APPENDIX I

Assessment of the Potential Impacts on Groundwater Resources

Assessment of the Potential Impact on Groundwater Resources of the Proposed Expansion of the Maui Research and Technology Park in Kihei, Maui

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March 2012

Table of Contents

List of Figures

List of Tables

Introduction

This report presents an assessment of the potential impact on groundwater resources of the proposed expansion of the Maui Research and Technology Park (MRTP). The plan of the MRTP expansion is shown on Figure 1. The presently developed portion of the Employment Core obtains its water supply from the Maui County Department of Water Supply (DWS). The DWS system is the preferred source of supply for the proposed MRTP expansion. However, due to its current source limitations, DWS can only commit to supplying the existing and planned portion of the Employment Core outlined in red on Figure 1. As an alternative to supply by DWS, MRTP has proposed a privately owned and operated system to supply the remainder of the Employment Core and the other four development areas.

Proposed Sources of Supply

In order to limit the potable supply required for the MRTP expansion that will not be supplied by DWS, a private dual system is proposed. Potable water will be supplied using brackish groundwater treated to potable quality by reverse osmosis (RO) filtration. Most of the non-potable water for irrigation use will be wastewater treated to R-1 quality at the County's Kihei Wastewater Treatment Plant (WWTP). This R-1 supply would be supplemented by (untreated) brackish groundwater when needed.

Projected Water Supply Requirements

Projected water supply requirements for the private dual system were compiled using Maui DWS unit use rate design criteria and splitting these amounts into potable and non-potable use components using the dual system guidelines prepared by the Honolulu Board of Water Supply. These results are presented for the project's two development phases on Tables 1 and 2. A summary of these compilations is also provided below. About 68 percent of the total required supply would be potable and the remaining 32 percent would be non-potable for irrigation use.

Summary of the Average Potable and Non-Potable Irrigation Requirements for the Portion of the MRTP Expansion Not Supplied by DWS

Phase	Developed Area	Average Demands (GPD)	
		Potable	Non-Potable Irrigation
1	Employment Core	18,877	19,609
	Village Center	225,743	114,854
	Makai Residential	211,260	25,660
	Retention	--	9,632
	Total for Phase 1	455,880	169,755
2	Knowledge Exp / Campus	40,084	59,460
	Option Land	302,101	144,114
	Total for Phase 2	342,185	203,574
Totals for Both Phases		798,065	373,329

