potable and irrigation supply will be provided by brackish wells. Four of these wells have already been developed, two onsite and two others offsite on the north side of Maui Meadows (Figure 1 shows their locations). The offsite wells are referred to herein as the Kamaole wells. Table 1 provides a compilation of the expected use of brackish groundwater by development phase. This compilation incorporates the following assumptions:

- Reverse Osmosis (RO) treatment of the brackish supply will provide the project's potable water. Sixty-five (65) percent of the feedwater supply would be converted to potable water and the remaining 35 percent would be a concentrate that would be reused for golf course irrigation.
- Domestic wastewater will be treated to R-1 quality and it will be reused for golf course irrigation.
- Landscape irrigation in areas outside of the golf course will be supplied by brackish well water.
- An allowance of 10 percent for unmetered use and losses is included in the calculations of potable and brackish irrigation requirements.

Based on these assumptions, year-round average pumpage of brackish groundwater is estimated to be 1.1, 1.4, and 1.7 million gallons per day (MGD) at the completion of Phases 1, 2, and 3, respectively. To provide for summertime maximum use periods and to have standby capacity, another offsite well will be needed for Phase 1 and one more will be needed for Phase 2. The total number of the project's wells would then be six. Depending on the actual water use rates that materialize, a fifth Kamaole well may or may not be needed to complete Phase 3.

