TRAFFIC IMPACT ASSESSMENT REPORT

FOR THE LIHUE PUHI MASTER PLAN
608-ACRE ZONING CHANGE

Lihue & Puhi, Kauai, Hawaii
Tax Map Keys: 3-3-02: por. 1,
3–3–03: por. 1 and 3-4-05: por. 7
Fourth Tax Division

April 1989

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EXHIBIT K-1

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EXECUTIVE SUMMARY

This traffic study identifies and evaluates the probable impact of traffic generated by the proposed development of 608 acres of land within Grove Farm's *Lihue Puhi Master Plan.*

The project site is located in the Lihue and Puhi areas of the island of Kauai. The site is bordered on the East by Nawiliwili Road and on the North by Kaumualii Highway. Presently, the land is used for sugar cane production and zoned as an "Agricultural" State Land Use District.

The project consists of 608 acres of land to be developed for commercial, industrial, residential, and recreational uses. About 36 acres is planned for commercial use, 1961 units of single and multi family residential dwellings, and 237 acres for a golf course. The proposed development is assumed to be completed and fully occupied by the year 2000.

The study focuses on intersections along Kaumualii Highway and Nawiliwili Road including Kaumualii Highway with Puhi Road, Kaumualii Highway with Nuhou Road (realigned), Kaumualii Highway with Nawiliwili Road, and Nawiliwili Road with Niumalu Road.

Recommendations and Conclusions

Even without the 608-acre development, we find that traffic along Kaumualii Highway is expected to be congested as a two-lane highway by the Year 1996. This Report therefore assumes that Kaumualii Highway will be widened to four lanes by the Year 1996. Previous studies have also shown the need to widen Kaumualii Highway to four lanes.

The results of our analysis also indicate that even without the project in the Year 2000, drivers from side-streets such as Nawiliwili Road and Puhi Road, will experience severe delays crossing or entering Kaumualii Highway if the intersections are not signalized. If unsignalized, left-turning traffic will encounter level-of-service (LOS) F, meaning

unacceptable delays during the afternoon peak hour. If signalized, the study intersections would operate under capacity *with* a four lane Kaumualii Highway in the Year 2000.

With the 608-acre development, traffic will increase from the side-streets (Puhi Road, Nuhou Road, etc.) to Kaumualii Highway causing the LOS for traffic movements entering and exiting the side-streets to worsen. The intersections of Kaumualii Highway with Nuhou Road and Kaumualii Highway with Puhi Road to need to be signalized to prevent severe traffic delays to vehicles entering or exiting the project:

To mitigate the impacts of the proposed project, provide for a smooth traffic operation, and to prevent the LOS dropping below acceptable levels, the following phased improvements are recommended:

1. Fully channelize the intersection of Kaumualii Highway with Nuhou Road and provide exclusive left-turn lanes on all approaches,
2. Signalize the intersections of Kaumualii Highway with Nuhou Road and Kaumualii Highway with Puhi Road when future traffic volumes meet signal warrants,
3. Implement speed control zones on approaches to intersections for safety,
4. Reduce speed limit on Kaumualii Highway from 50 to 35 miles per hour between Nawiliwili Road and Puhi Road, and
5. Reduce speed limit on Nawiliwili Road from 50 to 35 miles per hour between Kaumualii Highway and Niumalu Road.

The major trip generator/attractor on Kauai is the job center in Lihue. The effect of locating residential units as close to Lihue as the proposed project means the reduction of traffic on other roadways serving outlying areas. If the proposed homes were located in areas North of Wailua up to 800 vehicles (two-way) during the afternoon peak hour would be added to Kuhio Highway traffic between Lihue and the hypothetical site. As we have found in other studies such as for Kapolei City, locating employment centers and residential areas closer together minimizes regional commuting impacts.

INTRODUCTION

Grove Farm Properties, Inc., is proposing to develop 608 acres of land included in their Lihue Puhi Master Plan for commercial, residential, and recreational uses. The project location map and roadway network in the vicinity are shown in Figure 1.

The project site is located at the outskirts of Lihue and in Puhi on the island of Kauai and is identified by Tax Map Keys: 3-3-02: por. 1, 3–3–03: por. 1 and 3-4-05: por. 7, in the Fourth Tax Division. The site is bordered by Nawiliwili Road to the East and by Kaumualii Highway to the North.

The purpose of this Report is to present the results of a traffic impact study of the proposed 608-acre development. The Report presents a comparison of what traffic would be like *without* and *with* the proposed 608-acre development in the Lihue Puhi Master Plan area.

This traffic impact report identifies and evaluates the probable impact of the forecasted traffic generated by the proposed development in the Year 2000, when the project is expected to be completed. The analysis focuses on the traffic impact at major intersections including Kaumualii Highway with Puhi Road, Kaumualii Highway with Realigned Nuhou Road, Kaumualii Highway with Nawiliwili Road, and Nawiliwili with Niumalu Road. The study describes the impact on the Level-of-Service (LOS) at the study intersections when the project is completed in the Year 2000.

Lihue Puhi Master Plan

The Lihue Puhi Master Plan is an outgrowth of twenty years of past planning efforts by Grove Farm to incorporate future uses with the existing uses Grove Farm has developed to date. The master plan encompasses a total area of 945 acres. Presently, 340 acres of the Lihue Puhi Master Plan area is zoned State "Urban" land use. The remaining 608 acres of land is being used for sugar cane production and is in the "Agricultural" State Land Use District. Grove Farm is proposing to rezone the 608-acres to State "Urban" land use.

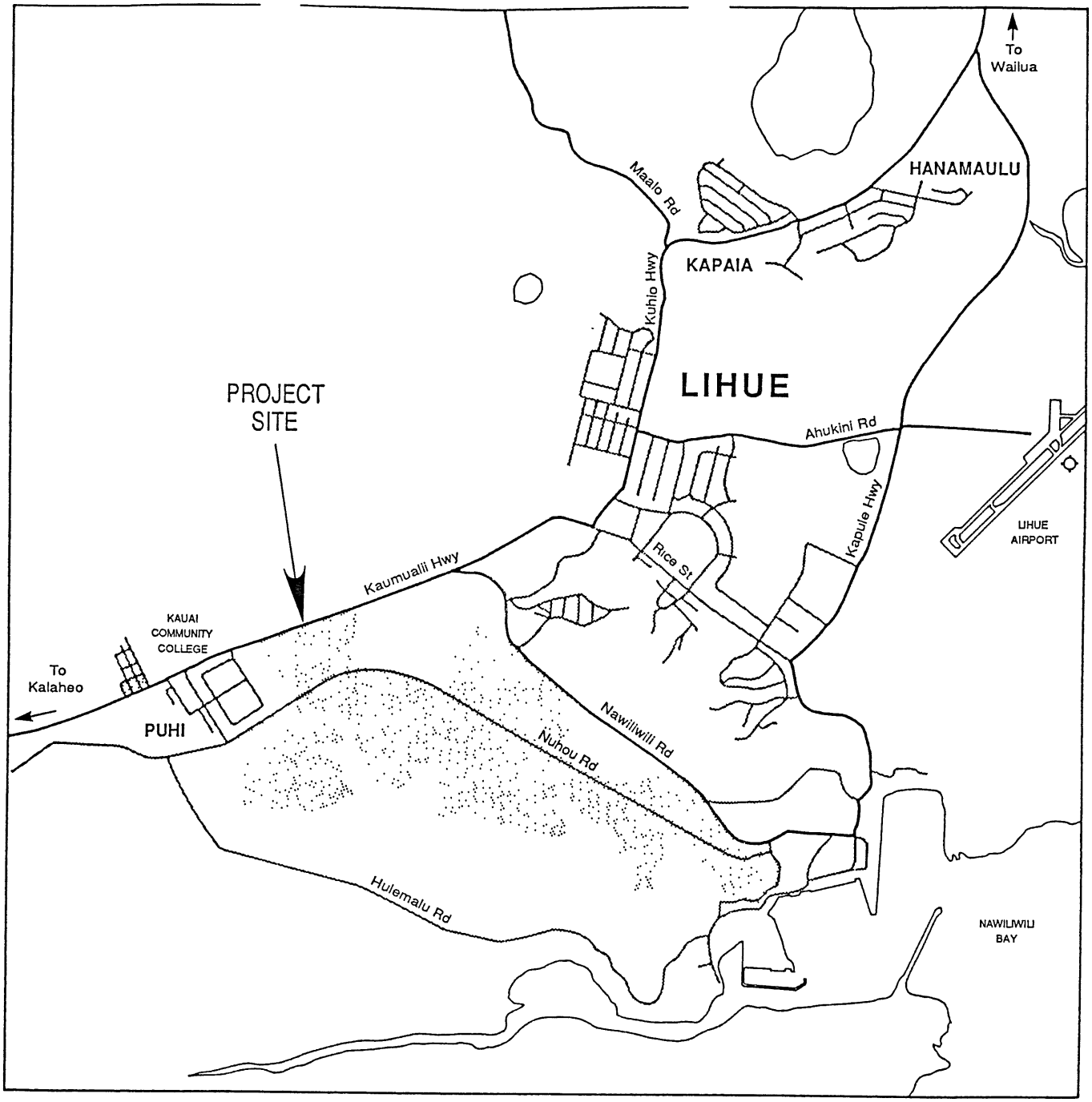
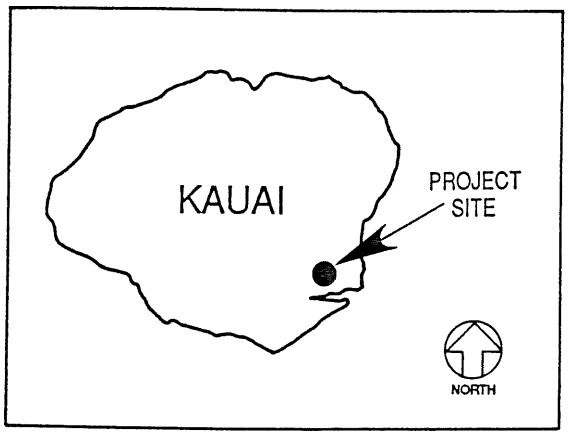