Figure 1
Planned Expansion of the Maui Research and Technology Park

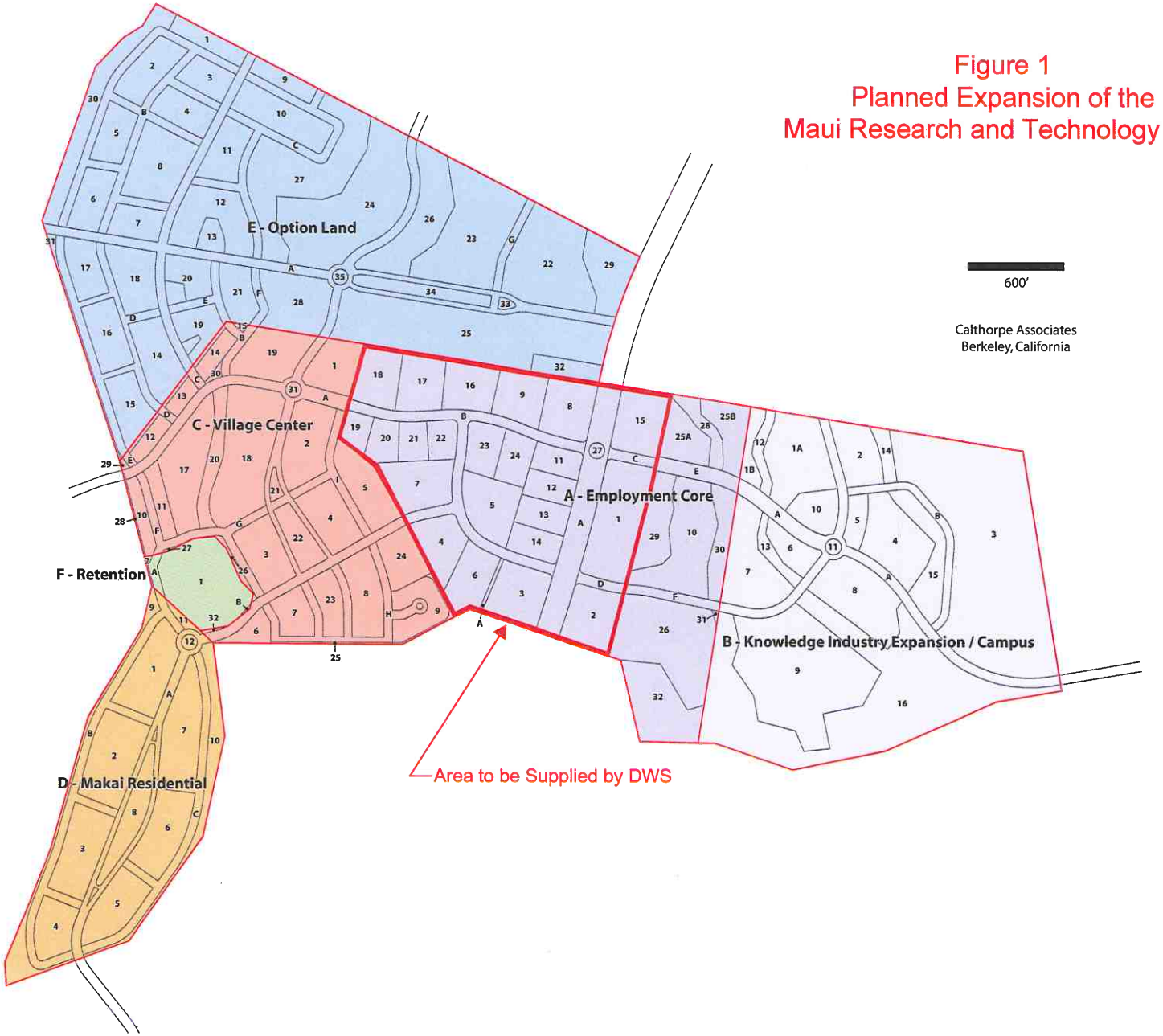


Table 1

Projections of Required Potable and Irrigation Supply for
Phase 1 of the Expansion of the Maui Research and Technology Park

Development Area	Land Use	Area		Number of Units	Potable		Non-Potable	
		Acres	Ft^2		Unit Use Rate (GPD / Unit)	Amount (GPD)	Unit Use Rate (GPD / Unit)	Amount (GPD)
Employment Core (Portion Not Supplied by DWS)	Employment	15.7	224,730	--	84 / 1000 Ft^2	18,877	56 / 1000 Ft^2	12,585
	Open Space (PI)	3.2	--	--	--	--	1700 / Ac.	5,440
	Roads	1.8	--	--	--	--	880 / Ac.	1,584
	Totals	20.7	224,730	0	--	18,877	--	19,609
Village Center	Hotel	2.1	60,000	150	203 / Unit	30,450	147 / Unit	22,050
	Mixed Use	8.9	109,200	--	84 / 1000 Ft^2	9,173	56 / 1000 Ft^2	6,115
	SF Residential	11.1	--	100	6000 / Unit	60,000	--	--
	MF Residential	9.9	--	300	386 / Unit	115,800	174 / Unit	52,200
	Civic	10.1	100,000	--	84 / 1000 Ft^2	8,400	56 / 1000 Ft^2	5,600
	Park	3.2	--	--	600 / Acre	1,920	3400 / Ac.	10,880
	Open Space (FI)	0.4	--	--	--	--	3400 / Ac.	1,360
	Open Space (PI)	0.75	--	--	--	--	1700 / Ac.	1,275
	Retention (PI)	1.9	--	--	--	--	1700 / Ac.	3,230
	Roads	13.8	--	--	--	--	880 / Ac.	12,144
	Totals	62.15	269,200	550	--	225,743	--	114,854
Makai Residential	SF Residential	21.0	--	350	600 / Unit	210,000	--	--
	Park	2.1	--	--	600 / Acre	1,260	3400 / Ac.	7,140
	Open Space (FI)	0.2	--	--	--	--	3400 / Ac.	680
	Open Space (PI)	4.8	--	--	--	--	1700 / Ac.	8,160
	Roads	11.0	--	--	--	--	880 / Ac.	9,680
	Totals	39.1	0	350	--	211,260	--	25,660
Drainage Retention	Open Space (PI)	5.5	--	--	--	--	1700 / Ac.	9,350
	Roads	0.32	--	--	--	--	880 / Ac.	282
	Totals	5.82	0	0				9,632
Totals for Phase 1		127.8	493,930	900		455,880		169,755

Table 2

Projections of Required Potable and Irrigation Supply for
Phase 2 of the Expansion of the Maui Research and Technology Park

Development Area	Land Use	Area		Number of Units	Potable		Non-Potable	
		Acres	Ft^2		Unit Use Rate (GPD / Unit)	Amount (GPD)	Unit Use Rate (GPD / Unit)	Amount (GPD)
Knowledge Industry Expansion Campus	Employment	40.9	188,272	--	84 / 1000 Ft^2	15,815	56 / 1000 Ft^2	10,543
	Mixed Use / Flex	2.2	33,200	--	84 / 1000 Ft^2	2,789	56 / 1000 Ft^2	1,859
	Employment (Reserve)	11.4	--	--	1800 / Ac.	20,520	1200 / Ac.	13,680
	Park	1.6	--	--	600 / Ac.	960	3400 / Ac.	5,440
	Traffic Circle (FI)	0.2	--	--	--	--	3400 / Ac.	680
	Open Space (PI)	12.1	--	--	--	--	1700 / Ac.	20,570
	Roads	7.6	--	--	--	--	880 / Ac.	6,688
	Totals	76.0	221,472	0	--	40,084	--	59,460
Option Land	SF Residential	28.6	--	300	600 / Unit	180,000	--	--
	MF Residential	5.9	--	179	386 / Unit	69,094	174 / Unit	31,146
	Employment	26.5	403,718	--	84 / 1000 Ft^2	33,867	56 / 1000 Ft^2	22,578
	Employment (Reserve)	8.0	--	--	1800 / Ac.	14,400	1200 / Ac.	9,600
	Parks	7.9	--	--	600 / Ac.	4,740	3400 / Ac.	26,860
	Traffic Circle (FI)	0.2	--	--	--	--	3400 / Ac.	680
	Open Space (PI)	18.9	--	--	--	--	1700 / Ac.	32,130
	Roads	24.0	--	--	--	--	880 / Ac.	21,120
	Totals	120.0	403,718	479	--	302,101	--	144,114
Totals for Phase 2		196.0	625,190	479		342,185		203,574

Description of the Potable Supply Alternatives

Two alternatives for brackish well development to feed the RO treatment plant are being considered. One is an array of five wells (one as standby) at 580-foot elevation on land inland of the MRTP site owned by Haleakala Ranch. It should be noted that implementation of this alternative would require an agreement with Haleakala Ranch. At present, no such agreement has been reached. The other alternative is an array of five wells at lower elevation and within the MRTP development site. Each of these alternatives is described below.