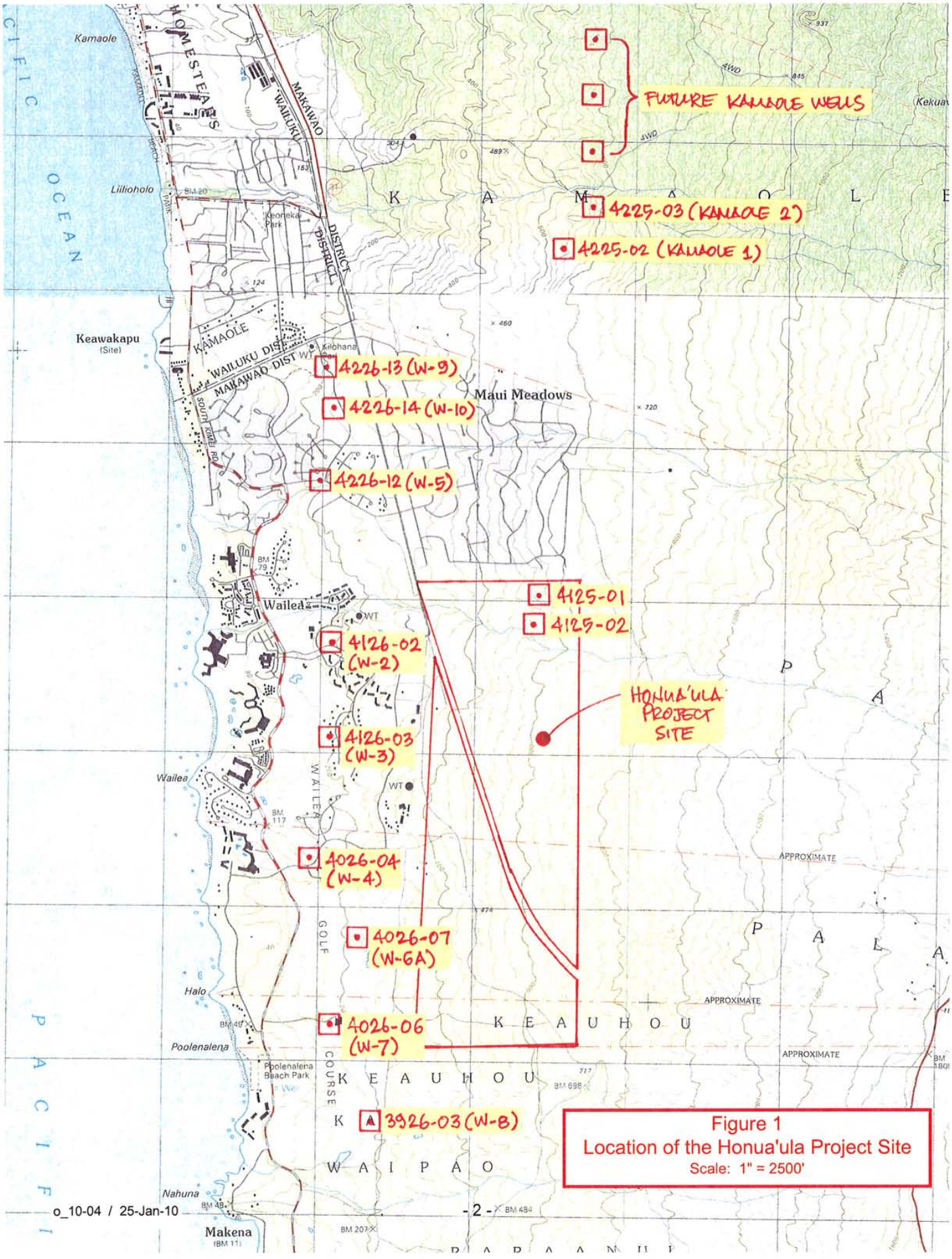

Figure 1
Location of the Honua'ula Project Site
Scale: 1" = 2500'

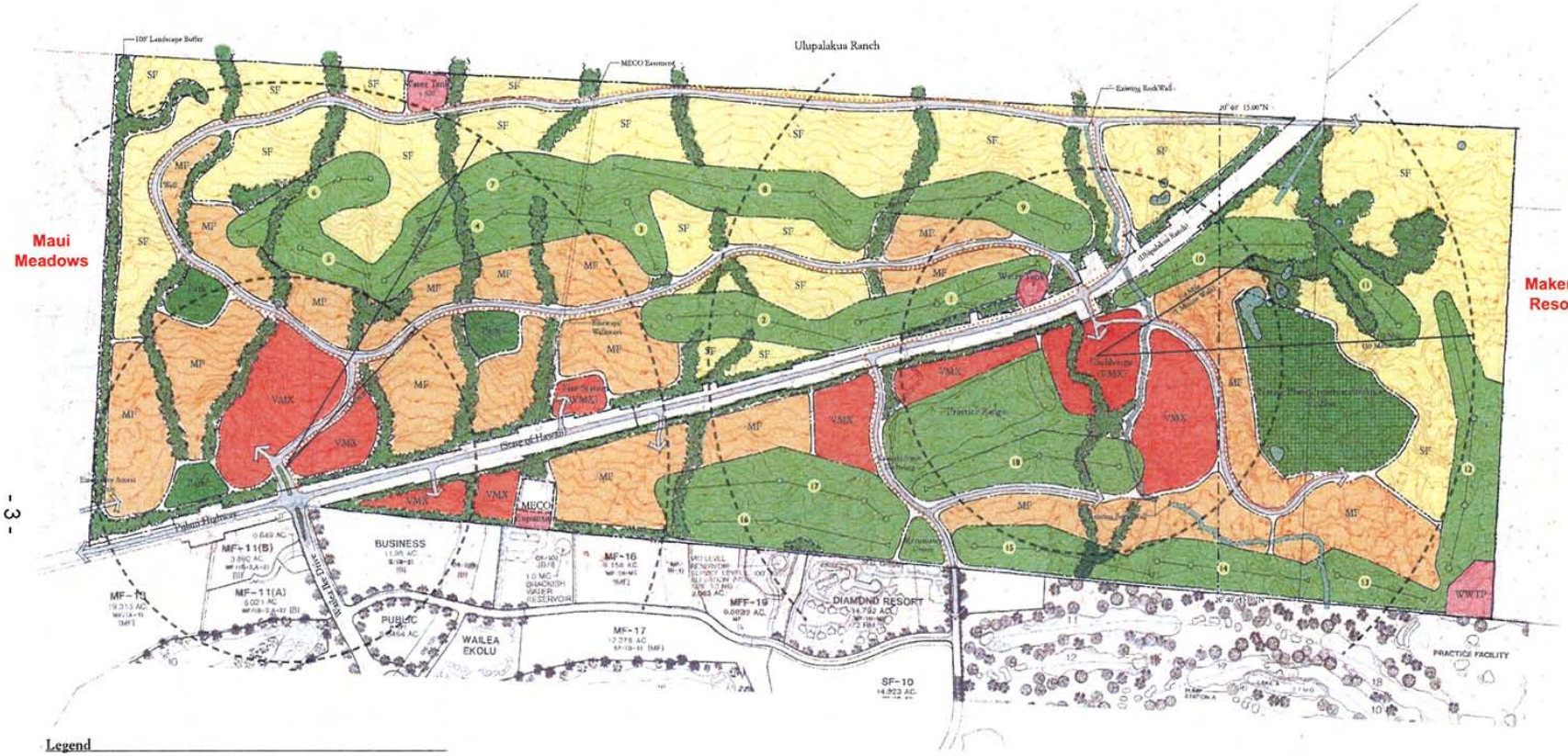

Figure 2
Project District Phase 2
Master Plan

Honua`ula Preliminary Land Use Summary

DRAFT November 20, 2009

(Information taken from the VITA Concept and Phasing Plans dated 12/1/2009)