Figure 1. Project Location Map and Roadway Network



PROJECT DESCRIPTION

The proposed 608-acre development will provide 35.5 acres of commercial area, 940 single-family residential units, 1021 multi-family residential units, and a 236.5 acre golf course. The development will also provide an internal roadway system to distribute traffic throughout the project.

Figure 2 shows the site plan for the proposed 608-acre development and Table 1 shows a breakdown of the proposed land uses. The entire development is planned to be completed and fully occupied by the year 2000.

The primary land use for the project is residential housing. Residential uses include affordable housing units with a density of about 6 units per acre, multi-family units with a density of 10-12 units per acre, and rental multi-family units. Single-family and multi-family units will also be sold at market price. Market units will be located by the proposed golf course and have densities of 4 units per acre and 10-12 units per acre, respectively.

An 18 hole golf course on about 235.5 acres of land will be developed for recreational use. The golf course will include a clubhouse, and a driving range. Other recreational uses include parks for the new residential communities. Proposed additional commercial land uses include the expansion of Kukui Grove Shopping Center and new general commercial areas along Kaumualii Highway.

The primary roadways providing vehicular access to 608-acre development as well as the existing developments in the Lihue Puhi Master Plan area are Kaumualii Highway and Nawiliwili Road. Internal roadways will be provided to permit travel between the all land uses within the project without having to access Kaumualii Highway or Nawiliwili Road.

Nuhou Road will be realigned to intersect Kaumualii Highway about midway between Nawiliwili Road and Puhi Road. Nuhou Road will function as a collector road for local traffic between Kaumualii Highway and Nawiliwili Harbor. Aakukui Road will be extended from Puhi Road to connect Nuhou Road providing access to the Puhi area.

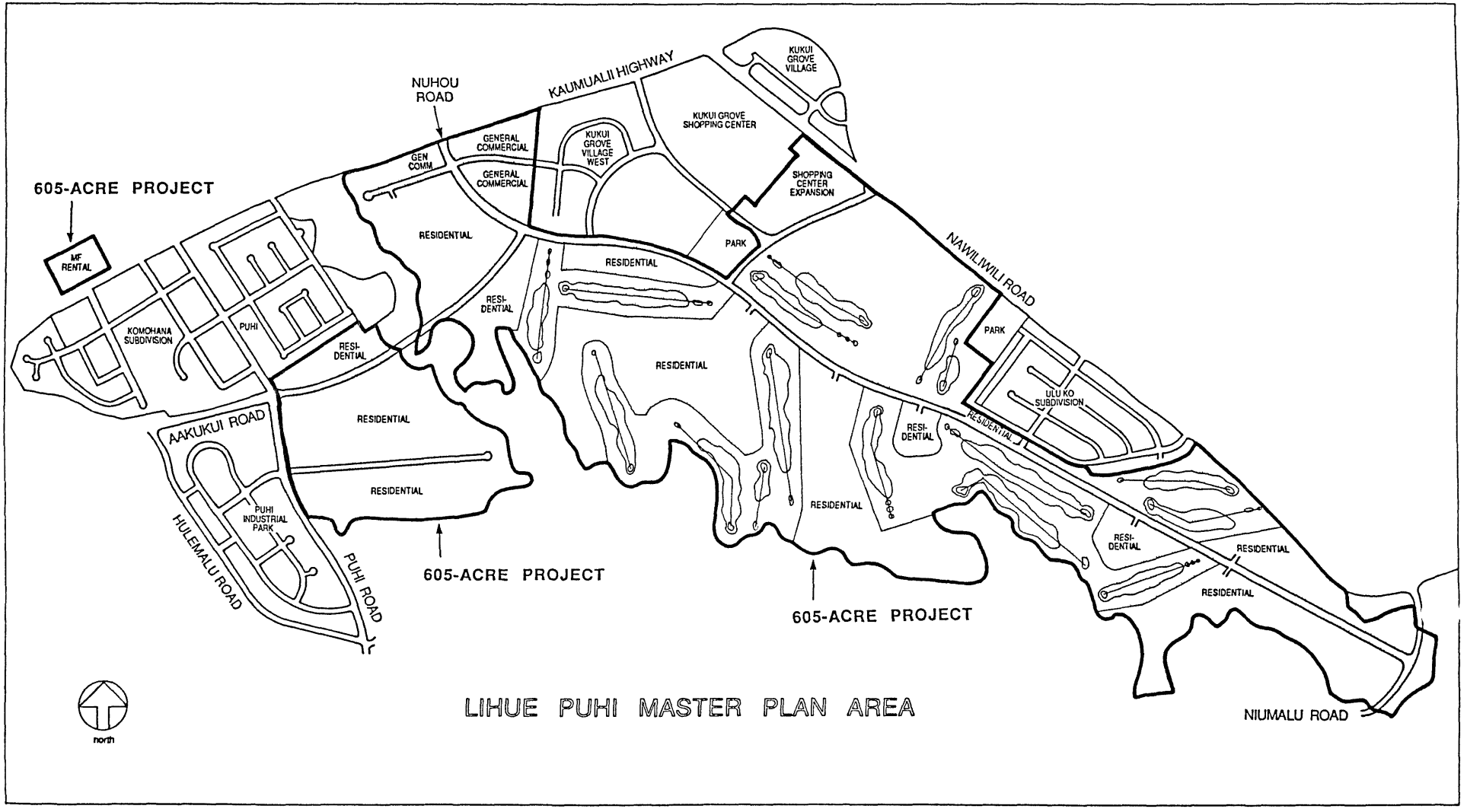


Figure 2. Project Site Plan

Table 1. Proposed Land Uses - 605-Acre Area

Land Use	Acreage	Units
Commercial		
Shopping Center Expansion	14.0	
General Commercial Areas	21.5	
Residential		
Single-Family	211.5	940 units
Multi-Family	78.5	1021 units
Recreational		
Golf Course	236.5	
Roads & Misc.	43.0	
Total	605.0	

Existing Land Uses in the Lihue Puhi Master Plan Area

Table 2 shows the urban land uses which Grove Farm has either completed or is in process of developing.

The Kukui Grove Shopping Center and Commercial Village are the main commercial areas which include retail sales, banking, fast food restaurants, health clubs, and other commercial services. The Puhi Neighborhood Commercial area is a secondary commercial area with markets and a gas station. The Puhi Light Industrial area includes warehousing and dairy product processing plant. The Puhi, Komohana, and Ulu Ko residential subdivisions are affordable subdivisions with nearby neighborhood parks.