Brackish Wells at 580-Foot Elevation. Infrastructure for this alternative is shown schematically and as it would be located in the field on Figures 2 and 3. Based on results of the nearby Maui Highlands wells (State Nos. 4424-01 and 4425-01), chlorides from these wells are likely to be on the order of 350 to 400 milligrams per liter (mg/l). For this salinity level, the RO product recovery is expected to be about two-thirds of the brackish supply. The remaining third would be the RO concentrate which would be disposed of in downgradient disposal wells.

The number of wells and their pump capacities have been sized to provide the maximum day requirement (defined as 1.5 times the average amounts in Tables 1 and 2) with one well as standby. For the two-thirds product recovery rates, this translates to an ultimate requirement of five wells, each with a 360 GPM pump capacity. A 240 GPM RO treatment train would be matched to each well pump, including the standby well pump.

Onsite Brackish Wells. The option to put the brackish RO feedwater supply wells onsite is illustrated on Figures 4 and 5. At this lower elevation, the well water salinity will be higher (chlorides of 500 to 600 mg/l), resulting in a lower, 60 percent RO product recovery rate. To provide the required supply, capacities of all five well pumps would be 400 GPM, each matched to a 240 GPM RO treatment train.

Description of the Non-Potable Irrigation System

The required maximum day irrigation supply capacity is projected to be 0.1698 MGD (118 GPM) at the end of Phase 1 and 0.3733 MGD (260 GPM) at the completion of both development phases. The primary source of supply will be R-1 reclaimed wastewater from the Kihei WWTP delivered as shown on Figures 2 through 5. The project's wastewater will be delivered to this WWTP for treatment. Even with this addition, an adequate R-1 supply from the County can not be assured, particularly during extended dry periods of maximum irrigation use. When an R-1 shortfall occurs, the standby brackish supply well would provide the needed supplemental supply for the non-potable system.

