TRAFFIC IMPACT ANALYSIS REPORT

Waikoloa Highlands Subdivision

Waikoloa, South Kohala, Hawaii

January 2007

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Exhibit "36"

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Introduction

The proposed Waikoloa Highlands project will include the subdivision of approximately 732 acres to create approximately 400 one-acre residential lots (portions of the site will remain vacant). The project is located southeast of the intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue and will be developed in two phases. This report summarizes the findings of a traffic study of the potential impacts of the entire project. The project location and the vicinity are shown in Figure 1.

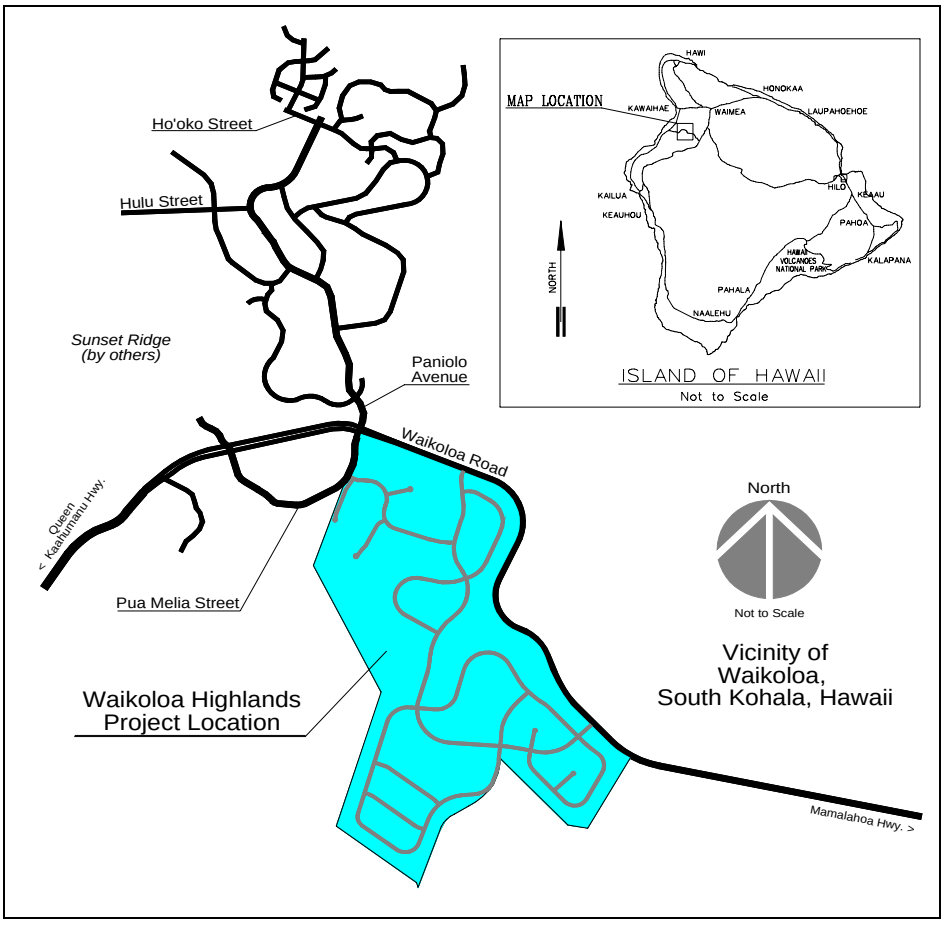

Figure 1 – Project Location

The project will provide a new traffic signal system to control vehicular and pedestrian movements at the intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue, as conditioned by the zoning approval for the project. The preliminary subdivision layout proposes that three street connections provide vehicular access into the project. One project street will intersect with Pua Melia Street at a new "T"-intersection south of its intersection with Waikoloa Road; another project street will intersect with Waikoloa Road at two locations, at each location as the south leg of a new "T"-intersection. Future conditions at each of these new intersections, as well as the intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue were determined. In addition, the project impact to Waikoloa Road to the west and to the east were identified and compared with growth that would otherwise be expected on Waikoloa Road.

The analyses were based on the concepts and the procedures for two-lane highways and for signalized and unsignalized intersections described in the *Highway Capacity Manual*. For two-lane highways, the level of service is determined based on potential delays due to the inability to pass a slow-moving vehicle.

At intersections, the *Highway Capacity Manual* defines "Levels of Service" using average delays. The analytical procedure computes intersection capacity based on intersection layout and other traffic characteristics, and traffic signal operation parameters at signalized intersections; average delays are also computed and used to identify the Levels of Service for each approach. An overall average delay is computed and an overall Level of Service for the intersection is determined for signalized intersections. Level of Service C is desirable, and Level of Service D is considered acceptable for urban conditions. Criteria for levels of service are:

	Average delay per vehicle (seconds)					
Level of Service	A	B	C	D	E	F
Signalized intersection	≤ 10	> 10 and ≤ 20	> 20 and ≤ 35	> 35 and ≤ 55	> 55 and ≤ 80	> 80
Unsignalized intersection	≤ 10	> 10 and ≤ 15	> 15 and ≤ 25	> 25 and ≤ 35	> 35 and ≤ 55	> 55
Reference: *Highway Capacity Manual 2000*						

Existing (2005) Traffic

Manual counts taken in the field during weekday morning and afternoon peak periods in October 2005 were used to represent existing AM Peak Hour and PM Peak Hour traffic volumes at the Waikoloa Road intersection with Pua Melia Street and Paniolo Avenue. The field data are summarized in the attached appendix. Existing lane arrangements and peak hour traffic volumes at these intersections are shown in Figure 2.

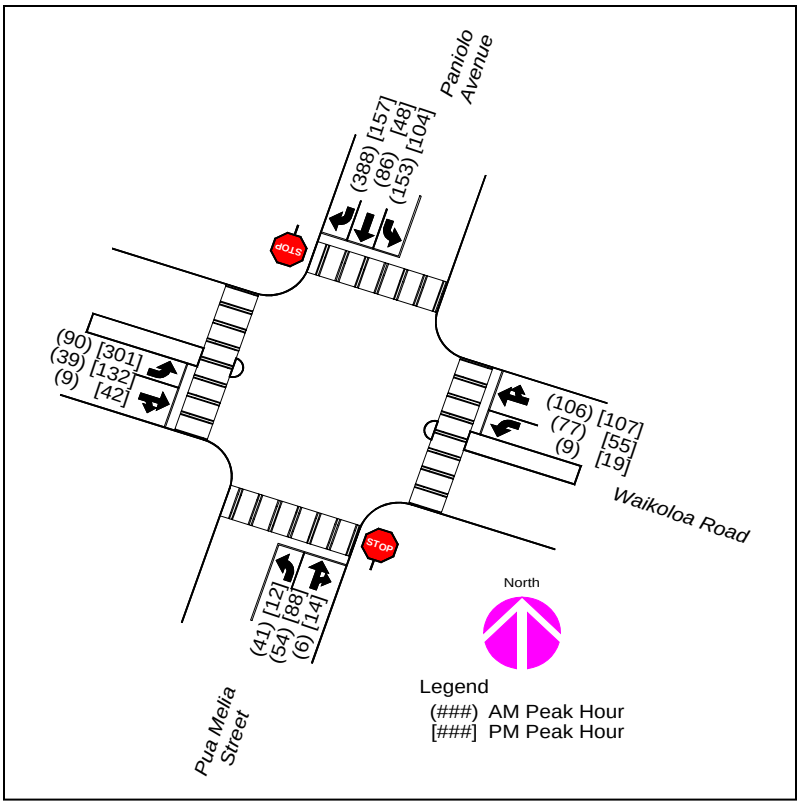

Figure 2 – Existing (2005) Peak Hour Traffic at Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

Stop signs control traffic on the Paniolo Avenue southbound approach and the Pua Melia Street northbound approach. Through traffic on Waikoloa Road have the right-of-way at this unsignalized intersection. Left turns from Waikoloa Road yield to opposing traffic, and a median is provided to separate opposing taffic on Waikoloa Road. There is sufficient capacity to serve even peak hour volumes, although left turns experience some long delays. Queues of up to four vehicles form in the southbound and northbound left turn lanes during

short periods within each the peak hour. The results of the analyses, shown in Table 1, correspond with conditions observed in the field.