Phase 1 -

Zone 640

Land Use Types	Approx. Unit Count	Approx. Roadway / Landscape Buffer Lineal Footage (L.F.)	Approx. Land Area (Acre)
SF Type A - Custom	21	--	12.2
SF Type B - Hale	53	--	29.2
SF Type C - Cottage	62	--	32.5
MF Duplex	40	--	16.9
MF Affordable Housing	75	--	10.5
Parkway (100' ROW)	--	250	0.6
Major Collector Road (60' ROW)*	--	7,150	10
Minor Collector (56' ROW)	--	--	0
Minor Street (44' ROW)	--	2,200	2.2
25' Landscape Buffer Along Piilani Highway	--	850	0.5
Mixed-use Village	--	--	7
Golf Course Envelope	--	--	105.3
Puplic parks	--	--	0
Pillani Highway Extension (150' ROW)	--	--	0
Fire Station	--	--	0
MECO Expansion	--	--	0
Golf Clubhouse	--	--	10
Golf Maintenance Yard	--	--	1.8
Native Plant Preservation Area	--	--	22
Water Tank Site	--	--	0
Waste Water Treatment Plant	--	--	2
Natural Open Area (Drainage Detention, Arch. Preserve, etc.)	--	--	3.1
		Land Area Subtotal :	**265.8**

Zone 810

Land Use Types	Approx. Unit Count	Approx. Roadway / Landscape Buffer Lineal Footage (L.F.)	Approx. Land Area (Acre)
SF Type A - Custom	22	--	12.8
SF Type B - Hale	60	--	32.9
SF Type C - Cottage	46	--	19.1
MF Duplex	16	--	5.6
MF Affordable Housing	0	--	0
Parkway (100' ROW)	--	0	0
Major Collector Road (60' ROW)*	--	4,850	6.7
Minor Collector (56' ROW)	--	--	0
Minor Street (44' ROW)	--	0	0
25' Landscape Buffer Along Piilani Highway	--	0	0
Mixed-use Village	--	--	0
Golf Course Envelope	--	--	65
Puplic parks	--	--	0
Pillani Highway Extension (150' ROW)	--	--	0
Fire Station	--	--	0
MECO Expansion	--	--	0
Golf Clubhouse	--	--	0
Golf Maintenance Yard	--	--	0
Native Plant Preservation Area	--	--	0
Water Tank Site	--	--	1.8
Waste Water Treatment Plant	--	--	0
Natural Open Area (Drainage Detention, Arch. Preserve, etc.)	--	--	8.5
		Land Area Subtotal :	**152.4**

Phase 2 -

Zone 640

Land Use Types	Approx. Unit Count	Approx. Roadway / Landscape Buffer Lineal Footage (L.F.)	Approx. Land Area (Acre)
SF Type A - Custom	11	--	6.4
SF Type B - Hale	0	--	0
SF Type C - Cottage	80	--	41.6
MF Duplex	114	--	28.6
MF Affordable Housing	200	--	18.7
Parkway (100' ROW)	--	--	0
Major Collector Road (60' ROW)*	--	5,000	6.8
Minor Collector (56' ROW)	--	--	0

Zone 810

Land Use Types	Approx. Unit Count	Approx. Roadway / Landscape Buffer Lineal Footage (L.F.)	Approx. Land Area (Acre)
SF Type A - Custom	--	--	0
SF Type B - Hale	--	--	0
SF Type C - Cottage	--	--	0
MF Duplex	6	--	1.7
MF Affordable Housing	--	--	0
Parkway (100' ROW)	--	--	0
Major Collector Road (60' ROW)*	--	--	0
Minor Collector (56' ROW)	--	--	0

Minor Street (44' ROW)	--	--	0
25' Landscape Buffer Along Piilani Highway	--	6,000	3.4
Mixed-use Village	--	--	0
Golf Course Envelope	--	--	0
Pillani Highway Extension (150' ROW)	--	4,000	15
Puplic parks	--	--	6
Fire Station	--	--	2
MECO Expansion	--	--	1
Golf Clubhouse	--	--	0
Golf Maintenance Yard	--	--	0
Native Plant Preservation Area	--	--	0
Water Tank Site	--	--	0
Waste Water Treatment Plant	--	--	0
Natural Open Area (Drainage Detention, Arch. Preserve, etc.)	--	--	5.5
		Land Area Subtotal :	**135**