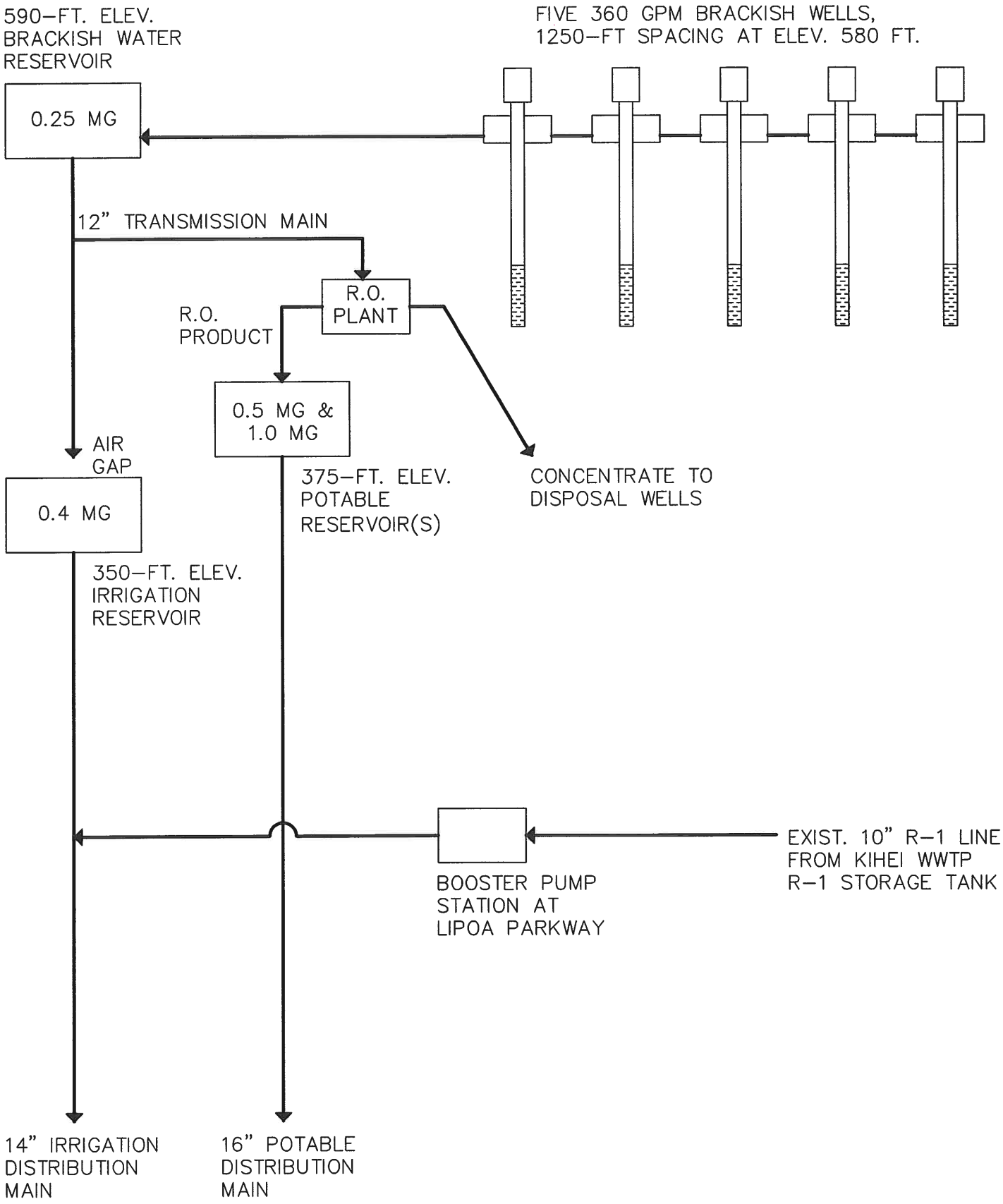
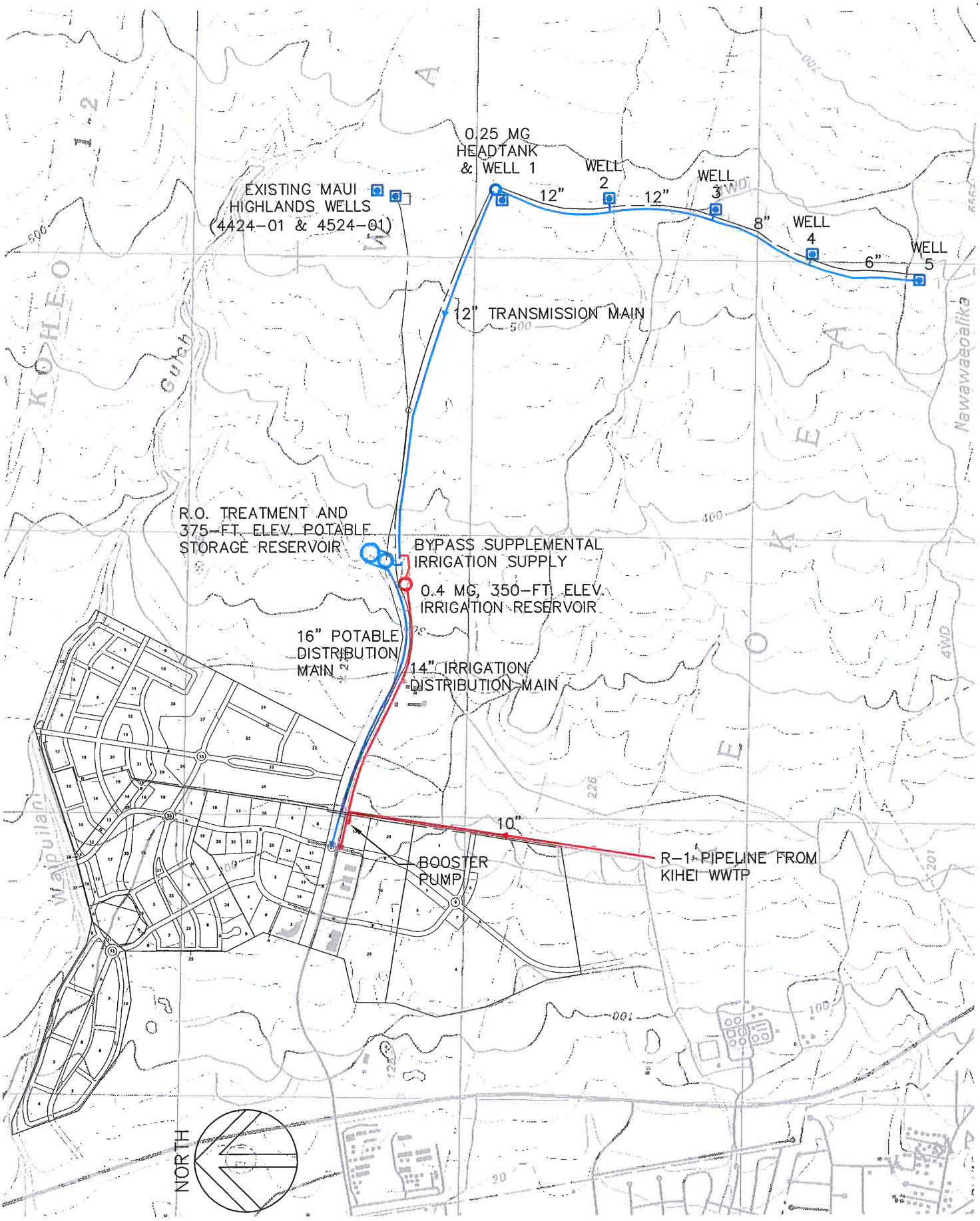


FIGURE 2
SCHEMATIC OF THE OFFSITE BRACKISH WELLS ALTERNATIVE



GRAPHIC SCALE:

1500' 750' 0 1500' 3000'