Table 1 – Existing Conditions – Unsignalized Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

	AM Peak Hour			PM Peak Hour		
	v/c	AD	LOS	v/c	AD	LOS
Left turns from Waikoloa Road (yields)						
Westbound	0.01	7.4	A	0.02	7.7	A
Eastbound	0.08	8.0	A	0.24	8.5	A
Stopped southbound approach (Paniolo Avenue)						
Left turn lane	0.35	15.6	C	0.86	106.7	F
Through lane	0.18	13.0	B	0.22	24.0	C
Right turn lane	0.53	13.9	B	0.20	10.0	B
Approach (average)		14.2	B		44.7	E
Stopped northbound approach (Pua Melia Street)						
Left turn lane	0.41	55.0	F	0.08	29.0	D
Through / right turn lane	0.13	12.7	B	0.41	26.8	D
Approach (average)		29.9	D		27.0	D
v/c = volume/capacity ratio AD = average delay (seconds) LOS = Level of Service						

Future Baseline Traffic Conditions (without Waikoloa Highlands)

Traffic on all roadways in the area will increase as development continues with several projects. The following projects are expected to be completed by 2010 and the traffic volumes generated by these projects have been estimated using methods similar to the methods used for project traffic (discussed later):

a. completion and full occupancy of 200 single-family detached dwelling units at Kilohana Kai (currently under construction).

b. completion of the Sunset Ridge project and a new bridge over Auwaiakeakua Gulch and linking roadways west of the existing Waikoloa Village, which will provide an alternative route for traffic from the existing Waikoloa Village via Hulu Street.

c. partial completion and occupancy of two projects located beyond the existing north end of Paniolo Avenue (the County of Hawaii workforce housing project and Waikoloa Heights, assuming a 50/50 mix of detached single-family units and multi-

family units, based on four years of product delivery at 10 units per month, or a total of 480 dwelling units).

Other projects, including infill of existing undeveloped property, are not expected to generate significant volumes of traffic. The new bridge over Auwaiakeakua Gulch is part of an ongoing development that has access directly to Waikoloa Road, but will also relieve traffic on Paniolo Avenue. The impact of the new bridge on peak hour traffic volumes at the intersection of Paniolo Avenue and Waikoloa Road has been based on traffic forecasts from the traffic report for that project*. Figure 3 shows the traffic assignments for 2010 at the intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue.

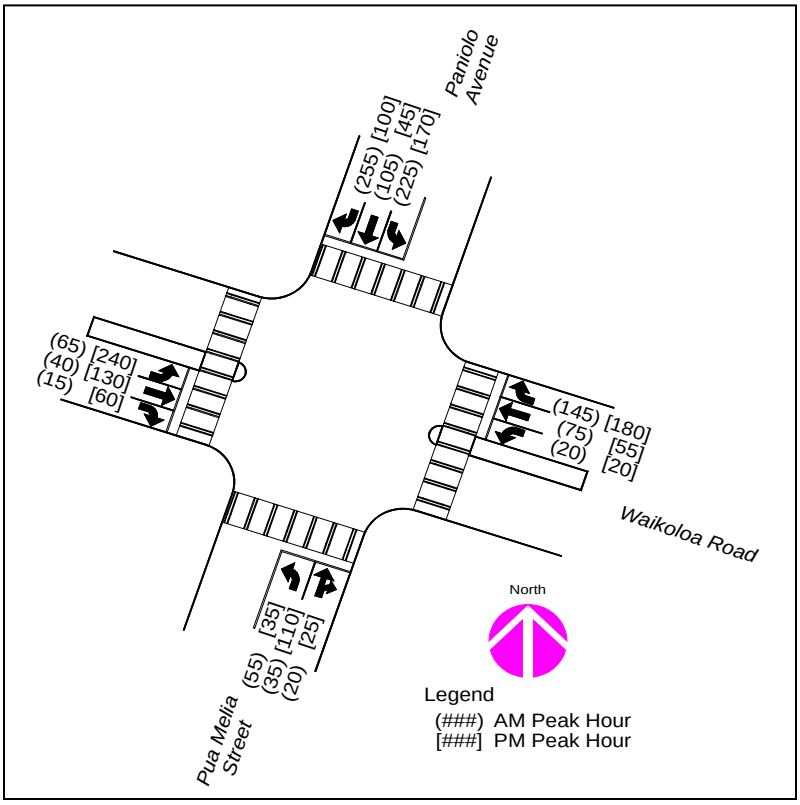

Figure 3 – 2010 Baseline Peak Hour Traffic
Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

* M&E Pacific, Inc., *Auwaiakeakua Gulch Bridge Crossing Traffic Study Update*, April 2004.

Table 2 shows the peak hour conditions at the intersection, assuming the existing paved shoulder areas on Waikoloa Road have been restriped as dedicated right turn lanes. Even with the separate right turn lanes, the changes in traffic volumes will result in over-capacity conditions at the intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue.

Table 2 – 2010 Peak Hour Conditions
Unsignalized Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

	AM Peak Hour			PM Peak Hour		
	v/c	AD	LOS	v/c	AD	LOS
Left turns from Waikoloa Road (yields)						
Westbound	0.02	7.5	A	0.02	7.8	A
Eastbound	0.06	8.0	A	0.21	8.6	A
Stopped southbound approach (Paniolo Avenue)						
Left turn lane	0.46	16.5	C	1.17	179.9	F
Through lane	0.21	12.8	B	0.17	20.0	C
Right turn lane	0.32	10.7	B	0.12	9.2	A
Approach (average)		13.3	B		102.7	F
Stopped northbound approach (Pua Melia Street)						
Left turn lane	0.27	25.4	D	0.15	22.1	C
Through / right turn lane	0.10	11.6	B	0.45	24.6	C
Approach (average)		18.5	D		24.1	C
v/c = volume/capacity ratio AD = average delay (seconds) LOS = Level of Service						

Figure 4 shows that traffic signals would be warranted with traffic volumes at the intersection for four hours of an average day, using projections based on the peak hour traffic assignments and the hourly distribution from the traffic counts.

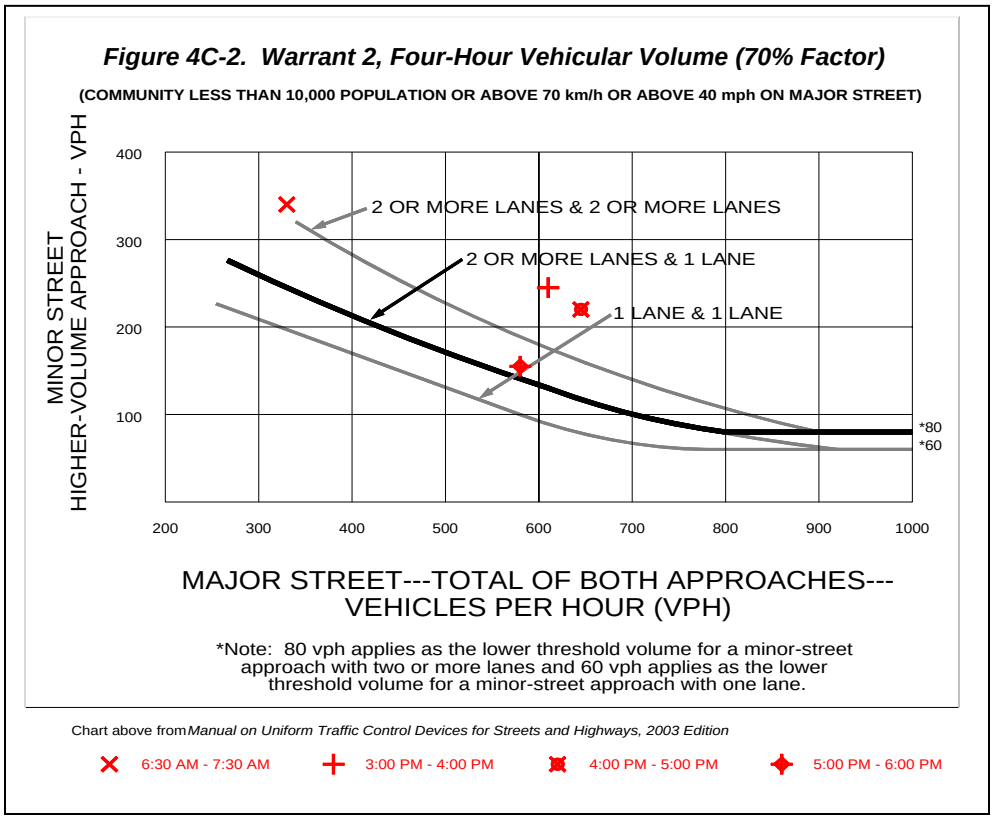

Figure 4 – Signal Warrant (2010 traffic) at Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