Table 2. Existing Land Uses - 340 Acre "Urban" Land Use Area

Land Use	Acreage	Units
Commercial:		
Kukui Grove Shopping Center	35.0	
Kukui Grove Commercial Village	18.0	
Kukui Grove Village West[1]	48.2	
Puhi Neighborhood Commercial	10.0	
Light Industrial:		
Puhi Light Industrial Area	28.0	
Puhi Industrial Park[1]	60.0	
Residential:		
Komohana Residential Subdivision	23.0	96 single-family
Puhi Residential Subdivision	44.0	148 single-family
Ulu Ko Residential Subdivision	41.0	164 single-family
Recreational:		
Puhi Neighborhood Park	4.4	
Puhi Passive Park	2.9	
Ulu Ko Neighborhood Park	4.0	
Kukui Grove Village West Park[1]	5.8	
Total	287.5	

[1] The Puhi Industrial Park, Kukui Grove Village West, and Kukui Grove Village West Park are currently under development by Grove Farm. These uses are assumed to be developed before the year 2000. For the purposes of this report, they are considered "existing."

EXISTING CONDITIONS

A review of the areas was conducted to better understand future traffic conditions surrounding the proposed project. The review included the land uses, roadway facilities, and traffic conditions.

Area Conditions

The immediately adjacent land uses surrounding the project are generally agricultural. Lihue Airport and Lihue Town are located Northeast of the project site and beyond Lihue are the towns of Hanamalu, Wailua, Kapaa and Hanalei. Kauai Community College is located in Puhi across Puhi Road on the mauka side of Kaumualii Highway. Nawiliwili Harbor is located on the southeast end of the project site. Westward are the towns of Koloa, Kalaheo, Hanapepe, Waimea, and Kekaha.

Roadway Facilities

The primary vehicular access to the proposed development will be from Kaumualii Highway (Route 50) which is the only highway providing through traffic between the Lihue and Koloa Districts. Kaumualii Highway is a two-lane rural arterial which runs on an east-west orientation along the southern region of Kauai.

Kaumualii Highway is a State maintained facility, it has two 12–foot lanes with 4-foot paved and 10-foot unpaved shoulders on each side. The posted speed limit is generally 50 miles per hour (mph), and is 25 to 35 mph in populated areas near Puhi Road and Kukui Grove Shopping Center.

Fronting the project site, the major intersections on Kaumualii Highway are provided with left turn pockets, acceleration/deceleration lanes, and are stop-controlled. The layouts of the study intersections are shown in Figure 3. Nawiliwili Road and Puhi Road are the roadways which form major intersections with Kaumualii Highway.

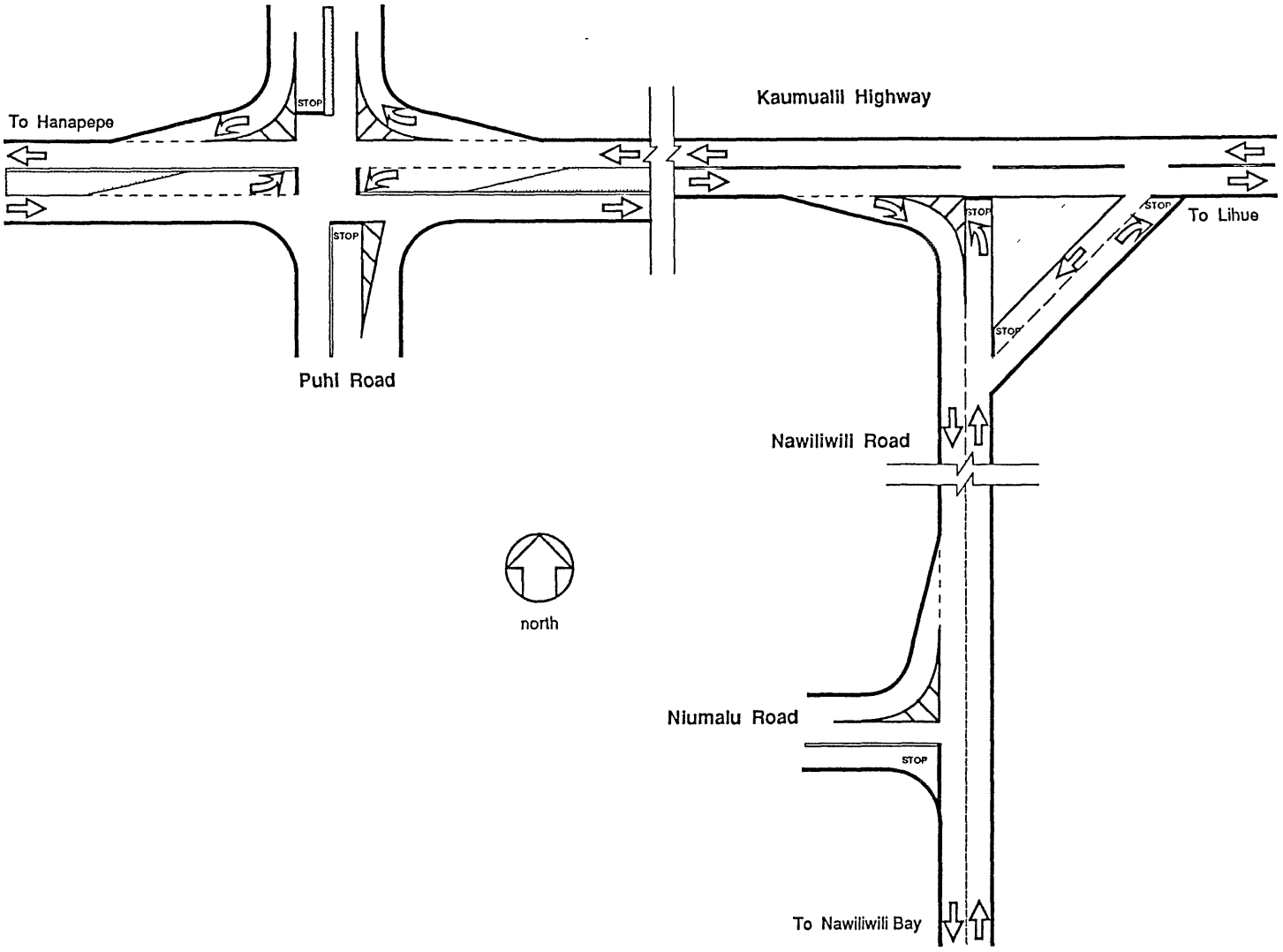


Figure 3. Study Intersections

The other vehicular access to the existing development is from the direction of Nawiliwili Harbor on Nawiliwili Road (Route 58). Nawiliwili Road is a State maintained two-lane minor arterial which runs in a northwest-southeast direction connecting Nawiliwili Harbor with Kaumualii Highway. It has two 12-foot lanes with 4-foot stabilized and 10-foot unpaved shoulders on each side. The posted speed limit is 50 miles per hour. The intersection of Nawiliwili Road with Kaumualii Highway is stop-controlled at the Nawiliwili approach.

Puhi Road is a two-lane County road that forms a four-way unsignalized intersection, as shown in Figure 3, with Kaumualii Highway and the access to the Kauai Community College. Presently, Puhi Road provides access to commercial and industrial areas near the highway and to the sugar cane fields beyond. Past the industrial areas, Puhi Road narrows almost to a single lane width.

Nuhou Road is a narrow two-way road generally used for hauling sugar cane. Presently, Nuhou Road intersects Puhi Road South of Kaumualii Highway and heads West parallel to the highway. Nuhou Road then curves southeastward just before the planned Kukui Grove commercial area toward Nawiliwili Harbor. Nuhou intersects Niumalu Road and then Nawiliwili Road about one-half mile from Waapa Road.

Traffic Conditions

DOT traffic count data indicates that peak traffic on Kaumualii Highway between Nawiliwili Road and Puhi Road occurs during the afternoon, generally between 3:30 and 4:30 pm on a weekday. Manual turning movement traffic counts were taken by Pacific Planning & Engineering (PPE) at the intersections of Kaumualii Highway with Nawiliwili Road, Kaumualii Highway with Puhi Road, and Nawiliwili Road with Waapa Road during the afternoon peak hour on Monday, November 21, 1988.

The weather conditions were cloudy, with occasional heavy rain. The recorded volumes are shown in Figure 4. The existing traffic volumes were analyzed to determine their level-of-service, utilizing the analysis techniques for unsignalized intersections from the Highway Capacity Manual. The results are discussed in the chapter titled "Traffic Impact Analysis".