Minor Street (44' ROW)	--	--	0
25' Landscape Buffer Along Piilani Highway	--	--	0
Mixed-use Village	--	--	0
Golf Course Envelope	--	--	0
Pillani Highway Extension (150' ROW)	--	--	0
Puplic parks	--	--	0
Fire Station	--	--	0
MECO Expansion	--	--	0
Golf Clubhouse	--	--	0
Golf Maintenance Yard	--	--	0
Native Plant Preservation Area	--	--	0
Water Tank Site	--	--	0
Waste Water Treatment Plant	--	--	0
Natural Open Area (Drainage Detention, Arch. Preserve, etc.)	--	--	0
		Land Area Subtotal :	**1.7**

Phase 3 -

Zone 640

Land Use Types	Approx. Unit Count	Approx. Roadway / Landscape Buffer Lineal Footage (L.F.)	Approx. Land Area (Acre)
SF Type A - Custom	2	--	1.2
SF Type B - Hale	0	--	0
SF Type C - Cottage	13	--	8.2
MF Duplex	15	--	5.2
MF Affordable Housing	175	--	12.5
Parkway (100' ROW)	--	0	0
Major Collector Road (60' ROW)*	--	0	0
Minor Collector (56' ROW)	--	0	0
Minor Street (44' ROW)	--	--	0
25' Landscape Buffer Along Piilani Highway	--	--	3
Mixed-use Village	--	--	0
Golf Course Envelope	--	--	0
Pillani Highway Extension (150' ROW)	--	--	0
Puplic parks	--	--	0
Fire Station	--	--	0
MECO Expansion	--	--	0
Golf Clubhouse	--	--	0
Golf Maintenance Yard	--	--	0
Native Plant Preservation Area	--	--	0
Water Tank Site	--	--	2
Waste Water Treatment Plant	--	--	0
Natural Open Area (Drainage Detention, Arch. Preserve, etc.)	--	--	3
		Land Area Subtotal :	**35.1**

Zone 810

Land Use Types	Approx. Unit Count	Approx. Roadway / Landscape Buffer Lineal Footage (L.F.)	Approx. Land Area (Acre)
SF Type A - Custom	25	--	14.6
SF Type B - Hale	68	--	39.6
SF Type C - Cottage	41	--	23.8
MF Duplex	5	--	1.7
MF Affordable Housing	0	--	0
Parkway (100' ROW)	--	--	0
Major Collector Road (60' ROW)*	--	6,100	8.3
Minor Collector (56' ROW)	--	0	0
Minor Street (44' ROW)	--	--	0
25' Landscape Buffer Along Piilani Highway	--	--	3.5
Mixed-use Village	--	--	0
Golf Course Envelope	--	--	0
Pillani Highway Extension (150' ROW)	--	--	0
Puplic parks	--	--	0
Fire Station	--	--	0
MECO Expansion	--	--	0
Golf Clubhouse	--	--	0
Golf Maintenance Yard	--	--	0
Native Plant Preservation Area	--	--	0
Water Tank Site	--	--	0
Waste Water Treatment Plant	--	--	0
Natural Open Area (Drainage Detention, Arch. Preserve, etc.)	--	--	3.5
		Land Area Subtotal :	**95**
		TOTAL LAND AREA :	**685**

* Approximately 1.5 acres major collector road ROW are in Ulupalakua Ranch property and they are irrigated by the project.
** The ROW of Highway Extension (approximately 15 acres) is within the land of State of Hawaii and Ulupalakua Ranch. They are irrigated by the project.

Table 1

Average Brackish Water Use by Development Phase

Component of Supply	Phase 1 (MGD)	Phase 2 (MGD)	Phase 3 (MGD)
Potable System			
Average + 10%	0.1474	0.2735	0.3766
Required Raw Water Supply (65% RO Recovery)	0.2268	0.4208	0.5794
Concentrate From RO for Golf Course Irrigation Reuse	0.0794	0.1473	0.2028
WWTP R-1 Effluent (80% of Average Potable Use)	0.1072	0.1989	0.2739
Golf Course Irrigation			
Average Use	0.7167	0.7167	0.7167
Supply From RO Concentrate	0.0794	0.1473	0.2028
Supply From WWTP R-1 Effluent (80% of Potable Use)	0.1072	0.1989	0.2739
Required Supplement From Non-Potable System	0.5301	0.3705	0.2400
Supply From Brackish Wells			
Feedwater to RO System	0.2268	0.4208	0.5794
Supplement for Golf Course Irrigation	0.5301	0.3705	0.2400
Supply for Non-Potable System (Average + 10%)	0.3623	0.6390	0.8908
Total Average Withdrawal From Brackish Wells	1.1192	1.4303	1.7102