Traffic signals at the Waikoloa Road intersection with Paniolo Avenue and Pua Melia Street will distribute the delays to all movements, mitigating the over-capacity condition. Analyses of the intersection, assuming separate phases for left turns from Waikoloa Road, show that the intersection would operate at 39 percent of capacity in the AM Peak Hour and 45 percent of capacity in the PM Peak Hour. Table 3 shows the results of the analysis of this intersection as a signalized intersection.

Table 3 – 2010 Baseline Conditions
Signalized Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

	AM Peak Hour			PM Peak		
	v/c	AD	LOS	v/c	AD	LOS
overall intersection:	**0.39**	**27.4**	**C**	**0.45**	**37.7**	**D**
Southbound approach (Paniolo Avenue)		26.4	C		36.7	D
Left turn lane	0.63	34.6	C	0.54	48.9	D
Through lane	0.25	26.4	C	0.14	40.2	D
Right turn lane	0.39	17.2	B	0.14	14.2	B
Westbound approach (Waikoloa Road)		23.0	B		36.6	D
Left turn lane	0.13	37.4	D	0.09	45.5	D
Through lane	0.27	34.1	C	0.23	47.8	D
Right turn lane	0.25	15.3	B	0.39	32.1	C
Eastbound approach (Waikoloa Road)		38.1	D		36.6	D
Left turn lane	0.40	43.3	D	0.52	39.3	D
Through lane	0.15	32.2	C	0.27	33.9	C
Right turn lane	0.07	31.3	C	0.15	31.6	C
Northbound approach (Pua Melia Street)		30.2	C		44.4	D
Left turn lane	0.18	30.2	C	0.11	39.9	D
Through / right turn lane	0.18	30.2	C	0.42	45.5	D

v/c = volume/capacity ratio
AD = average delay (seconds)
LOS = Level of Service

Further development of the County workforce housing project and Waikoloa Heights is expected beyond 2010. Other projects may also be proposed and developed. For the purpose of estimating future traffic volumes beyond 2010, individual projects were not considered; rather, the traffic assignments for 2010 were increased at an average rate of 2.5% per year to account for the expected continued growth. Figure 5 shows the 2025 peak hour baseline (without Waikoloa Highlands) traffic assignments and Table 4 shows the results of the analyses..

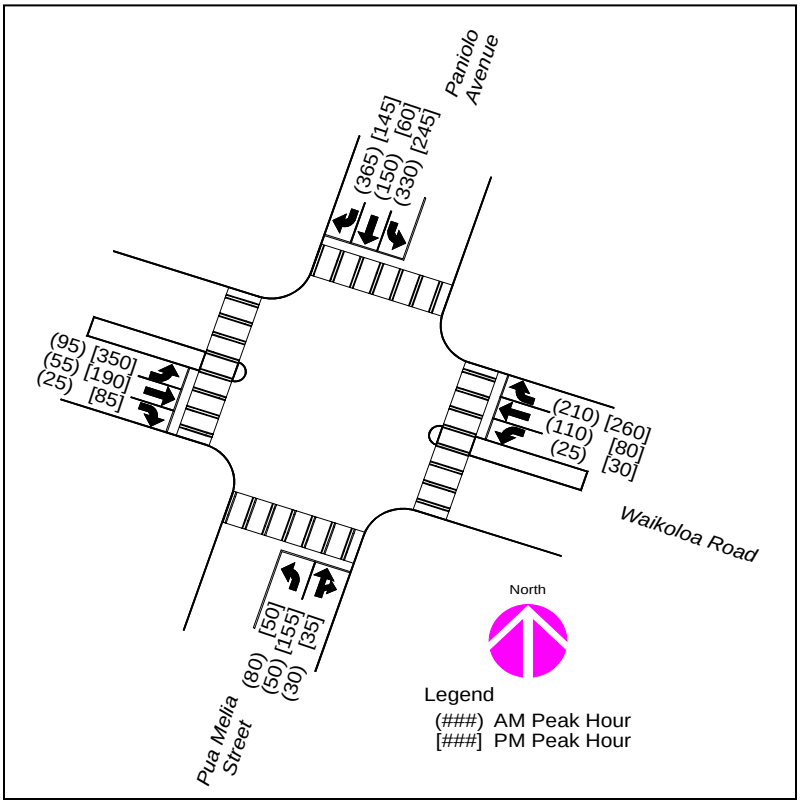

Figure 5 – 2025 Baseline Peak Hour Traffic
Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

Table 4 – 2025 Baseline Conditions
Signalized Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

	AM Peak Hour			PM Peak Hour		
	v/c	AD	LOS	v/c	AD	LOS
overall intersection:	**0.54**	**31.0**	**C**	**0.64**	**39.7**	**D**
Southbound approach (Paniolo Avenue)		31.3	C		30.3	C
Left turn lane	0.81	44.2	D	0.48	47.1	D
Through lane	0.35	27.9	C	0.21	41.4	D
Right turn lane	0.63	21.1	C	0.31	15.9	B
Westbound approach (Waikoloa Road)		24.2	C		40.2	D
Left turn lane	0.15	37.8	D	0.13	46.2	D
Through lane	0.40	36.4	D	0.34	50.0	D
Right turn lane	0.35	16.2	B	0.56	36.5	D
Eastbound approach (Waikoloa Road)		42.4	D		42.8	D
Left turn lane	0.59	50.6	D	0.76	48.9	D
Through lane	0.20	33.0	C	0.39	36.1	D
Right turn lane	0.11	31.8	C	0.21	32.3	C
Northbound approach (Pua Melia Street)		31.3	C		48.5	D
Left turn lane	0.26	31.3	C	0.16	40.6	D
Through / right turn lane	0.26	31.4	C	0.59	30.6	D

v/c = volume/capacity ratio
AD = average delay (seconds)
LOS = Level of Service

Future (2025) Traffic Conditions with Waikoloa Highlands

In order to assess the project impact to future traffic conditions, the additional traffic generated by the project during the morning (AM) and afternoon (PM) peak hours of a typical weekday were developed using factors for dwelling units from *Trip Generation, 7th Edition*, a publication of the Institute of Transportation Engineers. The applicable trip factors and directional distribution are shown in Table 5.

Table 5 – Trip Generation

	Trip rates per detached dwelling unit *		Trips Generated by 398 dwelling units	
Time Period	Vehicle trips	% entering	entering	exiting
Average Weekday	9.57	50%	1,900	1,900
AM Peak Hour	0.75	25%	75	224
PM Peak Hour	1.01	63%	252	149
* Source: Institute of Transportation Engineers, *Trip Generation, 7th Edition*				

The project traffic was distributed to local destinations within Waikoloa Village and onto Waikoloa Road in proportion to the existing turning movements at the intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue. The project impact to Waikoloa Road are summarized in Tables 6 and 7.