FIGURE 3

LAYOUT OF THE ALTERNATIVE WITH OFFSITE BRACKISH WELLS

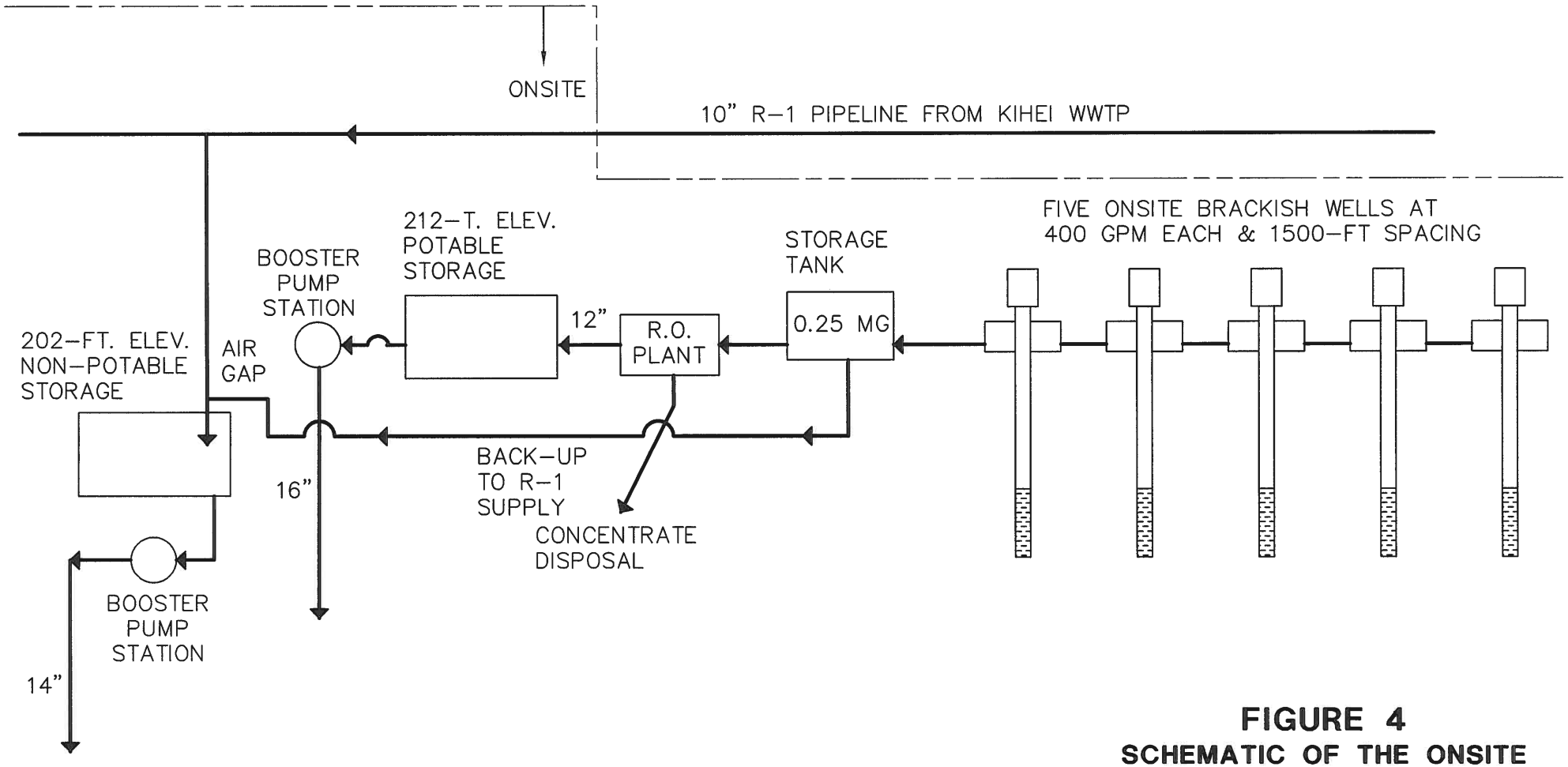
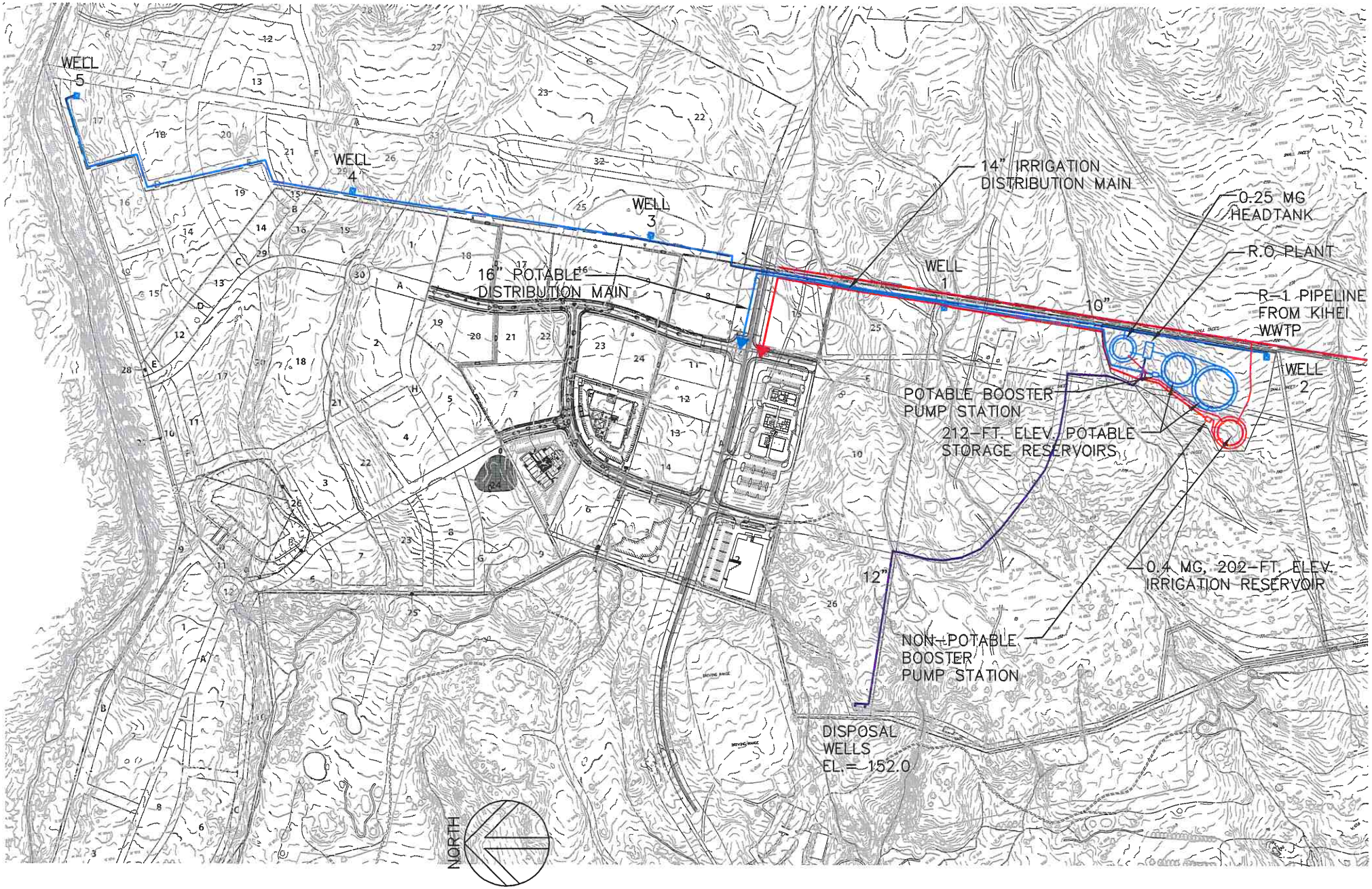