Wastewater Generation, Treatment, and Reuse. Two alternatives are being considered for the treatment of the project's domestic wastewater: (1) use of the nearby Makena Resort's wastewater treatment plant (WWTP); or (2) constructing a new, onsite WWTP. In either case, treatment would be to R-1 quality and the treated effluent would be used for golf course irrigation. For 110 turf acres of golf course and driving range, irrigation is expected to be 0.72 MGD as a year-round average (refer to Table 2). As shown on Table 1, the portion provided by the WWTP effluent would be about 15 percent at the end of Phase 1 and increase to about 38 percent at full build-out.

Collection and Detention of the Project's Increase in Rainfall-Runoff. As identified in the February 2010 Preliminary Engineering Report by Wilson Okamoto Corporation (WOC, 2010), the tributary watershed above the project consists of almost 4000 acres. Runoff from this area, from the 670-acre project site, and from the 15-acre Piilani extension ROW drains through the Wailea Resort and its golf courses prior to discharging along the shoreline. In conformance with County drainage regulations, the project will utilize detention basins so that there will be no increase in the peak rate of stormwater runoff leaving the site as a result of the project's development.

To quantify the required stormwater retention volume, WOC, 2010 divided the project site into 27 drainage areas and did pre- and post-development rainfall-runoff analyses. All analyses were based on the 100-year, 24-hour storm event. For this hypothetical storm event, WOC, 2010 calculated the required detention volumes so for each basin that there would be no increase in the peak runoff rate. The combined detention storage volume was computed to be 76.56 acre-feet. WOC, 2010 proposes to meet this requirement with the installation of 26 stormwater detention basins with a combined storage volume of 81.6 acre-feet.

Each of the 26 proposed detention basins would have a drain outlet consisting, in part, of a vertical perforated pipe within a gravel mound which would act as a filter. In addition to reducing the peak runoff rate by detention storage, this configuration will also capture floatables and suspended solids in the basin, thereby reducing the sediment load in water released from the detention basins. Based on this proposal, the assessment herein assumes the pre- and post-development volumes of runoff leaving the project site are the same. As a consequence, it is also assumed that the volume of rainfall which percolates to groundwater is essentially unchanged. Seepage from the detention basins will actually increase the amount of percolation, but no credit for that is included in the analyses which follow.

Percolation to Groundwater of Excess Landscape Irrigation. Percolation of excess applied irrigation water will occur from the golf course and driving range, from irrigated landscaping in roadway and buffer areas, from parks and other landscaped public areas, and from the residential parcels. The quantities of applied irrigation as year-round averages by development phase are compiled below. As a first order approximation, it is assumed that 10 percent of the applied irrigation on the golf course (with close management of application rates) percolates to groundwater and that elsewhere, the excess application rate is 15 percent. The percolation quantities are included in the summary below.

Table 2

Estimated Golf Course Irrigation Requirement

Month	Rainfall (Inches)	Pan Evaporation (Inches)	Crop Requirement (Inches)	Supply Requirement	
				(GPD / Acre)	GPD for 110 Acres
January	3.13	5.06	3.182	3,484	383,221
February	1.75	5.30	4.250	4,653	511,845
March	1.63	6.50	5.522	6,046	665,037
April	0.89	6.74	6.206	6,795	747,414
May	0.57	7.74	7.398	8,100	890,971
June	0.41	7.72	7.474	8,183	900,124
July	0.31	7.98	7.794	8,533	938,663
August	0.37	8.05	7.828	8,571	942,758
September	0.51	7.60	7.294	7,986	878,446
October	0.47	6.36	6.078	6,655	731,998
November	1.18	5.68	4.972	5,444	598,798
December	2.24	4.76	3.416	3,740	411,403
Annual	13.46	79.49	71.414	6,516	716,723

Notes:
1. Rainfall is the average of Gages 260 and 260.2.
2. Pan evaporation is the average of Gages 361, 363.1, and 372.3.
3. In computing the crop requirement, plant evapotranspiration (ET) is assumed to be equal to pan evaporation and the rainfall is assumed to be 60% effective.
4. The required supply assumes 80% application efficiency. This accounts for leakage, overspray, and periodic salt flushing.
5. The total required supply assumes 110 turf acres of golf course and driving range will be irrigated.