Table 6 – Waikoloa Road Traffic Increases

EB = eastbound WB = westbound	**West of Waikoloa Village**				**East of Waikoloa Village**			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	EB	WB	EB	WB	EB	WB	EB	WB
Existing	140	505	475	225	200	190	250	180
2025 without project	300	800	900	450	415	345	470	370
Project impact	30	110	85	45	50	30	30	30
2025 with project	330	910	985	495	465	375	500	400
% increase in volume	10%	14%	9%	10%	12%	9%	6%	8%

Table 7 – Waikoloa Road Levels of Service

v/c = volume/capacity LOS=Level of Service	AM Peak Hour				PM Peak Hour			
	Eastbound		Westbound		Eastbound		Westbound	
	v/c	LOS	v/c	LOS	v/c	LOS	v/c	LOS
West of Waikoloa Village								
Existing (2005 counts)	0.14	D	0.36	E	0.34	F	0.16	D
2025 without project	0.13	D	0.39	F	0.42	F	0.20	D
2025 with project	0.16	D	0.47	F	0.48	F	0.23	D
East of Waikoloa Village								
Existing (2005 counts)	0.15	D	0.15	D	0.18	D	0.17	D
2025 without project	0.32	E	0.26	D	0.34	E	0.27	D
2025 with project	0.33	E	0.29	D	0.34	E	0.29	D

Figure 6 shows the 2025 peak hour traffic assignments at the intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue.

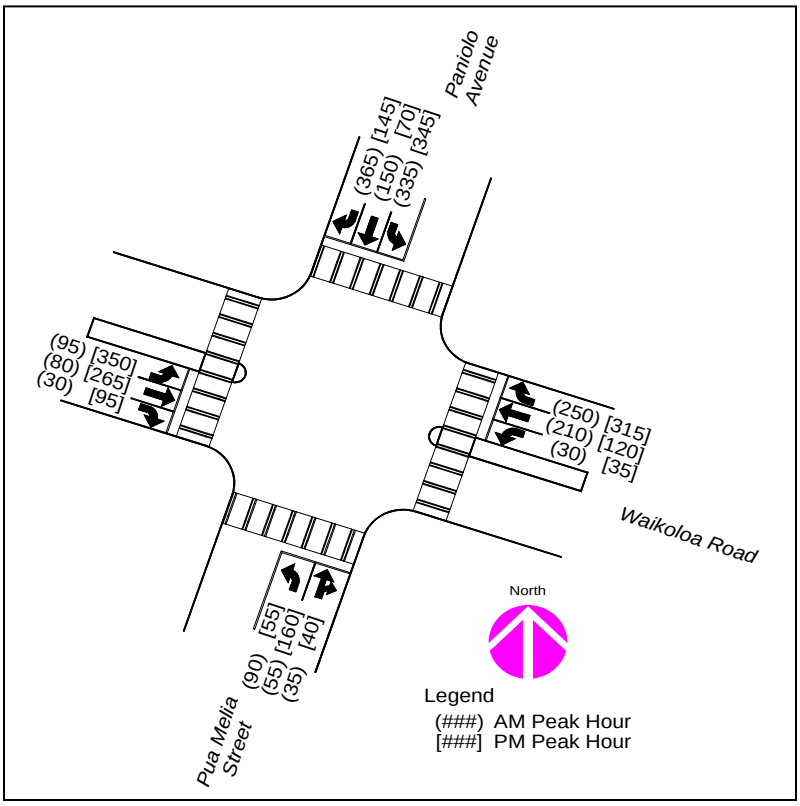

Figure 6 – 2025 Peak Hour Traffic with Waikoloa Highlands
Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

Table 8 shows the results of the analyses of the intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue with the 2025 peak hour traffic assignments. While overall intersection level of service can be maintained within acceptable range, the high volume left turn movements (eastbound and southbound) will experience very long delays and Level of Service E conditions.

Table 8 – 2025 With Waikoloa Highlands

Signalized Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

	AM Peak Hour			PM Peak Hour		
	v/c	AD	LOS	v/c	AD	LOS
overall intersection:	**0.63**	**33.3**	**C**	**0.73**	**44.0**	**D**
Southbound approach (Paniolo Avenue)		31.8	C		36.1	D
Left turn lane	0.82	45.3	D	0.73	55.5	E
Through lane	0.35	27.9	C	0.22	40.0	D
Right turn lane	0.63	21.1	C	0.29	13.6	B
Westbound approach (Waikoloa Road)		32.9	C		40.4	D
Left turn lane	0.18	38.4	D	0.16	46.6	D
Through lane	0.77	51.2	D	0.51	54.6	D
Right turn lane	0.42	16.9	B	0.41	31.3	C
Eastbound approach (Waikoloa Road)		41.6	D		49.3	D
Left turn lane	0.59	50.6	D	0.89	59.5	E
Through lane	0.29	34.4	C	0.52	37.5	D
Right turn lane	0.13	32.1	C	0.16	30.4	C
Northbound approach (Pua Melia Street)		31.9	C		53.3	D
Left turn lane	0.29	31.9	C	0.08	42.7	D
Through / right turn lane	0.29	31.9	C	0.59	54.6	D

v/c = volume/capacity ratio
AD = average delay (seconds)
LOS = Level of Service

On Waikoloa Road, at each approach to the intersection with Pua Melia Street and Paniolo Avenue, the left turn lane is separated from the through lane by a paved area that is striped as a traffic island. Conversion of this striped area on the eastbound approach to a second

left turn lane into Paniolo Avenue, along with a retiming of the traffic signal, would mitigate the unacceptable Level of Service E conditions in the 2025 PM Peak Hour. Table 9 shows the results of the analyses of peak hour traffic volumes with these changes.

Table 9 – 2025 With Waikoloa Highlands (mitigated)

Signalized Intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue

	AM Peak Hour			PM Peak Hour		
	v/c	AD	LOS	v/c	AD	LOS
overall intersection:	**0.57**	**32.7**	**C**	**0.59**	**38.3**	**D**
Southbound approach (Paniolo Avenue)		31.8	C		31.8	C
Left turn lane	0.82	45.3	D	0.63	47.0	D
Through lane	0.35	27.9	C	0.19	36.4	D
Right turn lane	0.63	21.1	C	0.29	13.6	B
Westbound approach (Waikoloa Road)		32.9	C		40.4	D
Left turn lane	0.18	38.4	D	0.16	46.6	D
Through lane	0.77	51.2	D	0.51	54.6	D
Right turn lane	0.42	16.9	B	0.41	31.3	C
Eastbound approach (Waikoloa Road)		41.6	D		39.5	D
Left turn lane	0.30	38.9	D	0.52	38.8	D
Through lane	0.29	34.4	C	0.58	42.3	D
Right turn lane	0.13	32.1	C	0.18	33.4	C
Northbound approach (Pua Melia Street)		31.9	C		53.3	D
Left turn lane	0.29	31.9	C	0.08	42.7	D
Through / right turn lane	0.29	31.9	C	0.59	54.6	D

v/c = volume/capacity ratio
AD = average delay (seconds)
LOS = Level of Service

Three new intersections will be formed at the connections of the project roads with the existing street system. Westbound project traffic on the access road connected to Pua Melia Street will be controlled by a stop sign and the intersection has been analyzed with a single lane shared by left and right turn traffic. Figure 7 shows the year 2025 peak hour traffic assignments and Table 10 shows the results of the analyses.

