

TRAFFIC FORECAST BASED ON ANTICIPATED LAND USE AND CURRENT TRAVEL HABITS

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SYNOPSIS

THIS PAPER presents a method used for forecasting traffic in the metropolitan area of San Juan, Puerto Rico, on the basis of anticipated land use and current travel habits. In Puerto Rico, land use is controlled by the Planning, Urbanizing, and Zoning Board through its zoning regulations and master plans for development. It is possible to determine the probable distribution of population by sections, once the overall increase has been statistically determined.

Expansion factors determined were punched in trip cards from an origin-and-destination survey conducted in 1948 to produce the future travel pattern.

The principal steps followed in the procedures were: (1) determination of total trips to take place within the area; (2) determination of factors to punch in existing cards to yield the total trips; and (3) determination of final factors to alter the trip distribution in accordance with expected unequal changes in major traffic generators.

Total internal and external trips were determined separately by vehicle type. Internal auto driver and taxi trips were determined by applying current trip-generating characteristics to the future population. Internal truck trips were determined through the ratio that this type of trip bears to the total internal trips.

External zones were divided into three rings of decreasing traffic influence in the following sequence: suburbs, neighboring towns, and remaining external zones. The method of expansion varied for each group of zones. Trips to be generated by the suburbs were arrived at by applying to their future population present trip-generating characteristics of similar areas. The number of these trips to cross the inner area cordon were estimated on the basis of present trip behavior. Trips to and from neighboring towns were expanded using the 1970÷1948 population ratio of the town in question and trips to and from the remaining external zones were estimated by expanding 1948 trips by a uniform factor.

From previous estimates the future size of central business districts, industrial areas, port facilities, and other major traffic generators were obtained and trips destined to these areas were proportionately redistributed. In cases where from the original estimate the number of trips having termini in an area, for certain specific purposes, exceeded a determinate amount, these were reduced by re-adjusting the expansion factor. The trips thus deducted were transferred to areas where there was a deficiency by duplicating the original cards changing the code of origin or destination. The expansion factors punched in the duplicated cards was such that the original trip total was not altered. After this final step the set of cards available had all the needed trip data and were ready for analysis.

While developing the procedures certain minor assumptions were made for the sake of simplifying the work. With the data obtained, a route analysis was made which served as a check of the adaptableness of the expansion method used. The forecast yielded results compatible with the accuracy expected in any long-term projection.

● TECHNIQUES for conducting origin-destination surveys to obtain total traffic flow within an area have been highly developed. Great strides have also been made in the processing and analysing of the information thus obtained. However, the results achieved in the development of methods for expanding the

data to the future have not been entirely satisfactory. The greatest difficulty lies in the determination of a method which would correlate future land use with traffic generation and which would lend itself to analysis by mechanical means.

In Puerto Rico, where a comprehensive

origin-destination survey was conducted in the metropolitan area of San Juan in the summer of 1948, the final report did not receive the wholehearted acceptance that it merited due to the method followed in projecting the data to 1970. In the original study, it was determined that traffic as a whole would increase by 126 percent from 1948 to 1970. This percentage increase was applied uniformly to all facilities. The application of a uniform traffic-increase factor over the whole area does not take into consideration the changes caused in the traffic pattern by the unequal growth of various sections and the changes in land use accompanying the development of the area.

In order to arrive at a more realistic forecast of future traffic, it was decided to correlate the present traffic-generating characteristics of various land uses with the estimated land use and population distribution for the area in 1970.

Land use in Puerto Rico is controlled by the Puerto Rico Planning, Urbanizing, and Zoning Board, henceforth referred to as the *planning board*, through its zoning regulations and master plans for development. Through the zoning control of population density, it is possible to determine the probable distribution of population by sections, once the overall increase has been statistically determined. Both this probable population distribution and land use served as the basis for the procedures developed in this report.

DATA USED IN FORECAST

Before embarking in the procedures, it was determined that certain basic information was necessary. Some was available from the original O.D. study, other had already been estimated by the planning board and was at our disposal.

The most important data used is described briefly below:

Estimated 1970 Population Distribution. The 1970 population of the internal area, distributed by O.D. zones, was determined from a 1970 population map prepared by the planning board in which the population was subdivided by small areas similar to census tracts. This map also supplied the estimated 1970 population of the suburbs and the neighboring towns.

Classification of the Estimated 1970 Popula-

tion. This was determined from the Plans for Improvement and Land Use prepared by the planning board. This map shows residential districts of various types, classified commercial and industrial areas and areas left for public use and for future development.

Tabulations from the 1948 San Juan O.D. Study. (1) Dwelling unit information by sub-zones. This tabulation shows all the information contained in the dwelling unit interview forms. From this the index of trips per person was determined and used in the procedures, while the remaining information served as a check of the 1948 classification of O.D. sub-zones.

(2) Trips by residents of each subzone by mode of travel and trip purpose. This served to determine the percent by mode of travel of all trips and percent by trip purpose of auto driver trips.

(3) Auto driver trips by residents of each zone by purpose. This was used to determine a factor for the trip cards by residents of each zone, by comparing with the 1970 auto-driver trips, once these were determined.

(4) Total internal vehicle trips by vehicle type. From this the percentage of 1948 total trips by each type of vehicle were determined. A knowledge of the ratio of internal truck trips to total internal trips was necessary for estimating 1970 internal truck trips.

(5) Trips by internal residents and by vehicles registered in the area, to and from suburbs and neighboring towns, by mode of travel, external zone of origin or destination, and card count. This was used in estimating 1970 trips to and from the suburbs and neighboring towns by residents of the internal area or by vehicles registered in the area.

(6) Total external trips to and from suburbs and neighboring towns by external zone of origin or destination, vehicle type and card count. The number of trips and cards were used as a base for determining 1970 expansion factors for trips to and from these areas.