Summary of Estimated Percolation to Groundwater of Excess Applied Irrigation

Component of Irrigation Supply	Phase 1 (MGD)	Phase 2 (MGD)	Phase 3 (MGD)
Non-Potable System (Brackish Well Water)	0.362	0.639	0.891
- Amount Percolating to Groundwater (15%)	0.054	0.096	0.134
Golf Course System			
- RO Concentrate	0.079	0.147	0.203
- WWTP R-1 Quality Effluent	0.107	0.199	0.274
- Brackish Well Water From N-P System	0.531	0.371	0.240
- Total Irrigation Application	0.717	0.717	0.717
- Amount Percolating to Groundwater	0.072	0.072	0.072
Total Percolation to Groundwater	0.126	0.168	0.206

Description of Water Resources in the Honua'ula Project Area

Overview. Owing to the relatively dry conditions in and above the project site, there are no perennial streams in the area. Runoff occurs in the mauka-to-makai gulches which cross the site only during and for a short time following intense rainfall events. This being the case, the assessment of impacts on water resources focuses primarily on groundwater.

The project site and its offsite wells are within the Kamaole Aquifer System, an 89-square mile area delineated and regulated by the State Commission on Water Resource Management (CWRM). The Kamaole Aquifer is triangular-shaped, with its apex at the top of Haleakala and its base along the 11-mile length of shoreline from Waiakoa Gulch on the north to Cape Kinau on the south. The Waiakoa Gulch boundary of the aquifer is coincident with the Wailuku-Makawao district boundary, but it is otherwise of no known hydrologic significance. The southern boundary of the aquifer is the southeast rift zone of Haleakala which is likely to be a barrier to groundwater flow.

As far as has been demonstrated by drilled wells and by geophysical soundings, groundwater in the Kamaole Aquifer exists as a basal lens from the shoreline as far inland as the 1700-foot contour. Groundwater pumpage from the aquifer is estimated to be a little more than four MGD (a number of active wells do not have reported use). Most of this pumpage is by the nine Wailea Resort and 11 Makena Resort brackish wells which irrigate a total of five 18-hole golf courses.

In 1990, the CWRM set the sustainable yield of the Kamaole Aquifer at 11 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 the aquifer. Several far more

detailed and sophisticated studies on the aquifer's recharge have been completed since then. These suggest that the recharge amount on which the CWRM's sustainable yield is based is substantially underestimated (refer to the tally below). As such, these studies also indicate that the actual sustainable yield for the aquifer may be as much as 50 percent greater. The most recent of these studies is considered to be the most reliable. Using the results of the latest USGS study (Engott and Vana, 2007), the groundwater flowrate may be on the order of 3.4 MGD per mile. This rate is used in the section on impacts to groundwater following later in this report.

Studies With Computations of the Kamaole Aquifer's Recharge Since 1990

Study	Year	Computed Recharge	
		M G D	% of Precipitation
USGS Water Resources Investigations Report 98-04159 by Pat Shade	1999	24	21
Water Resource Review of the Kamaole Aquifer by Waimea Water Services, Inc.	2004	29	22
USGS Scientific Investigations Report 2007-5103 by John Engott and Thomas Vana	2007	37.4	37

The project's impacts to groundwater will occur in two geographically distinct areas: (1) beneath and downgradient of the project site itself; and (2) downgradient of the project's offsite Kamaole wells on the north side of Maui Meadows. The project site spans a 1.9-mile length of the coastline. Assuming lateral dispersion on the order of 10 degrees, the project's impacts may occur across a 2.3-mile section of the shoreline. Using 3.4 MGD per coastal mile, the pre-development groundwater flowrate discharging into the marine environment is assumed to have been on the order of 7.8 MGD. Five of Wailea Resort's nine golf course irrigation wells are within this potentially impacted zone. (Of Wailea's other four wells, three are to the north and downgradient of Maui Meadows and the fourth is to the south.) Table 3 identifies these five Wailea wells and provides a compilation of their average water quality based on annual sampling by Marine Research Consultants (Dr. Steven Dollar) since 1991. According to CWRM records, the draft of these five wells is about 1.4 MGD as a year-round average. Wailea's other four wells average about 1.0 MGD.