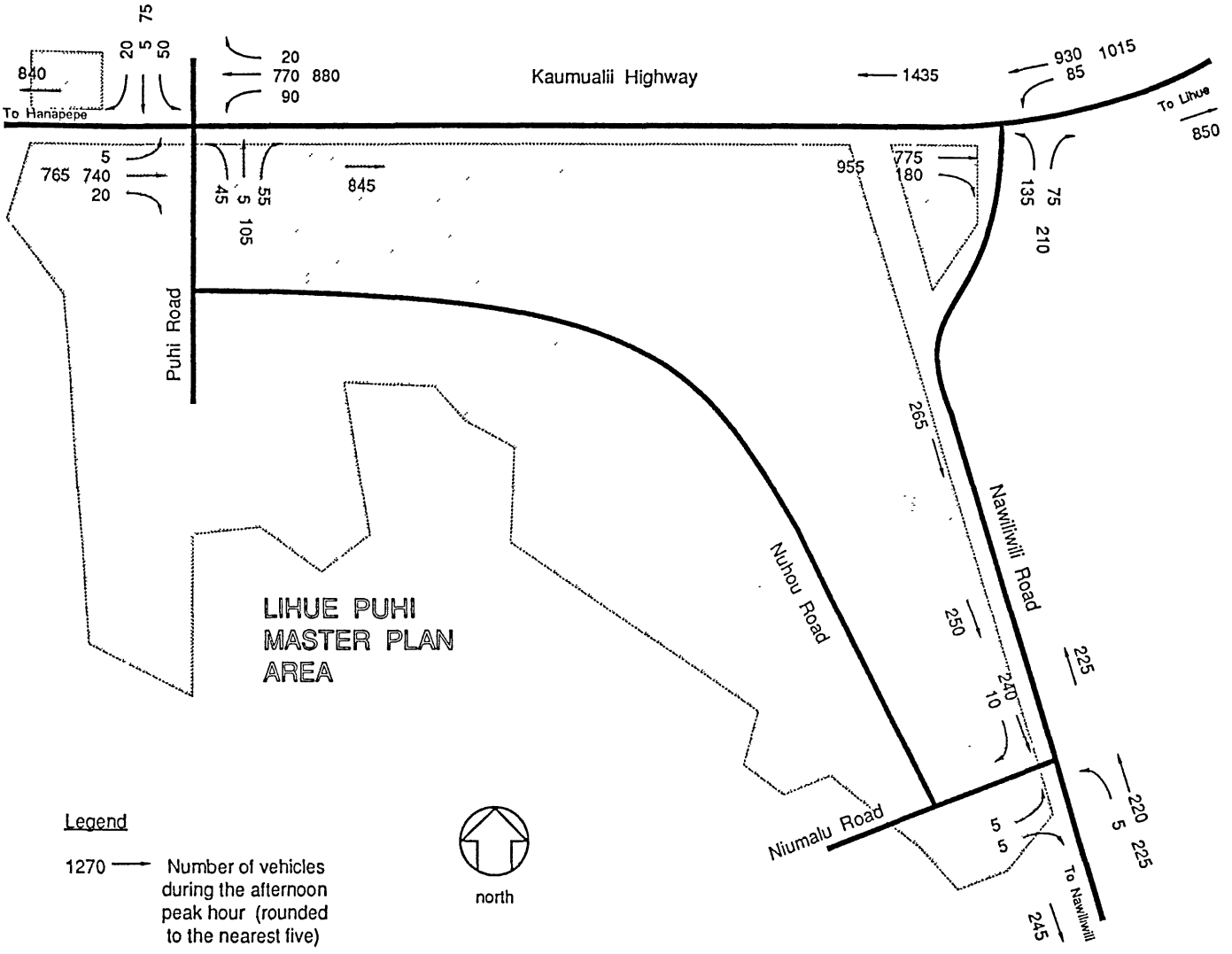


Figure 4. Existing Traffic Volumes 1988 Afternoon Peak Hour

Comparing the afternoon peak hour volumes recorded on the field survey with those obtained from the DOT, taken in 1987, generally show that traffic volumes increased over the one year period. Traffic volume on Nawiliwili Road increased considerably more than the other roadways probably due to the completion of the extension of Kapule Highway from Ahukini Road to Kuhio Highway near Hanamaulu.

The Kapule Highway Extension allows drivers to bypass Hanamaulu and Lihue Town from Kuhio Highway the North to end Rice Street in Nawiliwili on the South. The successful use of the bypass highway is reflected in the increase traffic observed on Nawiliwili Highway and Waapa Road. At Kaumualii Highway, Nawiliwili Road's traffic volume increased by about 50% and at Waapa Road, it increased by about 100% over the one year period.

On Kaumualii Highway the westbound traffic was slightly more (52%) than the eastbound traffic (48%) at both intersections of Nawiliwili and Puhi Roads. About 20% of the eastbound traffic on Kaumualii Highway turned right onto Nawiliwili Road and about 64% of the traffic on Nawiliwili Road, northbound, turned left to head westward on Kaumualii Highway.

All left turn movements from minor roads along Kaumualii were observed to be difficult due to heavy traffic volumes in each direction on the Highway. This was especially evident at the Nawiliwili Road and Puhi Road intersections with Kaumualii Highway. Vehicles attempting left turns at these two intersections encountered long delays. The next most troublesome movement was the left turn from Kaumualii Highway onto the minor roads. This movement was slightly easier due to platooning of vehicles in the opposing lane.

FUTURE CONDITIONS

Area Conditions

Kauai Community College, according to the its planning projections, is not expected to exceed 25% growth in enrollment by the year 2005. No other significant developments were identified in our research that would affect the traffic conditions through the study area, aside from traffic generated by the Project itself.

Roadway Facilities

The Department of Transportation is planning to realign Nawiliwili Road between the Kukui Grove Center and the Kukui Grove Commercial Village and relocate the present intersection with Kaumualii Highway slightly to the West. The new intersection will be signalized with exclusive turn lanes. The project is presently under design and is expected to be completed early 1991 by the DOT. Figure 5 shows the future roadway plans in the project area.

There are no other definite plans for improvement of major roadways near the project site. Previous studies have recommended improvements to the nearby roads but there are no definite plans to initiate such improvements.

The project's internal roadway plan will realign and extend some of the existing roads within the project site. Nuhou Road will be realigned to intersect Kaumualii Highway about midway between Nawiliwili Road and Puhi Road. Nuhou Road will function as a collector road for local traffic between Kaumualii Highway and Nawiliwili Harbor. Aakukui Road will be extended from Puhi Road to connect Nuhou Road providing access to the Puhi area.