FIGURE 4
SCHEMATIC OF THE ONSITE WELLS ALTERNATIVE



GRAPHIC SCALE:

800' 400' 0 800' 1600'

FIGURE 5
LAYOUT OF THE ALTERNATIVE WITH ONSITE WELLS

Potential Changes in the Groundwater Flowrate

Aspects of the project's development that will impact the underlying groundwater resource will consist of: withdrawal of brackish groundwater for RO treatment for potable use; disposal of the RO concentrate in downgradient disposal wells; withdrawal of brackish groundwater to supplement the R-1 irrigation supply; percolation of excess applied irrigation in landscaped areas; and the change in quantity and/or quality of onsite rainfall recharge. These aspects are described and quantified as year-round average amounts in the sections following.

Present Groundwater Flowrate Beneath the Project Site. Groundwater beneath the project site occurs as a brackish basal lens overlying saline groundwater at depth and in hydraulic contact with seawater offshore. This groundwater body has been named as the Kamaole Aquifer by the State Commission on Water Resource Management (CWRM). The most recent, detailed, and therefore reliable estimate of this aquifer's rate of recharge and resulting groundwater flowrate is in U.S. Geological Survey Scientific Investigations Report 2007-5103 (Engott & Vana, 2007). It puts the aquifer's total recharge at about 37 MGD, equivalent to an average of about 3.4 MGD per coastal mile of the aquifer. Present pumpage in the aquifer is on the order of four to five MGD, most of it occurring for golf course irrigation in the Wailea-Makena area to the south and unlikely to significantly influence the rate of flow beneath the MRTP site. Relative to the potentially impacted, mauka-to-makai corridor of groundwater flowrate, the alternative with offsite wells will impact a 1.9-mile wide corridor, beneath which the groundwater flowrate is on the order of 6.5 MGD. The alternative with onsite wells would impact a narrower, 1.5-mile wide corridor with an estimated 5.1 MGD of underlying groundwater flowrate.

Design Criteria Versus Actual Water Use. Projected water supply requirements compiled in Tables 1 and 2 are design numbers which are used to size water system infrastructure components. If compiled appropriately, these design amounts are typically somewhat greater than actual water use. However, for the purposes of this assessment, it is assumed that actual water use is exactly equal to the required supply amounts in Tables 1 and 2.

Water Use in the DWS-Supplied Portion of the Employment Core. The DWS-supplied portion of the Employment Core will ultimately consist of 671.000 square feet of employment floor area, 11 acres of roads, and a 0.2-acre traffic circle. Using DWS design criteria for the Employment Core, the amount supplied by DWS would ultimately amount to 93,940 GPD. Using the non-potable system to irrigate the roads and traffic circle, this supply would ultimately amount to 10,360 GPD.

R-1 and Brackish Groundwater Supply for the Non-Potable Irrigation System. As indicated previously, the County cannot commit to being able to supply the MRTP expansion's entire non-potable supply with R-1 reclaimed wastewater from its Kihei WWTP. For the purposes of this assessment, it is

assumed that two-thirds of the non-potable supply is R-1 wastewater and the other third is brackish groundwater.