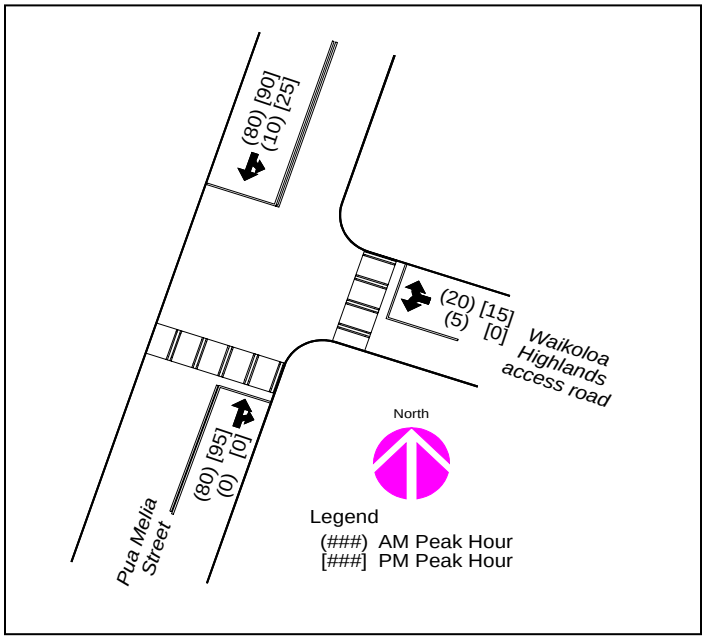

Figure 7 – 2025 Peak Hour Traffic with Waikoloa Highlands
Intersection of Pua Melia Street and Access Road Connection

Table 10 – Pua Melia Street and Access Road Unsignalized Intersection

v/c=volume/capacity 95% Q=design queue CD=control delay (sec)	AM Peak Hour				PM Peak Hour			
	v/c	95% Q	CD (sec)	LOS	v/c	95% Q	CD (sec)	LOS
Southbound left turn, Pua Melia Street (yield)	0.01	0.02	7.6	A	0.02	0.06	7.7	A
Westbound approach, Project Road (stop)	0.04	0.11	9.9	A	0.02	0.07	9.8	A

Traffic assignments for year 2025 at the two new intersections with Waikoloa Road are shown in Figures 8 and 9. At each intersection, the project street will be the stem of a "T"-intersection and traffic on this approach will be controlled by a stop sign. The approach is assumed to be wide enough to accommodate separate lanes for left turns and for right turns. On Waikoloa Road, a separate median left turn lane would be provided, and extended to the west to serve as a median shelter lane to provide a refuge area for drivers making the left turn onto Waikoloa Road. Results of the analyses of these unsignalized intersections are shown in Table 4.

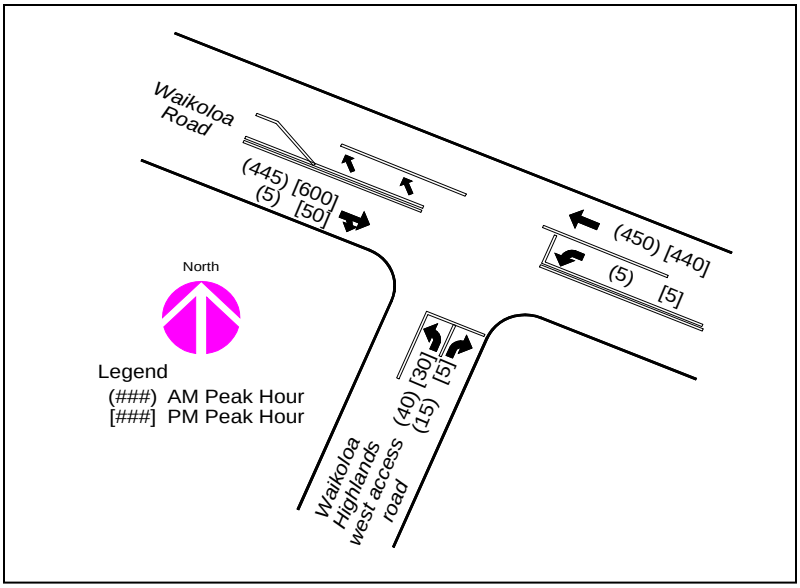

Figure 8 – 2025 Peak Hour Traffic with Waikoloa Highlands
Intersection of Waikoloa Road and West Access Road Connection

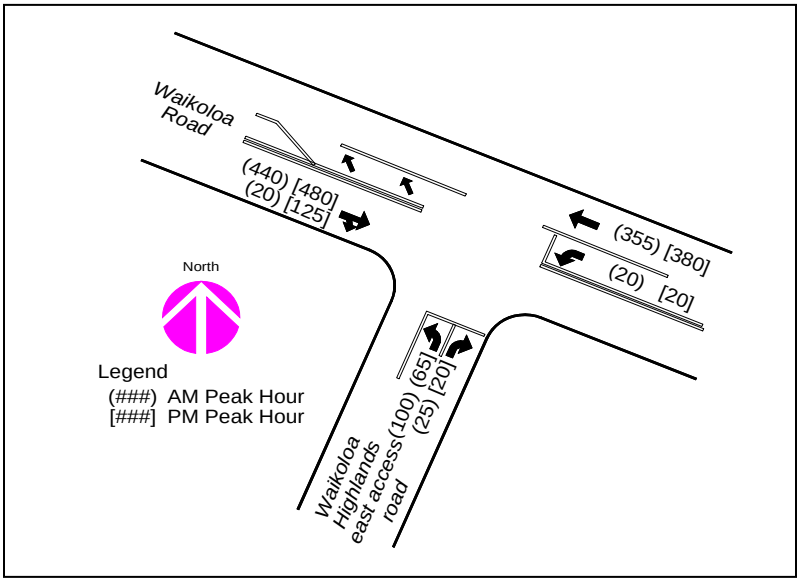

Figure 9 – 2025 Peak Hour Traffic with Waikoloa Highlands
Intersection of Waikoloa Road and East Access Road Connection

Table 11 – Waikoloa Road Unsignalized Intersections

v/c=volume/capacity 95% Q=design queue CD=control delay (sec) LOS=Level of Service	AM Peak Hour				PM Peak Hour			
	v/c	95% Q	CD (sec)	LOS	v/c	95% Q	CD (sec)	LOS
Waikoloa Road and West Access Road								
Westbound left turn, Waikoloa Road (yield)	0.00	0.01	8.5	A	0.01	0.02	9.3	A
Project Road northbound approach								
Shared lane, Case A	0.22	0.84	21.2	C	0.14	0.49	20.0	C
Shared lane, Case B	0.16	0.54	15.3	C	0.10	0.33	14.9	B
Separate left turn lane, Case A	0.19	0.70	23.2	C	0.13	0.45	20.7	C
Separate left turn lane, Case B	0.12	0.42	15.9	C	0.09	0.29	15.1	B
Separate lanes (right turn lane)	0.03	0.10	11.8	B	0.01	0.03	12.3	B
Waikoloa Road and East Access Road								
Westbound left turn, Waikoloa Road (yield)	0.02	0.07	8.6	A	0.02	0.07	8.7	A
Project Road northbound approach								
Shared lane, Case A	0.49	2.58	28.6	D	0.29	1.16	19.5	C
Shared lane, Case B	0.35	1.54	18.2	C	0.22	0.82	15.1	C
Separate left turn lane, Case A	0.44	2.13	28.9	D	0.25	0.94	20.3	C
Separate left turn lane, Case B	0.30	1.22	17.9	C	0.18	0.63	15.1	C
Separate lanes (right turn lane)	0.05	0.17	11.9	B	0.04	0.13	11.7	B
Case A: undivided Waikoloa Road Case B: median left turn lane and median shelter lane on Waikoloa Road								

The 95% queue lengths represent the maximum length of the queue that could be expected with a 95% probability during the peak hour. This length is used to determine the minimum length of storage that should be provided for the affected movement. The queue lengths for the westbound left turns from Waikoloa Road are much less than the two-vehicle length that is used as a minimum storage length; therefore, a design using the minimum storage would be adequate. The queue lengths for the northbound approaches could be used to determine parking restrictions on those approaches to provide separate lanes for left and right turns.

Impacts at Queen Kaahumanu Highway and at Mamalahoa Highway

As indicated in Table 6, traffic volumes on Waikoloa Road are expected to increase as a result of the proposed project. Project impacts at the Waikoloa Road intersections with Queen Kaahumanu Highway and with Mamalahoa Highway were identified by estimating future peak hour traffic volumes at these intersections, adding the project impact, and evaluating future conditions with and without the project traffic.

Traffic volumes on both the Queen Kaahumanu Highway and Mamalahoa Highway have been steadily increasing. Recent estimates of the average daily traffic volumes were used with regression analyses to extrapolate future average daily volumes on each highway, as shown in Table 12.