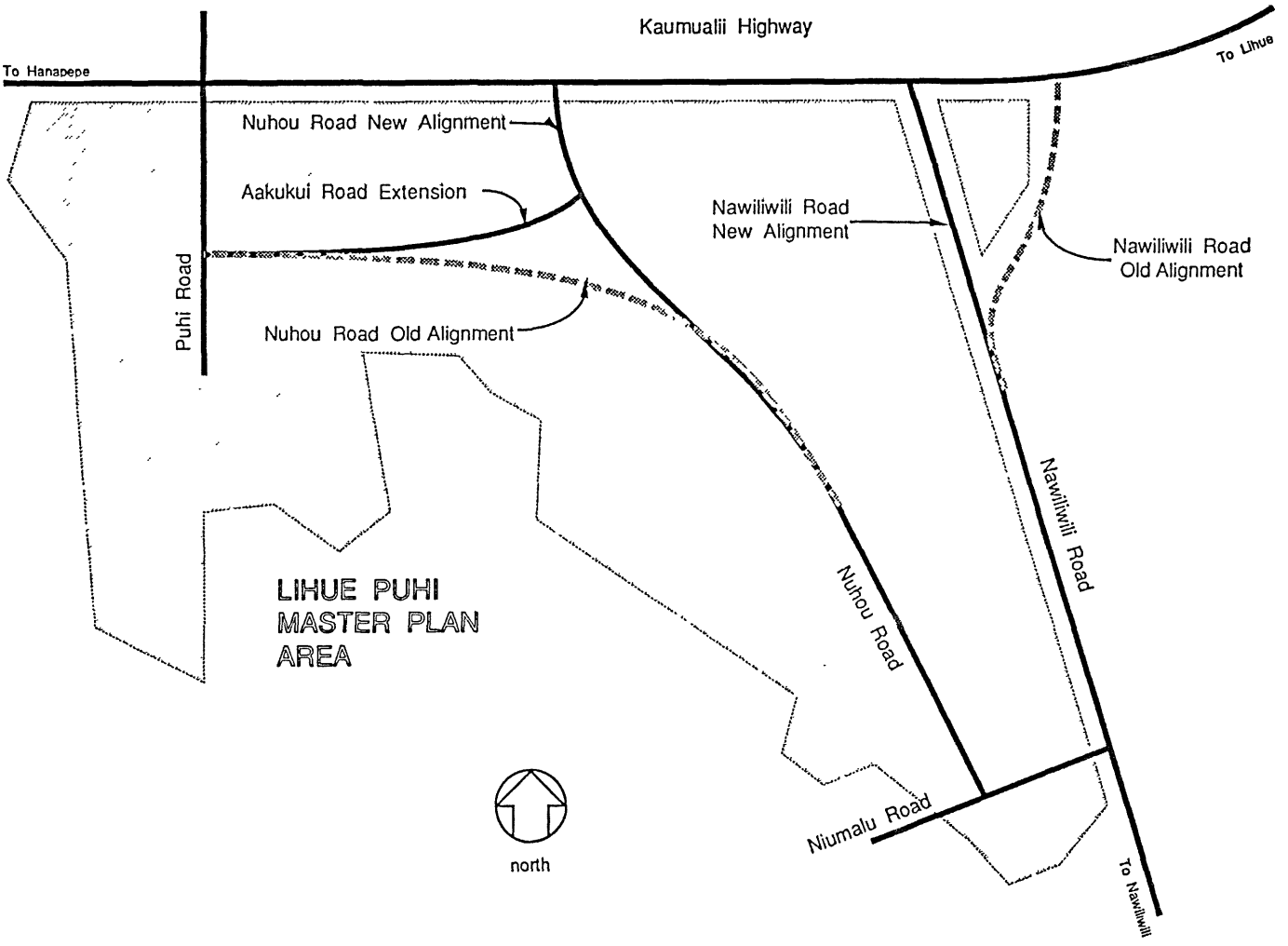


Figure 5. Future Roadway Network

Recommendations from Previous Studies

One of the recommendations is the widening of Kaumualii Highway to four lanes between Puhi and Lihue. This was included in the Lihue Development Plan prepared by EDAW, Inc. and Muroda and Associates, Inc. in 1976. They further recommended the widening of Rice Street between Kapule Highway and Nawiliwili Road.

The traffic study completed in conjunction with the Environmental Impact Statement for Grove Farm Properties, Inc., Proposed Lihue/Puhi Master Plan, completed in 1986 by Belt Collins and Associates, Inc. recommended several improvements by the year 2000. First, the signalization of the proposed extension of Nawiliwili Road to Kaumualii Highway between the Shopping Center. Second, to improve Kaumualii Highway between Lihue and Puhi to accommodate the future traffic increases. And last, to signalize the intersection of Kaumualii Highway with Puhi Road which provides access to the Community College.

The "Lihue Traffic Circulation Study" by Austin Tsutsumi & Associates, recommended widening Kaumualii Highway to four lanes, two in each direction, between Kuhio Highway and Puhi. This improvement would be needed by around the Year 1996.

PROJECTED TRAFFIC

Traffic conditions *without* and *with* the project were estimated for the year 2000, when the project is assumed to be fully occupied. Future traffic on Kaumualii Highway and Nawiliwili Road was estimated based on the expected growth of Kauai. Project generated traffic was estimated by using trip generation data from similar types of land uses.

Year 2000 Traffic on Kaumualii Highway

Future traffic on Kaumualii Highway in the year 2000 was forecasted using a model which incorporates the standard methods of trip generation, trip distribution, and traffic assignment to estimate the traffic without and with the project. The model estimates traffic based on the amount and location population and jobs on Kauai.

Traffic on Kauai is expected to increase with projected increases in population and jobs. In 1987, there was approximately 47,400 people and 22,750 jobs, respectively, on Kauai. By the year 2000, these totals are projected to rise to 68,200 people and 34,200 jobs, an increase of 44% and 50%, respectively. Population and jobs are directly related to vehicle trip generation.

The number of trips were estimated using Year 2000 population and employment forecasts for Kauai and average trip production and attraction rates. These rates were adjusted to account for the special trip production or attractions characteristics of the Waimea, Koloa, Lihue, Kawaihau, and Hanalei District areas. The average trip production and attraction rates are shown on Table 3.

Table 3. Vehicle Generation Rates--Afternoon Peak Hour

Predictor Variable	Trip Productions From an Area	Trip Attractions To an Area
Population	0.06[1]	0.14
Employment	0.35[2]	0.28

[1]Vehicle trips/hour per person
[2]Vehicle trips/hour per employee

Locations and amounts of existing population and jobs for the Year 1987 were based on the "Kauai County Transportation Planning Study - Technical Memoranda" by Kaku Associates. Future population and job projections for the year 2000 were based on projections by the Department of Business and Economic Development. Locations for future growth in residences and employment areas were estimated based on information from the Kauai County Planning Department. The information along with discussions with the County planners, formed the basis for forecasting future traffic on Kaumualii Highway. The trip generation rates were based on data compiled by the Institute of Transportation Engineers.

The trip distribution step assigns trips to their expected origins and destinations. Trips were distributed to and from all districts using the *Gravity Model.* This model is based on the assumption that all trips "produced" from a given area are attracted to all areas in direct proportion to the "attractions" at each area and in inverse proportion to the travel impedance separating the areas.

Some example attractions that people would make trips for are jobs, shopping, and recreation. An example producer of trips is the home. The travel impedance is related to human behavior and is based on estimated travel times between districts. The more difficult the trip (long distance or travel time) the less likely a driver would make the trip.

The gravity model can be mathematically expressed as:

$$T_{ij} = P_i \frac{A_j F_{ij}}{\sum_{j=1}^{n} A_j F_{ij}}$$

where,

T_{ij} = trips produced in analysis area i, and attracted to analysis area j;
P_i = total trip production at i;
A_j = total trip attraction at j;
F_{ij} = friction factor for trip interchange ij;
i = origin analysis area number, $i = 1, 2, 3, \ldots n$;
j = destination analysis area number, $j = 1, 2, 3, \ldots n$;
n = number of analysis areas.

The traffic assignment step assigns trips to a specific route on the roadway network that will take the driver from origin to destination. All traffic between districts was assigned to Kaumualii Highway, the only major highway connecting the districts and the major population centers on Kauai.

Actual 1987 traffic counts at the boundaries of each district were compared against trips forecasted by the model for 1987. The model was refined to achieve a relatively close match of 1987 actual volumes. The travel times or trip generation rates were modified slightly to achieve the close match, with reasonableness checks on relative times and area characteristics.

The model was run for conditions without and with the project. The results indicate that by the year 2000, traffic on Kaumualii Highway just West of Puhi will increase to about 1330 vehicles in the westbound direction and 840 vehicles in the eastbound direction without the project. With the project, traffic on Kaumualii Highway will increase to about 1290 vehicles in the westbound direction and 870 vehicles in the eastbound direction.

Project Generated Traffic

The standard three-step procedure of trip generation, distribution and assignment was applied to forecast future peak hour traffic from the proposed 608-acre development and the rest of the Lihue Puhi Master Plan area.

The trip generation step calculates the number of trips which would be generated during the afternoon peak hour by the developments in the Lihue Puhi Master Plan area. The resultant number of trips and the unit rates are shown in Table 4. The number of trips were estimated from:

- Average Trip Rates (for Peak Hour Traffic)
  Based on data from the Trip Generation Report (Fourth edition, 1987)
  by the Institute of Transportation Engineers (ITE).
- Type and amount of Land Uses for the Project and the Lihue Puhi Master Plan.

The trip distribution step assigns trips to their expected origins and destinations. Trips to and from the project were distributed using the location of population. Approximately 62% of the trips were distributed to and from the Lihue direction and 38% were distributed to and from the Koloa direction.

The traffic assignment step assigns trips to a specific route on the roadway network that will take the driver from origin to destination. The assignments were base on the shortest travel routes between origins and destinations. All project traffic was assigned to Kaumualii Highway, Nawiliwili Road, and the internal roadway network. The forecasted traffic volumes without and with the project were added to the project generated volumes to obtain the forecast volumes shown in Figures 6 and 7.