Irrigation Return. A portion of the water used for landscape irrigation will percolate below the plant root zone and ultimately reach the underlying groundwater. For the purpose of this assessment, it is assumed that the fraction reaching groundwater is 10 percent of the applied irrigation.

Onsite Rainfall Recharge. Average annual rainfall over the project site is about 12 inches. As a first order approximation, about one-third of this, equivalent to a relatively modest 0.12 MGD over the 400-acre project site, becomes groundwater recharge. Development will create impervious surfaces which will locally increase runoff. However, County Storm Drainage Standards require the installation of retention/detention basins so that peak runoff rates from the property are not increased due to development. Retention/detention storage designed for this purpose will do an excellent job of retaining essentially all runoff from lesser rainfall occurrences. Given this fact and the modest amount of present rainfall recharge, a reasonable approximation for this assessment is that the change in onsite rainfall recharge due to the development will be negligible.

Resulting Change in the Groundwater Flowrate Beneath the Project Site. Based on the foregoing, an estimate of the change of the groundwater flowrate beneath the project site due to its development is presented on Table 3. Calculations are presented for the two well development alternatives being considered, an array of wells offsite at 580-foot elevation and an array of wells within the project site. The resulting reductions in groundwater flowrate are relatively significant. For the offsite wells impacting a wider mauka-makai corridor, the estimated average flowrate reduction is 13.6 percent. Over the narrower corridor of the onsite wells alternative, the estimated reduction is 17.3 percent.

Potential Changes in Groundwater Quality

Changes to the groundwater flowrate, both as drafts from wells and returns by various processes, will also remove and add nutrients (nitrogen and phosphorus) which will ultimately discharge into the marine environment. To estimate these nutrient loading changes to the marine environment, the following assumptions have been made:

- Based on results of the nearby Maui Highlands wells and others, groundwater pumped by wells in either well field will have concentrations of 1.1 mg/l as nitrogen and 0.06 mg/l as phosphorus.
- The RO process will remove essentially all of the nitrogen and phosphorus from the feedwater supply and put it into the concentrate delivered to the disposal wells.
- R-1 reclaimed wastewater from the Kihei WWTP will have concentrations of 15 mg/l as nitrogen and 5 mg/l as phosphorus.

Table 3

Estimated Changes in the Groundwater Flowrate
Due to the Maui Research and Technology Park Expansion

Component of Groundwater Withdrawal and Return	Well Alternatives	
	580-Foot Elevation (MGD)	Onsite (MGD)
Pre-Development Groundwater Flowrate	6.5	5.1
Drafts From Groundwater by Wells		
RO Feedwater Supply	1.1971	1.3302
Supplement to the Non-Potable Supply	0.1279	0.1279
Total Draft of Groundwater	1.3250	1.4581
Returns to Groundwater by Various Processes		
RO Concentrate into Disposal Wells	0.3990	0.5321
Irrigation Return (10% of Applied)		
Originating as R-1 Effluent	0.0256	0.0256
Groundwater Supplement to N-P System	0.0128	0.0128
Employment Core Supplied by DWS	0.0038	0.0038
Total Return to Groundwater	0.4412	0.5743
Post-Development Groundwater Flowrate : Amount	5.6162	4.2162
: % Decrease	13.6	17.3

- While the amount of post-development rainfall recharge will be essentially the same as pre-development, it will have increases of nitrogen and phosphorus amounting to 0.3 and 0.06 mg/l, respectively.

- Fertilizer applications in landscaped areas will average three pounds per 1000 ft^2 per year of nitrogen and 0.5 pounds per year of phosphorus. Of these applied amounts, 10 percent of the nitrogen and two percent of the phosphorus will be carried with the excess applied irrigation water below the root zone.

- For all water percolating to the groundwater below, natural processes similar to a trickling filter will remove 80 percent of the dissolved nitrogen and 95 percent of the dissolved phosphorus. These removal rates are actually less than the natural removal rates occurring to the Kealakehe WWTP effluent which is disposed of in a shallow pit and ultimately enters the marine environment at the inland end 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. At MRTP, the drop through the vadose zone and the travel distance to shoreline discharge are substantially greater.

Based on the foregoing set of assumptions, Table 4 presents a compilation of changes to the amount of nitrogen and phosphorus carried by groundwater into the marine environment. For either of the well supply alternatives, the estimated increases of nitrogen and phosphorus are less than one percent.

Potential Impacts to Downgradient Users of the Groundwater Resource

In the area downgradient of the MRTP expansion's wells and development area (the corridor from Kihei Beach Park on the north to Kaloma Park on the south), there are 24 existing wells. Available information on these wells from the files of the CWRM is compiled in Table 5. Blanks in the table indicate items of information that are not on file with the CWRM. Many of the wells or more than 60 years old and obviously no longer in use. Several were drilled as test holes for observation and are not used for supply. However, none of the well owners or operators, even for the more recently drilled wells, reports their water use to the CWRM as required by their permits.

In the absence of information on actual use, it has been concluded that only the four wells that are shaded on Table 5 are actively used. For three of the wells (Nos. 4427-09, 14, and 16), their use amounts have been estimated assuming that 50 percent of their TMK gross areas are irrigated landscaping and that the irrigation averages 3000 GPD/acre as a year-round average. For the fourth well (No. 4427-08), it is assumed that its 40 GPM pump operates an average of six hours a day as a year-round average. For these assumptions, the combined average use of these four wells is approximated to be 40,000 GPD.