Table 12 – Highway Average Daily Traffic (ADT) near Waikoloa Road

	Queen Kaahumanu Highway		Mamalahoa Highway	
Year	North of Waikoloa Road	South of Waikoloa Road	North of Waikoloa Road	South of Waikoloa Road
1994	8,949	8,526	4,320	2,437
1996	9,254	9,042	4,419	2,685
1998	9,268	10,760	3,995	2,534
2000	10,251	11,592	4,818	3,061
2002	10,393	12,403	5,794	3,609
Source: State of Hawaii, Department of Transportation, Highways Division. *Traffic Summary – Island of Hawaii 2002*				

The average annual increases from the regression analyses and the extrapolations of future traffic volumes on these segments of roadways are shown in Table 13.

Table 13 – Extrapolation of Highway ADTs near Waikoloa Road

	Queen Kaahumanu Highway		Mamalahoa Highway	
Year	North of Waikoloa Road	South of Waikoloa Road	North of Waikoloa Road	South of Waikoloa Road
Annual increase	+2.0%	+5.1%	+3.4%	+4.7%
2007	11,510	16,230	6,270	4,280
2010	12,220	18,850	6,940	4,910
2025	16,520	39,850	11,500	9,770

The latest available "K" (peak hour volume divided by daily volume) and "D" (directional distribution) factors were applied to develop baseline future (2025) peak hour volumes on the segments of highways north and south of Waikoloa Road. While project traffic would likely be part of the future traffic, the increases in peak hour traffic from Table 6 were added to the future baseline traffic assignments for the "future with project" traffic assignments. The traffic assignments are shown in Figures 10 and 11.

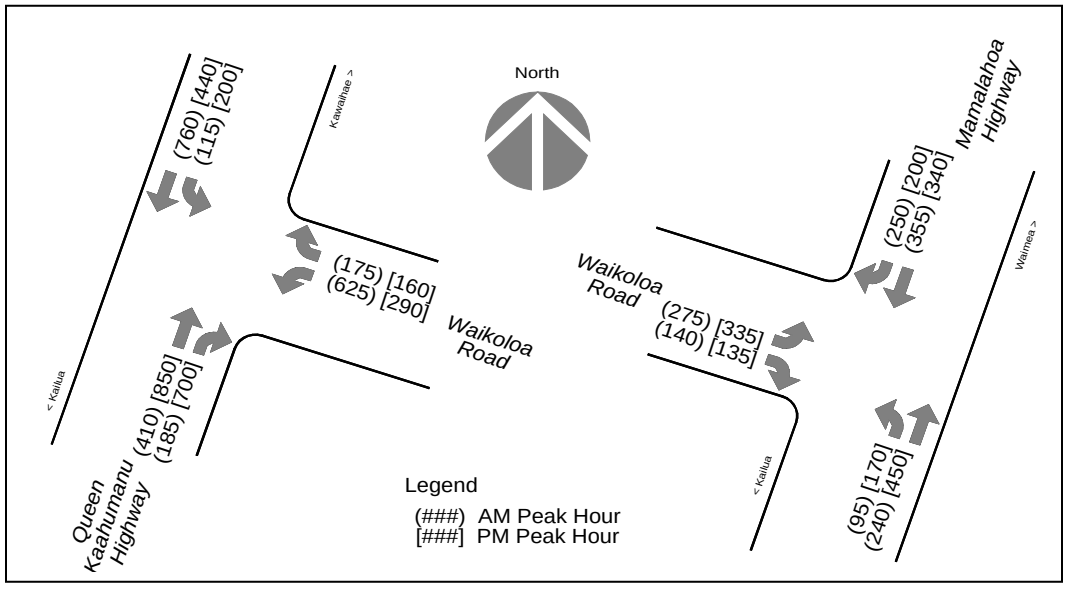

Figure 10 – 2025 Baseline Peak Hour Traffic Assignments at Highway Intersections

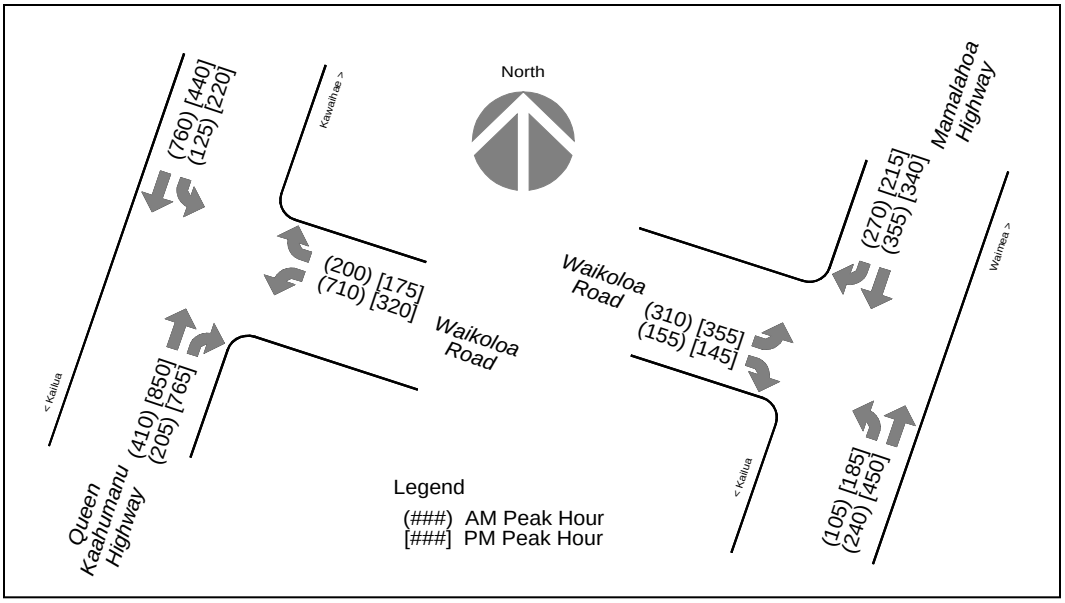

Figure 11 – 2025 With-Project Peak Hour Traffic Assignments at Highway Intersections

The analysis procedure described in the *Highway Capacity* Manual was applied to the existing intersection of Mamalahoa Highway and Waikoloa Road, where separate lanes are provided for each movement. Traffic signals would be needed for both the baseline and with-project traffic assignments, as capacity for left turns from Waikoloa Road would be exceeded. A critical movement analysis that had been described in an earlier edition of the *Highway Capacity* Manual was used to provide a planning-level evaluation of the signalized intersections. The critical movement analysis sums the peak hour volumes of the conflicting movements; sums of up to 1,200 passenger cars per hour indicate desirable "under capacity" conditions, sums greater than 1,200 and up to 1,400 describe "near capacity" conditions, and sums greater than 1,400 are "over capacity" requiring additional lanes or other improvements.

Table 14 shows the results of the critical movement analyses. At Queen Kaahumanu Highway, the daily traffic volumes indicate that widening of the existing two-lane highway to four lanes will be needed by year 2025. The high left turn volume from Waikoloa Road to Queen Kaahumanu Highway also indicate a need for a second turn lane; however, the sum of critical movements shown in Table 14 assume only a single turn lane is provided.

Table 14 – Results of Critical Movement Analyses of Signalized Intersections (2025)

Waikoloa Road and State Highways

	Queen Kaahumanu Highway		Mamalahoa Highway	
Peak Hour & Case	Sum	Condition	Sum	Condition
AM baseline	1,075	Under capacity	975	Under capacity
AM with-project	1,160	Under capacity	1,040	Under capacity
PM baseline	1,095	Under capacity	1,045	Under capacity
PM with project	1,145	Under capacity	1,095	Under capacity

Table 15 compares the project traffic with the baseline traffic volumes on the highways. Project traffic will be small compared to the expected growth of traffic from all development, as shown below (less than the traffic expected due from two years' growth on either highway, from first line in Table 13).