Table 4. Trip Generation

Existing Uses - 340 acre Urban Use Area

Land Use	Units	Adjusted Rates Enter	Exit	No. of Trips Enter	Exit
Commercial					
Kukui Grove Shopping Center	300,000 sf	1.81	2.04	543	612
Kukui Grove Village	201,000 sf	0.25	1.69	51	340
Kukui Grove Village West	400,000 sf	0.175	1.16	70	466
Commercial Recreation	6 acres	5.00	5.00	30	30
Puhi Neighborhood Commercial	10 acres	3.00	13.60	30	136
Industrial	88 acres	2.19	8.26	193	727
Single-Family Dwelling	408 units	0.67	0.39	280	164
Multi-Family Dwelling	35 units	0.49	0.26	17	9
Total Number of Trip Ends				1214	2484

Proposed Uses - 608 acre Area

Land Use	Units	Adjusted Rates Enter	Exit	No. of Trips Enter	Exit
Single Family Dwelling	940 units	0.67	0.39	632	371
Multi-Family Dwelling	1,021 units	0.36	0.21	369	216
Kukui Grove Shopping Center Expansion	120,100 sf	2.71	3.05	325	366
Commercial	21.5 acres	2.98	13.70	64	294
Golf Courses	236.5 acres	0.02	0.20	4	47
Total Number of Trip Ends				1394	1294