Table 4

Estimated Changes to the Nitrogen and Phosphorus in Groundwater
Discharged into the Marine Environment

Component of Flow	Wells at 580-Foot Elevation			Onsite Wells		
	Flowrate (MGD)	Nitrogen (lbs / day)	Phosphorus (lbs / day)	Flowrate (MGD)	Nitrogen (lbs / day)	Phosphorus (lbs / day)
Pre-Development Groundwater Flow	6.5	55.044	3.002	5.1	45.188	2.355
Drafts From Groundwater						
• As RO Feedwater	1.1971	10.982	0.599	1.3302	12.203	0.666
• To Supplement Non-Potable Irrigation	0.1279	1.173	0.064	0.1279	1.173	0.064
Total Draft From Groundwater	1.3250	12.155	0.663	1.458	13.376	0.730
Direct Delivery Back to Groundwater as RO Concentrate	0.3990	10.982	0.599	0.5321	12.203	0.666
Percolation of Excess Landscape Irrigation Back to Groundwater						
• Supplied as R-1 Effluent	0.0256	1.179	0.058	0.0256	1.179	0.058
• Supplied as Brackish Groundwater	0.0128	0.293	0.003	0.0128	0.293	0.003
• Supplied by DWS	0.0038	0.087	0.001	0.0038	0.087	0.001
Total Irrigation Return	0.0422	1.559	0.062	0.0422	1.559	0.062
On-Site Rainfall Recharge	No Change	0.060	0.003	No Change	0.060	0.003
Post Development : Amount	5.6162	55.490	3.003	4.2162	45.574	2.356
: Percent Change	- 13.6%	+ 0.8%	+ 0.03%	- 17.3%	+ 0.9%	+ 0.04%

Table 5

Listing of the 24 Downgradient Wells that May be
Impacted by the Maui Research and Technology Park Expansion

State Well No.	Well Name	Year Drilled	Casing Diameter (In.)	Ground Elevation (Feet MSL)	Total Depth (Feet)	Static Water Level (Feet MSL)	Chlorides (MG/L)	Drawdown @ GPM (Feet @ GPM)	Installed Pump Capacity (GPM)	Indicated Use
4426-01	Kihei Injection TH	1972	2		203					Unused
4426-02	Kihei Injection	1974	18	109	230	4.0		4.2 @ 2200		Disposal (?)
4426-03	Kihei MRTP	1990	8	124	157	1.9	370	0.0 @ 30		Unused
4427-01	TMK 3-9-05:52									Irrigation
4427-02	TMK 3-2-02:08	1945	8		30		575	? @ 16		Unused
4427-03	Medo	1948	10		22					Unused
4427-04	TMK 3-9-11:38	1949	8		24					Irrigation
4427-05	TMK 3-9-02:02	1950	8		82					Unused
4427-06	Kihei Fire B1	2009	2		16					Observation
4427-07	Kihei Fire B2	2009	2		40					Observation
4427-08	Kihei Fire B3	2009	2		70					Observation
4427-09	Kihei Baptist Chapel	1978	20		15					Irrigation
4527-01	TMK 3-9-02:36	1945	6		30			2 @ 250	120	Not Known
4527-02	TMK 3-9-02:32	1946	8		35		522	? @ 20		Not Known
4527-03	TMK 3-9-01:02	1947	8		20					Unused
4527-04	TMK 3-9-08: ?	1948	7		47					Unused
4527-05	TMK 3-9-08: ?	1948			70					Unused
4527-06	TMK-3-9-01:09	1948	6		28		540			Not Known
4527-07	TMK 3-9-23:30	1949	8		42					Unused
4527-08	Kihei - Piilani	1990	10	41	71	0.8	420	0.3 @ 25	40	Irrigation
4527-12	Waiohuli 1	1989	60		20					Abandon / Sealed
4527-14	Kauhale Makai	2001	6	9	86	1.7	2900	5.8 @ 100	150	Irrigation
4527-16	St. Theresa Church	2007	6		45		300		60	Irrigation
4527-17	Kihei		66		11					Unused

Notes: 1. Information from the files of the State Commission on Water Resource Management (CWRM). Blank spaces indicate that the information is not in the CWRM files.
2. Wells that may still be in use are shaded.

In this mauka/makai corridor of potential impact, the groundwater flowrate is about 6.5 MGD. Discounting the project's return of RO concentrate which will be delivered into the transition zone below the basal lens, the project's net draft of groundwater from the "usable" portion of the basal lens would be 1.28 MGD for the offsite wells alternative and 1.42 MGD for the onsite wells (refer back to Table 3). Using the higher number and adding the 40,000 GPD in downgradient wells results in a total draft of 1.46 MGD or about 22 percent of the groundwater flowrate in this mauka/makai corridor.

For a thin basal lens such as exists in this area, the CWRM sets the sustainable yield at 44 percent of the groundwater flowrate. By that measure, the MRTP expansion's use of groundwater would be well within the CWRM's definition of the sustainable supply. Even if a more conservative 33 percent as the sustainable supply, the prospective use of groundwater should be sustainable. However, the active downgradient wells are in nearshore locations where some salinity increase to their pumped water as a result of pumpage of the MRTP's proposed wells is likely to occur. Based on experience elsewhere, that expectable salinity increase may be on the order of 10 percent.