Table 15 – Comparison of Project Traffic with 2025 Baseline Traffic

	Queen Kaahumanu Highway		Mamalahoa Highway	
Peak Hour & Case	southbound	northbound	southbound	northbound
Annual growth to north	+2.0%		+3.4%	
AM to the north	1.1%	4.3%	3.3%	6.8%
PM to the north	3.1%	1.5%	2.8%	2.5%
Annual growth to south	+5.1%		+4.7%	
AM to the south	6.1%	3.4%	3.0%	3.0%
PM to the south	4.1%	4.2%	2.1%	2.4%

Traffic assignments were also made for year 2010, to provide estimates of the possible timing of the improvements that will be needed at each intersection. Figure 12 shows the 2010 baseline traffic assignments and Figure 13 shows the 2010 with-project traffic. The results of the unsignalized intersection analysis of the Mamalahoa Highway intersection are shown in Table 16 for the with-project traffic assignments. The very long delays for left turns onto Mamalahoa Highway in the PM Peak Hour could be mitigated by providing a shelter lane to allow left turn traffic to cross the southbound traffic and wait for a gap in the

northbound traffic before completing the turn. The shelter lane could be provided by restriping the existing median north of the intersection if the improvement is considered a temporary measure (the shelter lane will not be needed when the intersection is signalized; further discussion follows).

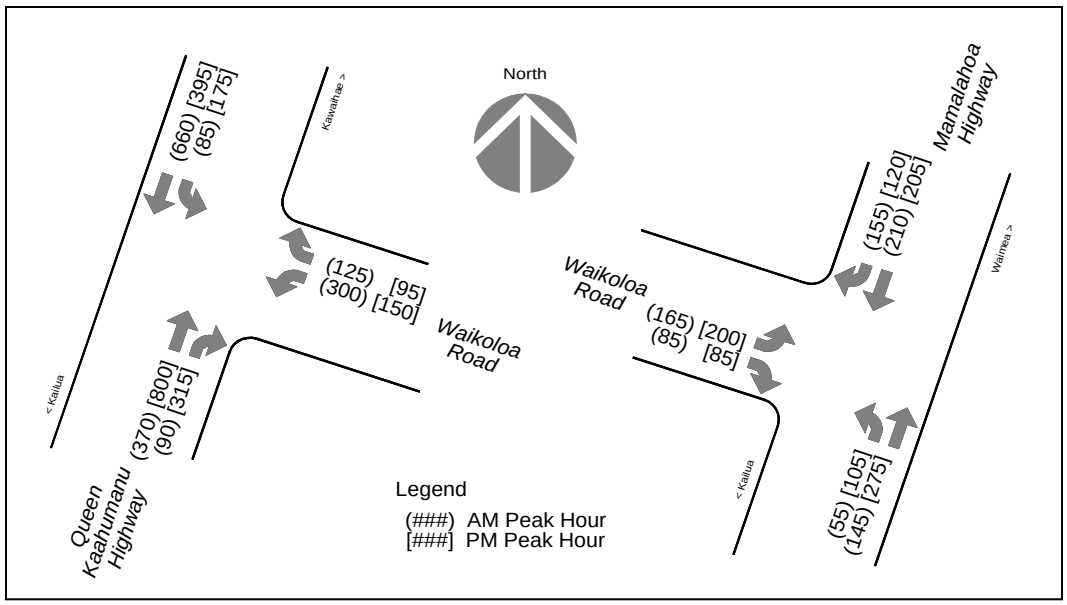

Figure 12 – 2010 Baseline Peak Hour Traffic Assignments at Highway Intersections

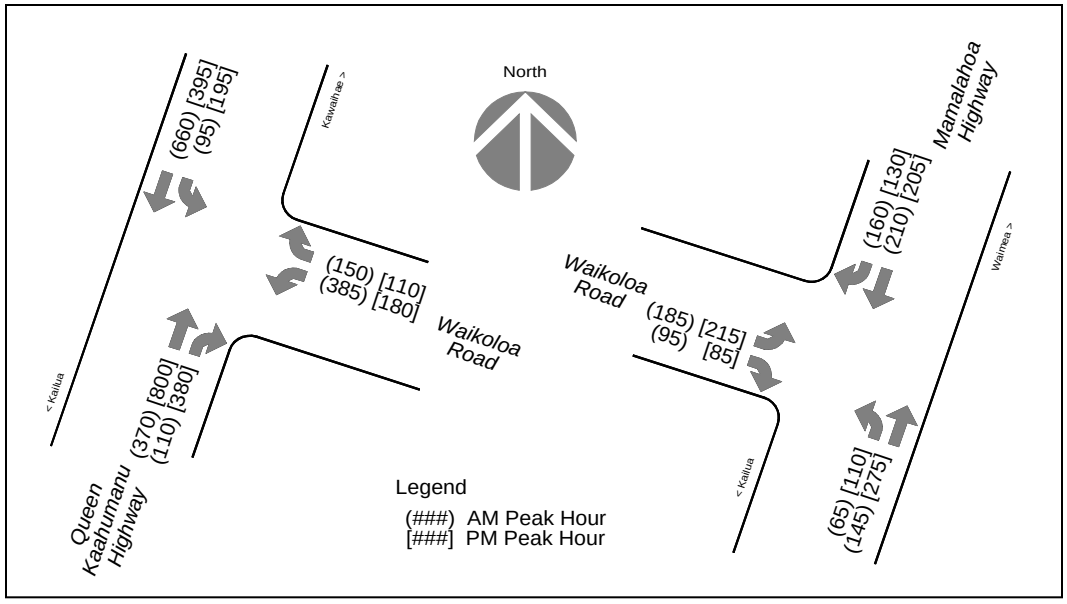

Figure 13 – 2010 With-Project Peak Hour Traffic Assignments at Highway Intersections

Table 16 – Results of Unsignalized Intersection Analysis (2010)

Waikoloa Road and Mamalahoa Highway

	AM Peak Hour			PM Peak Hour		
	Waikoloa Road		190NB	Waikoloa Road		190NB
Peak Hour & Case	Right Turn	Left Turn	Left Turn	Right Turn	Left Turn	Left Turn
With-project traffic and existing striping at Intersection						
Volume/capacity ratio	0.15	0.52	0.07	0.13	0.90	0.12
Average delay (seconds)	10.5	22.1	8.6	10.3	68.7	8.6
Level of Service	B	C	A	B	F	A
With-project traffic and improved intersection (shelter lane added)						
Volume/capacity ratio	0.15	0.43	0.07	0.13	0.67	0.12
Average delay (seconds)	10.5	17.1	8.6	10.3	31.2	8.6
Level of Service	B	C	A	B	D	A
190 NB = Highway 190 (Mamalahoa Highway) Northbound RT = right turn (stop condition) LT = left turn (stopped or yield)						

The analyses of the unsignalized intersection also show that the intersection with the addition of a shelter lane could adequately serve peak hour traffic until the year 2014, with the assumed growth rates and a maximum volume-to-capacity ratio of 0.85. The project impact would be to accelerate the need for improvements at the intersection of Mamalahoa Highway and Waikoloa Road, such as traffic signals, by about 1½ years.

At the intersection of Queen Kaahumanu Highway and Waikoloa Road, the project impact would be a similar acceleration of needed improvements. If the project were completed and fully occupied by 2010, the additional traffic would not significantly affect conditions in 2010. With the sum of critical movements is increasing at about 3.5% per year at the intersection of Queen Kaahumanu Highway and Waikoloa Road, near-capacity conditions are projected to occur between 2012 and 2018 with the baseline traffic assignments, and between 2011 and 2017 with project traffic added to the baseline volumes. The net effect of adding the traffic generated by the project, therefore, is the accelerating of the need for

improvements by one year. Table 17 shows the results of the critical movement analyses of the 2010 peak hour traffic assignments for the existing lane configuration at the intersection of Queen Kaahumanu Highway and Waikoloa Road.

Table 17 – Results of Critical Movement Analyses of Signalized Intersection (2010)
Queen Kaahumanu Highway and Waikoloa Road

	AM Peak Hour		PM Peak Hour	
Peak Hour & Case	Sum	Condition	Sum	Condition
baseline	960	Under capacity	1,125	Under capacity
with-project	1,045	Under capacity	1,175	Under capacity

As discussed earlier, the daily traffic volumes on Queen Kaahumanu Highway indicate a need to widen the highway to four lanes before 2025. At the growth rates assumed in this study, daily volumes on the highway in 2015 will be greater than 13,500 vehicles per day north of Waikoloa Road and greater than 24,000 vehicles per day south of Waikoloa Road.