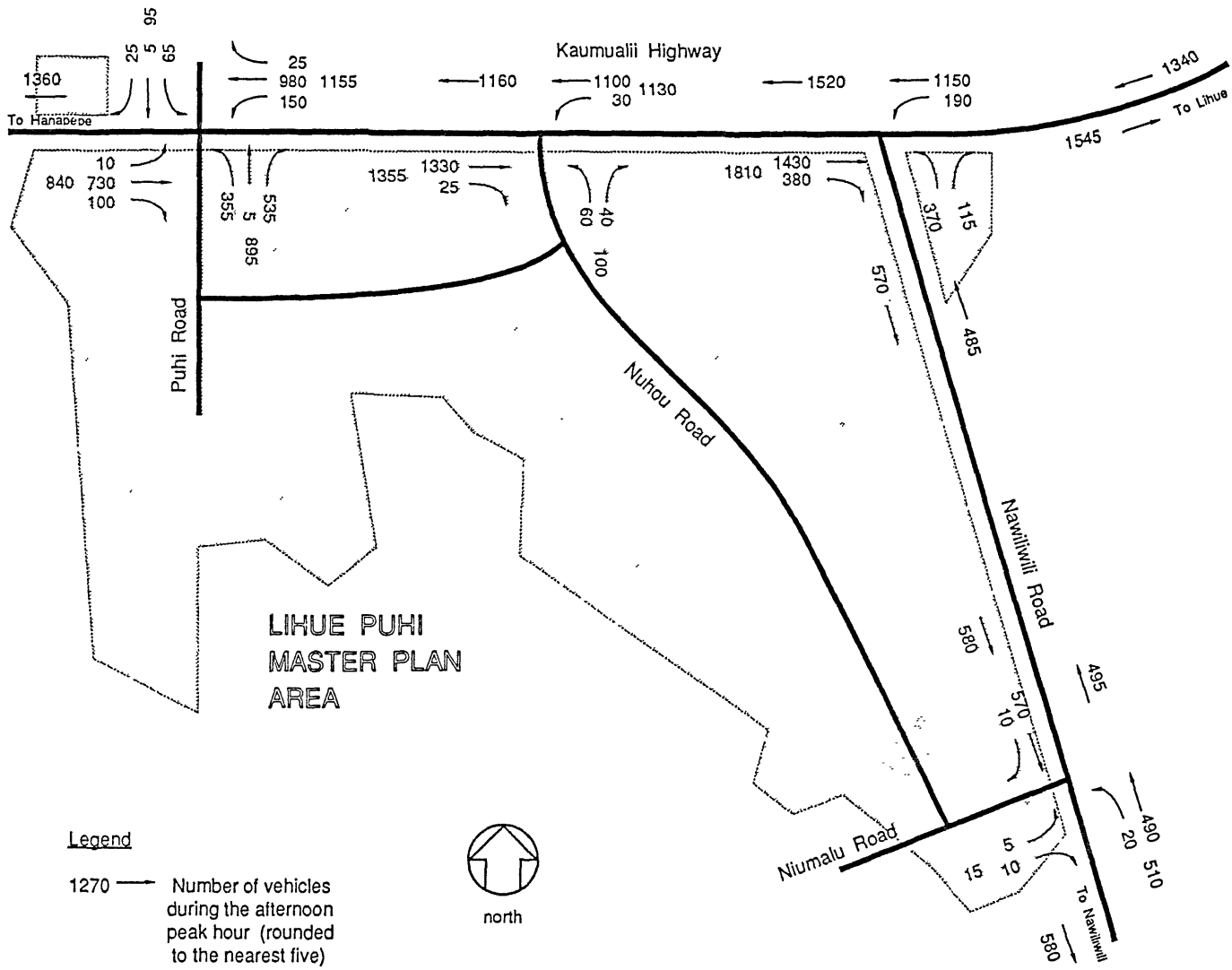


Figure 6. Year 2000 Traffic Without 608-Acre Development

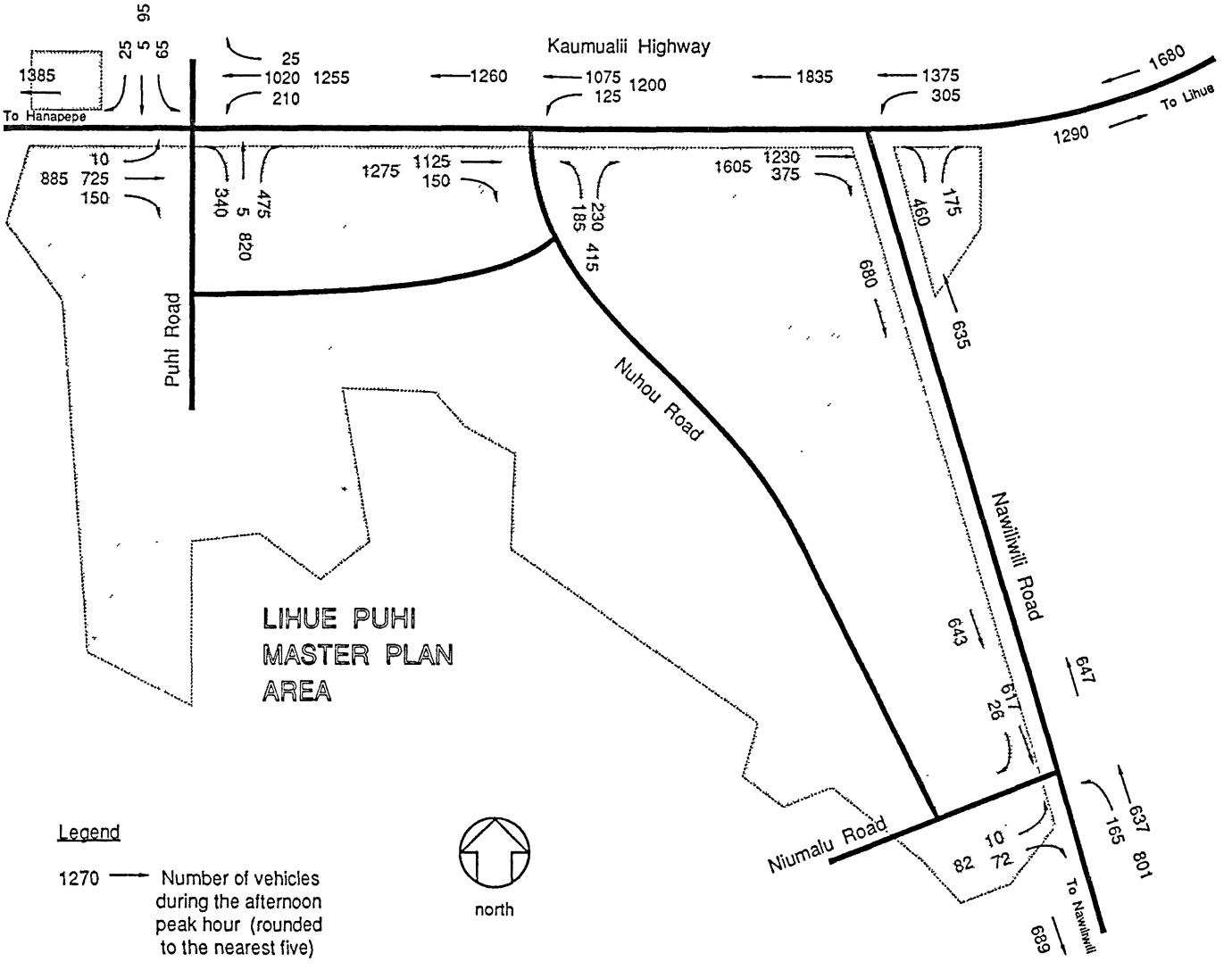


Figure 7. Year 2000 Traffic With 608-Acre Development

Kaumualii Highway and Nawiliwili Road

Impacts from the proposed project were measured by the change in the traffic's level-of-service of Kaumualii Highway and Nawiliwili Road without and with the project. The capacity of these roads was estimated in accordance with the latest Highway Capacity Manual, Special Report 209 (1986) analysis techniques. Kaumualii Highway (between Nawiliwili Road and Puhi Road) and Nawiliwili Road (between Kaumualii Highway and Niumalu Road) were analyzed for the existing, future ambient, and total forecast traffic volumes.

Level-of-service is classified into six categories ranging from LOS A, where motorists can drive at their desired speed, to LOS F, where motorists experience heavily congested flow with traffic demand exceeding capacity. The capacity of a two-lane rural road occurs at LOS E. The definition of LOS for two-lane rural highways is given in Appendix A.

The present estimated capacity of the two-lane Kaumualii Highway is about 2200 vehicles per hour in both directions during the afternoon peak hour. The estimated capacity of Nawiliwili Road is about 1900 vehicles per hour. The results of the analysis are shown in Table 5 below.

Table 5. Level-of-Service of Kaumualii Highway During Afternoon Peak Hour

	1989		2000 Without Project		2000 With Project	
	Volume	LOS	Volume	LOS	Volume	LOS
Kaumualii (2 Lanes)	1750	E	2500	F	2560	F
Kaumualii (4 Lanes)	n/a	n/a	2500	D	2560	D
Nawiliwili (2 Lanes)	480	C	1080	E	1290	E

The results of the analysis show that even without the project, Kaumualii Highway will be over capacity by the Year 2000. With Kaumualii Highway widened to four lanes, the capacity of the highway is increased to about 3800 vehicles per hour and would operate below capacity. Nawiliwili Road will remain below capacity to the Year 2000.

Study Intersections

Impacts from the proposed project were measured by the change in level of service (LOS) for specific turning movements *with* and *without* the project. The existing traffic volumes, the ambient traffic volumes, and the total forecast traffic volumes were analyzed. The analysis was done for two conditions, Kaumualii Highway with two lanes and with four lanes. These traffic conditions are shown in Figures 5, 6, and 7, respectively.

Impacts on traffic resulting from the proposed 608 acre expansion were measured by the Level-of-Service (LOS) at the intersections of Kaumualii Highway with Nawiliwili Road, Nuhou Road, and Puhi Road. The analysis was done for unsignalized intersections in accordance with the latest TRB Highway Capacity Manual, Special Report 209 (1986) analysis techniques. The methodology yields levels of service ranging from A to F (summarized in Appendix A).

The LOS for the traffic movements at an intersection is classified into six categories ranging from little or no delay (LOS A) to extreme delays (LOS F). Quantitative values of delay have not been associated with the level-of-service for unsignalized intersections. The results of the analysis are summarized on Table 6.

The analysis indicates that drivers on Nawiliwili Road and Puhi Road presently experience very long to extreme delays in attempting to cross or make left-turns onto Kaumualii Highway. The left-turn and through movements from Puhi Road are calculated to operate at LOS E. The left-turn movement from Nawiliwili Road is calculated to operate at LOS F.

LOS F is also an indication that traffic improvements for an intersection should be investigated. Traffic volumes at the intersection of Kaumualii Highway with Nawiliwili Road and Puhi Road exceed the minimum vehicular volumes that warrants signalization. Hence, presently, traffic signals could be warranted at the intersections of Kaumualii Highway with Nawiliwili Road and Puhi Road to reduce delays on minor roads. (The decision to install signals is based on judgement of other conditions beyond volume warrants.)

By the Year 2000 *even without* the 608 acre expansion, the LOS for traffic attempting to cross or make a left-turn onto Kaumualii Highway will worsen. The LOS for left-turns out of Puhi Road onto Kaumualii Highway will drop from LOS E to LOS F. The LOS for right-turns out of Nawiliwili Road onto Kaumualii Highway will drop from LOS A to LOS D and left-turns from Kaumualii Highway onto Nawiliwili Road will drop from LOS B to LOS F. The drop in level-of-service is mainly due to the increase volume of traffic on Kaumualii Highway.

With the 608 acre expansion, the LOS for traffic attempting to cross or make a left-turn onto Kaumualii Highway will worsen slightly due to increased traffic from the project. Traffic on the minor roads (Nawiliwili, Nuhou, and Puhi) attempting to enter Kaumualii Highway are expected to experience extreme delays. Thus, traffic signals could be justified at these intersections to reduce delay.

At the intersection of Nawiliwili Road and Niumalu Road, drivers presently experience very good level-of-service, little or no delays, . By the Year 2000 without the project, the intersection will continue to operate at very good LOS except for the left turn movement out of Niumalu Road onto Nawiliwili Road which will drop from LOS B (little delay) to LOS C (average delays). In the Year 2000 with the project, the LOS for the left turn movement will drop from LOS C to D (long delays).

Signalization of Study Intersections

Due to the expected delays for the minor streets, the study intersections were analyzed as signalized intersections for two and four lane conditions on Kaumualii Highway. The Planning Analysis technique from the HCM was used to estimate the capacity of the signalized intersections.

Planning analysis uses an intersection's critical volume to determine whether an intersection will be over, near, or under capacity. The critical volume measures intersection capacity using the volume of conflicting traffic movements. A critical volume of less than 1200 vehicles indicates that an intersection is under capacity, between 1200 and 1400 vehicles indicates near capacity, and greater than 1400 vehicles indicates over capacity.

The results of the analysis, shown in Table 7, indicate that if Kaumualii Highway remains a two lane highway the signalized intersections would operate near or over capacity both with and without the project. If Kaumualii Highway is widened to four lanes, the study intersections could operate under capacity, indicating that intersections require four lanes to successfully accommodate the increased in traffic on Kaumualii Highway.

Table 6. LEVEL OF SERVICE SUMMARY

Unsignalized Intersections

		1989	2000 Without Project	2000 With Project
Kaumualii Highway - Nawiliwili Road				
Nawiliwili Road	LT	F	F	F
	RT	A	D	D
Kaumualii Highway	LT	B	F	F
Kaumualii Highway - Nuhou Road				
Nuhou Road	LT	n/a	F	F
	RT	n/a	B	D
Kaumualii Highway	LT	n/a	D	E
Kaumualii Highway - Puhi Road				
Puhi Road				
Southbound	LT	E	F	F
	TH	E	E	E
	RT	B	E	D
Northbound	LT	E	F	F
	TH	E	E	E
	RT	B	A	A
Kaumualii Highway				
Eastbound	LT	A	B	C
Westbound	LT	A	C	D
Nawiliwili Road - Niumalu Road				
Niumalu Road	LT	B	D	E
	RT	A	A	A
Nawiliwili Road	LT	A	A	A

Table 7. Critical Volumes and Capacity Level

Planning Analysis--Signalized Intersection

Two-lane Undivided Kaumualii Highway

	2000 w/o 608-Acres		2000 w/ 608-Acres	
Intersection	Critical Vol.	Capacity Level	Critical Vol.	Capacity Level
Kaumualii @ Nawiliwili	1985	Over	2000	Over
Kaumualii @ Nuhou	1410	Over	1435	Over
Kaumualii @ Puhi	1455	Over	1460	Over

Critical Volumes and Capacity Level

Planning Analysis--Signalized Intersection

Four-lane Divided Kaumualii Highway

	2000 w/o 608-Acres		2000 w/ 608-Acres	
Intersection	Critical Vol.	Capacity Level	Critical Vol.	Capacity Level
Kaumualii @ Nawiliwili	1090	Under	1155	Under
Kaumualii @ Nuhou	750	Under	950	Under
Kaumualii @ Puhi	1030	Under	1075	Under

CONCLUSIONS AND RECOMMENDATIONS

Even without the 608-acre development, we find that traffic along Kaumualii Highway is expected to be congested as a two-lane highway by the Year 1996. This Report therefore assumes that Kaumualii Highway will be widened to four lanes by the Year 1996. Previous studies have also shown the need to widen Kaumualii Highway to four lanes.