Two of the project's offsite Kamaole wells have been drilled and pump tested (Nos. 4225-02 and 4225-03). At least two and possibly a third well will need to be developed. These will be located north of the two existing wells. These four or five wells will span a 0.8-mile long length at about 580-foot elevation and may impact the groundwater flow along a 1.4-mile long shoreline segment. Again using 3.4 MGD per coastal mile, the pre-development flowrate may have been on the order of 4.8 MGD. Based on CWRM records, there are 20 wells in this potentially impacted downgradient area (refer to Table 4). Most of

Table 3

Averaged Water Quality Data of the
Five Wailea Resort Golf Course Irrigation Wells
Downgradient of the Honua'ula Project Site

Well		Averaged Data, 1991 to 2009								
Wailea Number	State Number	NO_3 (µM)	NH_4 (µM)	DON (µM)	TN (µM)	PO_4 (µM)	DOP (µM)	TP (µM)	Silica (µM)	Salinity (PPT)
2	4126-02	238	1.32	7.89	248	1.66	0.66	2.32	450	1.43
3	4126-03	236	1.71	16.63	254	2.16	0.62	2.77	569	1.22
4	4026-04	196	1.31	10.42	208	2.08	0.32	2.40	580	1.64
6 A	4026-07	174	2.00	25.16	201	2.13	0.54	2.67	538	1.40
7	4026-06	332	1.42	11.60	345	2.27	0.51	2.79	550	1.81
Average of the Five Wells		235	1.55	14.34	251	2.06	0.53	2.59	538	1.50

Notes:
1. Data from Marine Research Consultants based on annual sampling from 1991 to 2009.
2. The units of µM can be converted to milligrams per liter by multiplying by the atomic weight and dividing by 1000.
3. DON and TN are dissolved organic nitrogen and total nitrogen, respectively.
4. Similarly, DOP and TP are total dissolved phosphorus and total phosphorus, respectively.

Table 4

Wells in the Downgradient Area Potentially
Impacted by the Honua'ula Project's Offsite Kamaole Wells
(Information From the Files of the State CWRM)

State Well No.	Year Drilled	Casing Diameter (Inches)	Ground Elevation (Feet MSL)	Well Depth (Feet)	Current Use
4226-06	1949	6	?	59	None
4226-10	1951	8	?	63	None
4226-11	1956	10	?	157	?
4226-15	1999	6	77	105	Landscape Irrigation
4226-17	2002	6	52	59	Landscape Irrigation
4326-02	1946	8	?	23	None
4326-03	1947	8	?	34	None
4326-04	1948	7	?	103	None
4326-05	1955	8	?	47	None
4326-06	1949	8	75	110	None (Lost)
4326-07	1990	6	64	84	?
4326-09	2001	6	64	95	Landscape Irrigation
4326-11	2004	6	80	95	Landscape Irrigation
4326-12	2004	6	83	100	Landscape Irrigation
4327-01	1947	8	?	38	None
4327-02	1947	10	?	37	None
4327-04	1949	8	?	22	None
4327-05	1949	8	?	38	?
4327-06	1967	?	?	45	None
4327-07	2000	6	56	80	Landscape Irrigation

these wells are more than 50 years old and are no longer in use. However, at least six are relatively recent (installed since the 1990s) and were developed to provide landscape irrigation for condominium parcels. The total draft of these wells is likely to be in the range of 0.12 to 0.30 MGD as a year-round average.

Potential Impacts to Groundwater Downgradient of the Honua'ula Project Site

Table 5 is a compilation of the potential year-round average changes to groundwater flowrate, salinity, and nitrogen and phosphorus loading downgradient of the project after full build-out. In addition to the data and calculations presented previously, the following assumptions are incorporated into the results compiled in Table 5:

- Of the 1.7 MGD average draft from the project's wells at full development, about 25 percent or 0.43 MGD would be supplied by the two existing onsite wells (Nos. 4125-01 and -02).

- Of the site's 18 inches of average annual rainfall, the pre- and post-development portion percolating to groundwater will be essentially the same. For this analysis, it is assumed that this amounts to one-third of the rainfall amount (the remaining two-thirds will evaporate to atmosphere or become runoff). In comparison to pre-development conditions, the post-development portion percolating to groundwater will have increases of nitrogen and phosphorus of 20 and 2.0 µM, respectively.

- For all of the sources of supply used to irrigate the golf course and other landscaped areas, the portion percolating through the root zone will have a salinity increase of 10 percent and a 50 percent reduction of their nitrogen and phosphorus concentrations as a result of plant uptake and processes in the soil.

- The R-1 WWTP effluent reused for golf course irrigation will have 775 µM (10.85 mg/l) nitrogen and 165 µM (2.00 mg/l) phosphorus.