If the widening of Queen Kaahumanu Highway through the Waikoloa Road intersection does not occur by 2017, other improvements will be necessary to alleviate over-capacity conditions at the intersection. A second left turn lane from Waikoloa Road to Queen Kaahumanu Highway could reduce the sum of critical movements, but will require a second southbound lane to accept the second lane of turning traffic. Alternatives that would reduce the sum of critical movements by eliminating left turn conflicts (two examples are shown in Figure 14 with 2010 PM with-project traffic assignments) could also be considered.

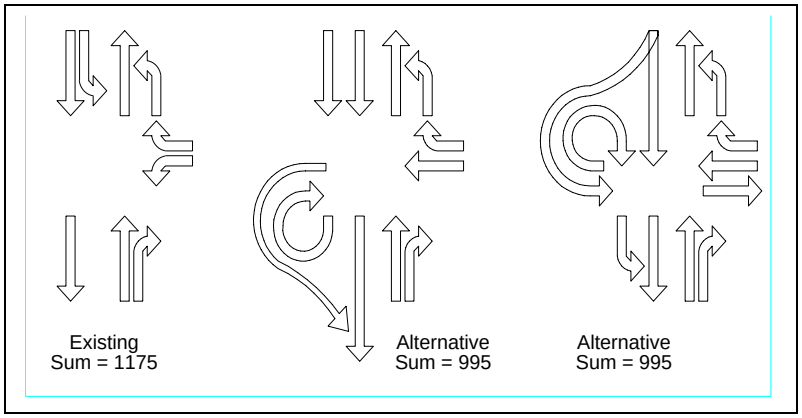

Figure 14 – Alternatives to Reduce Conflicts at Queen Kaahumanu Highway Intersection

Conclusions and Recommendations

The analyses show that while the proposed project will increase traffic volumes, the impact will not be significant enough to change the levels of service. In the short term, the installation of traffic signals at the intersection of Waikoloa Road, Pua Melia Street, and Paniolo Avenue will mitigate existing poor levels of service during the peak hours for left turns onto Waikoloa Road. With traffic signals and separate right turn lanes on Waikoloa Road, the intersection will have adequate capacity to serve peak hour volumes with the proposed project fully occupied. As traffic volumes increase due to other development in the Waikoloa area, peak hour conditions will worsen; a second eastbound left turn lane at the intersection is a mitigation measure that will improve conditions to acceptable levels for the peak hour volumes projected to year 2025.

The project road connections to Waikoloa Road and to Pua Melia Street will adequately serve peak hour volumes. Stop signs on the project road approaches will control turning movements at these "T"-intersections (left turns into the project would cross oncoming traffic and would yield). At the Waikoloa Road intersections, acceptable conditions will result from the provision of separate left turn lanes with median shelter lanes.

The addition of traffic from the proposed project will affect the Waikoloa Road intersections with Queen Kaahumanu Highway and with Mamalahoa Highway by accelerating the rate of growth of traffic volumes at each intersection. The analyses show that full occupancy of the project is expected to result in increases in traffic that would otherwise be expected in one to two more years. For the years 2010 and 2025, however, the addition of project traffic does not significantly change conditions at either intersection. The following improvements to State highway facilities are indicated by the analyses:

- add a shelter lane on Mamalahoa Highway for left turns from eastbound Waikoloa Road to northbound Mamalahoa Highway to serve expected growth in traffic (without project traffic) before 2010.
- signalize, when needed and warranted, the intersection of Mamalahoa Highway and Waikoloa Road; the analyses indicate that the most critical movement at the unsignalized intersection would exceed 85% of its capacity by 2014 (2013 with the addition of project traffic).
- widen Queen Kaahumanu Highway to a four-lane highway by 2015 (2014 with the addition of project traffic)

Appendix – Field Traffic Count Data

Unsignalized Intersection: Tuesday, October 25, 2005

Major Street, Waikoloa Road	West Leg (Eastbound approach)					East Leg (Westbound approach)				
	LEFT	THRU	RIGHT	PED	BIKE	LEFT	THRU	RIGHT	PED	BIKE
06:30 AM - 06:45 AM	14	5	4	0	0	2	30	18	1	0
06:45 AM - 07:00 AM	18	2	1	1	0	2	18	35	0	0
07:00 AM - 07:15 AM	20	9	4	1	0	1	20	17	0	0
07:15 AM - 07:30 AM	31	7	1	0	0	3	24	16	0	0
07:30 AM - 07:45 AM	17	7	1	0	0	2	15	37	0	0
07:45 AM - 08:00 AM	22	16	3	0	0	3	18	36	1	1
08:00 AM - 08:15 AM	16	11	3	0	0	2	11	20	0	0
08:15 AM - 08:30 AM	26	8	0	1	0	1	18	15	0	0
03:00 PM - 03:15 PM	43	27	8	2	0	2	6	23	0	0
03:15 PM - 03:30 PM	57	34	9	1	0	4	11	24	0	0
03:30 PM - 03:45 PM	71	22	7	2	0	3	10	34	0	0
03:45 PM - 04:00 PM	85	41	12	3	0	6	15	30	0	0
04:00 PM - 04:15 PM	68	31	12	2	0	4	21	19	0	0
04:15 PM - 04:30 PM	73	33	10	4	0	4	11	28	0	0
04:30 PM - 04:45 PM	75	27	8	0	0	5	8	30	0	0
04:45 PM - 05:00 PM	72	27	9	0	0	3	12	27	0	0
05:00 PM - 05:15 PM	76	21	11	0	0	4	11	31	0	0
05:15 PM - 05:30 PM	71	20	9	0	0	0	3	30	0	0
05:30 PM - 05:45 PM	75	17	6	1	0	0	8	31	0	0
05:45 PM - 06:00 PM	80	6	9	0	0	2	5	28	0	0
Minor Street (Paniolo Avenue and Pua Melia Street	North Leg (Southbound approach)					South Leg (Northbound approach)				
	LEFT	THRU	RIGHT	PED	BIKE	LEFT	THRU	RIGHT	PED	BIKE
06:30 AM -06:45 AM	30	13	105	0	0	5	10	2	0	0
06:45 AM -07:00 AM	37	7	80	0	0	3	4	1	0	0
07:00 AM -07:15 AM	51	53	97	0	0	17	23	1	0	0
07:15 AM -07:30 AM	45	10	106	0	0	7	17	2	2	0
07:30 AM -07:45 AM	35	13	96	4	0	9	4	2	1	0
07:45 AM -08:00 AM	22	10	89	0	0	8	10	1	1	1
08:00 AM -08:15 AM	31	12	70	0	0	4	10	2	0	0
08:15 AM -08:30 AM	33	16	47	0	0	3	6	1	0	0
03:00 PM -03:15 PM	24	22	46	0	0	2	16	1	0	0
03:15 PM -03:30 PM	30	15	28	1	0	4	27	1	0	0
03:30 PM -03:45 PM	34	9	36	0	0	1	21	4	0	0
03:45 PM -04:00 PM	24	18	40	0	0	5	22	2	0	0
04:00 PM -04:15 PM	30	12	40	0	0	5	19	7	0	0
04:15 PM -04:30 PM	28	9	32	0	0	2	23	1	0	0
04:30 PM -04:45 PM	22	9	45	0	0	0	24	4	0	0
04:45 PM -05:00 PM	40	9	37	0	0	3	17	2	0	0
05:00 PM -05:15 PM	24	4	28	0	0	2	20	3	0	0
05:15 PM -05:30 PM	25	4	30	0	0	1	17	2	0	0
05:30 PM -05:45 PM	22	3	35	0	0	0	11	1	1	0
05:45 PM -06:00 PM	21	7	33	0	0	1	17	0	0	0

Source: R. M. Towill Corporation