The results of our analysis also indicate that even without the project in the Year 2000, drivers from side-streets such as Nawiliwili Road and Puhi Road, will experience severe delays crossing or entering Kaumualii Highway if the intersections are not signalized. If unsignalized, left-turning traffic will encounter level-of-service (LOS) F, meaning unacceptable delays during the afternoon peak hour. If signalized, the study intersections would operate under capacity *with* a four lane Kaumualii Highway in the Year 2000.

With the 608-acre development, traffic will increase from the side-streets (Puhi Road, Nuhou Road, etc.) to Kaumualii Highway causing the LOS for traffic movements entering and exiting the side-streets to worsen. The intersections of Kaumualii Highway with Nuhou Road and Kaumualii Highway with Puhi Road to need to be signalized to prevent severe traffic delays to vehicles entering or exiting the project:

To mitigate the impacts of the proposed project, provide for a smooth traffic operation, and to prevent the LOS dropping below acceptable levels, the following phased improvements are recommended:

1. Fully channelize the intersection of Kaumualii Highway with Nuhou Road and provide exclusive left-turn lanes on all approaches,
2. Signalize the intersections of Kaumualii Highway with Nuhou Road and Kaumualii Highway with Puhi Road when future traffic volumes meet signal warrants,
3. Implement speed control zones on approaches to intersections for safety,
4. Reduce speed limit on Kaumualii Highway from 50 to 35 miles per hour between Nawiliwili Road and Puhi Road, and

5. Reduce speed limit on Nawiliwili Road from 50 to 35 miles per hour between Kaumualii Highway and Niumalu Road.

The major trip generator/attractor on Kauai is the job center in Lihue. The effect of locating residential units as close to Lihue as the proposed project means the reduction of traffic on other roadways serving outlying areas. If the proposed homes were located in areas North of Wailua up to 800 vehicles (two-way) during the afternoon peak hour would be added to Kuhio Highway traffic between Lihue and the hypothetical site. As we have found in other studies such as for Kapolei City, locating employment centers and residential areas closer together minimizes regional commuting impacts.

APPENDIX A

Definition of Level-of-Service
for
Unsignalized Intersections
and
Highways

APPENDIX A
DEFINITION OF LEVEL-OF-SERVICE FOR UNSIGNALIZED INTERSECTIONS

For unsignalized intersections, the traffic most impacted will be the minor or cross-street with the stop or yield control. The major roadway will have the right-of-way. The level-of-service is the amount of delay expected for the average vehicle desiring to cross or enter the major road. The following gives a general description of the measure.

The concept of levels of service is defined as a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers. A level of service definition generally describes these conditions in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Six levels of service are defined for each type of facility for which analysis procedures are available. They are given letter designations, from A to F, with level-of-service A representing the best operating conditions and level-of-service F the worst.

Level-of-Service definitions--In general, the various levels of service are defined as follows for uninterrupted flow facilities:

Level-of-service A represents free flow. Individual users are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to maneuver within the traffic stream is extremely high. The general level of comfort and convenience provided to the motorist, passenger, or pedestrian is excellent.

Level-of-service B is in the range of stable flow, but the presence of other users in the traffic stream begins to be noticeable. Freedom to select desired speeds is relatively unaffected, but there is slight decline in the freedom to maneuver within the traffic stream from LOS A. The level of comfort and convenience provided is somewhat less than at LOS A, because the presence of others in the traffic stream begins to affect individual behavior.

Level-of-service C is in the range of stable flow, but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by

DEFINITION OF LEVEL-OF-SERVICE FOR HIGHWAYS

The highest quality of traffic service occurs when motorists are able to drive at their desire speed. Without strict enforcement, this highest quality, representative of *level-of-service A,* would result in average speeds approaching 60 mph on two-lane highways. ...almost no platoons of three or more vehicles are observed. Drivers would be delayed no more than 30 percent of the time by slow-moving vehicles.

Level-of-service B characterizes the region of traffic flow wherein speeds of 55 mph or slightly higher are expected on level terrain. Drivers are delayed up to 45 percent of the time on the average.

Level-of-service C results in noticeable increases in platoon formation, platoon size, and frequency of passing impediment. Average speed still exceeds 52 mph on level terrain... While traffic flow is stable, it is becoming susceptible to congestion due to turning traffic and slow-moving vehicles.

Level-of-service D traffic approaches unstable traffic flow. ...passing becomes extremely difficult. Mean platoon sizes of 5 to 10 vehicles are common, although speeds of 50 mph can be maintained under ideal conditions. Maximum service flow rates of 1,800 passenger cars per hour, total in both directions, can be maintained under ideal conditions. This is the highest flow rate that can be maintained for any length of time over an extended section of level terrain without a high probability of breakdown.

Level-of-service E is defined as traffic flow conditions having a percent time delay of greater than 75 percent. Passing is virtually impossible under these conditions, and platooning becomes intense when slower vehicles or other interruptions are encountered. The highest attainable volume under E is the capacity of the highway. Under ideal conditions, capacity is 2800 pcph, total in both directions. This value decreases as the directional split of traffic changes from a 50/50 split to 0/100.

When traffic demand exceeds capacity, *Level-of-service F* is heavily congested flow. Volumes are lower than capacity, and speeds are below capacity speed.

REFERENCE: Highway Capacity Manual (Special Report 209, 1985)

interactions with others in the traffic stream. The selection of speed is now affected by the presence of others, and maneuvering within the traffic stream requires substantial vigilance on the part of the user. The general level of comfort and convenience declines noticeably at this level.

Level-of-service D represents high-density, but stable, flow. Speed and freedom to maneuver are severely restricted, and the driver or pedestrian experiences a generally poor level of comfort and convenience. Small increases in traffic flow will generally cause operational problems at this level.

Level-of-service E represents operating conditions at or near the capacity level. All speeds are reduced to a low, but relatively uniform value. Freedom to maneuver within the traffic stream is extremely difficult, and it is generally accomplished by forcing a vehicle or pedestrian to "give way" to accommodate such maneuver. Comfort and convenience levels are extremely poor, and driver or pedestrian frustration is generally high. Operations at this level are usually unstable, because small increases in flow or minor perturbations within the traffic stream will cause breakdowns.

Level-of-service F is used to define forced or breakdown flow. This condition exists wherever the amount of traffic approaching a point exceeds the amount which can traverse the point. Queues form behind such locations. Operations within the queue are characterized by stop-and-go wave, and they are extremely unstable. Vehicles may progress at reasonable speeds for several hundred feet or more, then be required to stop in a cyclic fashion. Level-of-service F is used to describe the operating conditions within the queue, as well as the point of the breakdown. It should be noted, however, that in many cases operating conditions of the vehicles or pedestrians discharged from the queue may be quite good. Nevertheless, it is the point at which arrival flow exceeds discharge flow which causes the queue to form, and level-of-service F is an appropriate designation for such points.

These definitions are general and conceptual in nature, and they apply primarily to uninterrupted flow. Levels of service for interrupted flow facilities vary widely in terms of both the user's perception of service quality and the operational variables used to describe them.

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GROVE FARM PROPERTIES, INC.

BEFORE THE LAND USE COMMISSION

OF THE STATE OF HAWAII

In the Matter of the Petition of GROVE FARM PROPERTIES, INC. to Amend the Land Use District Boundary of Property Situated at Lihue, Island and County of Kauai, State of Hawaii.	DOCKET NO. A89-636 (GROVE FARM PROPERTIES, INC.) CERTIFICATE OF SERVICE (FOURTH AMENDMENT)

DML/042089/3186K(5&6)

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that on the date set forth below, a true and correct copy of the FOURTH AMENDMENT TO PETITION FOR LAND USE DISTRICT BOUNDARY AMENDMENT was duly served upon the those noted below by depositing unfiled copies of same in the United States Mail, postage prepaid, and addressed as follows::

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