- On a long term basis, it is assumed that the salinity of the combined brackish well water supply is 0.95 PPT. With a 65 percent product recovery rate, the salinity of the remaining 35 percent, the concentrate for irrigation reuse on the golf course, will be 2.41 PPT.

- Essentially all of the nitrogen and phosphorus in the brackish water that is run through the RO treatment process will be contained in the 35 percent of the feedwater that becomes RO concentrate and is reused for golf course irrigation.

Table 5

Compilation of Potential Changes to Groundwater in the
Area Downgradient of the Honua'ula Project Site After Full Build-Out

Component of Flow	Flowrate (MGD)	Salinity (PPT)	Nitrogen (lbs / day)	Phosphorus (lbs / day)
Pre-Development Groundwater	7.8	1.00	228.3	5.217
Withdrawal by Onsite Well Nos. 4125-01 and -02	0.43	0.95	12.59	0.288
Percolation From the Project Site to Groundwater				
- Percolating Rainfall	No Change	No Change	0.14	0.0077
- Percolation From the Golf Course				
- RO Concentrate	0.0203	2.651	0.170	0.0010
- WWTP Effluent	0.0274	0.440	0.248	0.0114
- Brackish Water	0.0240	1.045	0.070	0.0004
- Applied Fertilizer Dissolved in Percolate	--	--	0.788	0.0066
- Percolation From Other Landscaped Areas				
- Brackish Water	0.1336	1.045	0.391	0.0022
- Applied Fertilizer Dissolved in Percolate	--	--	0.981	0.0082
Post-Development Groundwater				
- Amounts	7.5753	1.0062	218.498	4.9665
- Change Compared to Pre-Development Flowrate	- 2.9%	+ 0.62%	- 4.3%	- 4.8%

- Fertilizer applications in landscaped areas will be at three pounds per 1000 square feet per year for nitrogen and at 0.5 pounds per 1000 square feet per year for phosphorus. Of these applications, 10 percent of the applied nitrogen and 2 percent of the applied phosphorus will be carried in percolate below the root zone.

- In the hundreds of feet of travel by the percolate through the vadose zone (the unsaturated lavas between the ground surface and groundwater) and the thousands of feet of travel with groundwater to discharge at the shoreline, natural processes will remove 80 percent of dissolved nitrogen and 95 percent of dissolved phosphorus. These removal rates are based on the natural removal rates of the Kealakehe WWTP effluent which is disposed of in a shallow pit upgradient of Honokohau Harbor in Kona on the Big Island. At that location, vertical travel through the vadose zone is only about 50 feet and the movement in groundwater to discharge into the upper end of the harbor is about 3500 feet.

As shown on Table 5, the computed changes to groundwater are as follows: a 2.9 percent reduction in flowrate; a 0.6 percent increase in salinity; a reduction in nitrogen loading of 4.3 percent; and a reduction in phosphorus of 4.8 percent. The largest factor contributing to these results is that most of the groundwater supply (about 75 percent) will come from the offsite Kamaole wells. These calculations indicate that, with the possible exception of a salinity increase in Wailea Resort's Well 2 (No. 4126-02) which is downgradient of Honua'ula's two onsite wells, development of the project will not impair Wailea Resort's golf course irrigation.

Potential Impacts to Groundwater Downgradient of the Offsite Kamaole Wells

About 75 percent or 1.28 MGD of the project's brackish supply will be provided by the project's four (or five) offsite Kamaole wells. As indicated previously, the downgradient area that may be impacted by this pumping is a 1.4-mile long coastal segment with a pre-development groundwater flowrate that may have been on the order of 4.8 MGD. Pumpage of the project's Kamaole wells would reduce this flowrate by about 27 percent. Some salinity increase in the downgradient wells as a result of this flowrate reduction is almost certain to occur, particularly in those wells which are closest to the shoreline.

Figure 3 was created to provide an approximation of salinity increases in the six active wells. Static water levels and salinity data for these wells, as on file with the CWRM, are plotted on the graph and a curve fitted to these data was created. The groundwater level reduction can be expected to vary with the square root of the flowrate, meaning that a 27 percent reduction in flow is likely to create a 15 percent drop in static water levels. If the static level-to-salinity relationship remains as defined by the fitted curve on Figure 3, projected salinity increases may be on the order of five percent. If the actual impact impairs the utility of the downgradient landscape irrigation wells, additional Kamaole wells to distribute the draft over a greater area would alleviate this.

Figure 3. Relationship of Static Water Level to Pumped Water Salinity in Active Wells Downgradient of the Honua'ula Project's Kamaole Wells