(7) Trips to and from external zones not included in the preceding tables, by vehicle type and card count. To these trips a uniform factor of increase was applied to obtain 1970 trips.

(8) Total trips in and out of the study area and card count by vehicle type from Puerto Nuevo Supplementary O.D. study. This study was conducted in January 1950 and supplied

origin-and-destination data of trips by residents of this newly developed suburb. The trip cards from this study plus a limited number of cards already existing from the original study, with a suitable factor later determined, served to produce the estimated number of 1970 trips to and from this suburb.

(9) Total trips by internal subzone of destination, vehicle type and trip purpose. This tabulation served to estimate the approximate size of C.B.D.'s, industrial areas, etc. on the basis of trips attracted for certain specific purposes.

(10) Various other tabulations were used to check the estimates and for comparison purposes.

From the planning board and from other sources, data as to the location and approximate capacity of future port facilities, government center, industrial areas, and international airport, and the estimated commercial floor-space in existing business districts and estimated future size were obtained. These data were considered highly reliable and were accepted as accurate.

GENERAL METHODS USED IN FORECAST

The procedures which are about to be outlined are generally applicable, with reasonable limitations, to any area. The readiness with which this method can be applied depends on the character and amount of basic data available. Where the development of the area is controlled by zoning regulations, the determination of internal trips is simplified, since future land use can be readily estimated.

Estimates of future population are essential and to be directly usable, this population must be segregated by small units both within the cordon and in suburban areas.

The procedures used in the *1970 Traffic Forecast for the San Juan Metropolitan Area* can best be described by discussing briefly the successive steps followed in their application.

Throughout the application of the procedures, certain assumptions were made which are not specifically outlined. The ones considered more important are:

1. Traffic-generating characteristics of people within a specific economic group will not vary. This was implied when present traffic-generating characteristics were applied to the future population. This assumption was neces-

sary in the absence of more precise data that proved otherwise.

2. Residential districts will develop to their full extent by 1970 to the type restricted by zoning regulations. It was realized that this would not be exactly so; nevertheless, it was felt that the degree to which this is attained would be balanced among the many small units of population considered.

3. The ratio of internal truck trips to total internal trips will be the same in 1970 as in 1948. This was assumed because of the lack of precise statistical data from which to determine truck registration and trip trends.

4. Suburban areas will generate trips in accordance with the classification of the population residing there. The traffic-generating characteristics of this population will be similar to those of internal residents of a similar classification.

5. External trips to and from suburbs and neighboring towns by internal residents or by vehicles registered internally will vary as internal trips of a similar type. These trips constituted close to 2 percent of the total traffic in 1948.

6. Trips to and from neighboring towns not by internal residents or vehicles registered internally, will vary with the population of the town in question. The trips to and from the four places classified as neighboring towns constituted less than 6 percent of the total traffic in 1948.

7. Trips to and from other external areas will increase by 80 percent from 1948 to 1970. This was the percentage increase in traffic for the island as a whole determined in a forecast made in conjunction with the San Juan O.D. Study in which population, vehicle registration, gasoline consumption, and other economic factors were made use of. These trips constituted close to 18 percent of the total traffic in 1948 while in 1970 they will make up about an estimated 11 percent.

Three general steps were followed in the procedures: (1) determination of total 1970 trips in the area both internal and external by vehicle type; (2) determination of a factor to punch on existing trip cards to yield the total trips determined above; and (3) determination of a final factor to alter the trip distribution.

Since all trips are caused by people, either directly or indirectly, the 1970 estimated

population of the internal area, suburbs, adjacent towns and other external zones was used as a basis for determining total trips.

For the internal auto driver and taxi-publico driver trips, the population by O.D. zones and residential type was used in conjunction with traffic-generating characteristics by residential type as determined from the basic data of the San Juan O.D. study. Internal truck driver trips were determined by assuming the same proportion of this type of trip to total internal trips in 1970 as in 1948.

External trips were determined by dividing external zones into three rings of decreasing traffic influence thus: (1) suburbs, (2) neighboring towns, and (3) remaining external zones. Trips to and from the suburbs were determined by using the estimated 1970 population of the suburbs classified by residential type and applying to these traffic-generating characteristics of similar internal O.D. zones. Trips to and from neighboring towns were determined by obtaining from the O.D. data the number of trips between the town in question and the internal area, dividing these into trips by internal residents or by vehicles registered within the area and other, increasing the former trips by the same ratio of internal 1970 trips to 1948 by vehicle type, and the latter by the 1970 to 1948 population ratio of the town in question. Trips to and from remaining external zones were determined by applying a uniform factor of increase already estimated in the *Forecast of Vehicle Traffic for 1970* for the island as a whole made in conjunction with the San Juan O.D. Study.

Using 1970 internal and external trips by vehicle type, expansion factors to punch on existing trip cards were computed. If the cards were analyzed with these factors, a travel pattern similar to that of 1948 would result. The only variation in the travel pattern thus introduced would be that caused by unequal internal population increases, addition of new residential zones, and traffic increases at the external stations.

Additional changes were required to obtain a more rational trip distribution. This was accomplished by computing a new factor which would take care of unequal changes expected in certain specific traffic generators, such as central business districts, port facilities, new government center, new international airport, and new industrial areas.

DETAILED APPLICATION OF PROCEDURES

The total number of trips expected to take place within the cordon area in 1970 were determined in the following order:

1. *Internal Trips*
 - a. Auto driver
 - b. Taxi-publico
 - c. Truck
2. *External Trips*
 - a. Trips between internal area and suburbs.
 - b. Trips between internal area and neighboring towns.
 - c. Trips between internal area and remaining external zones.
 - d. Trips between external zones (through).

INTERNAL AUTO-DRIVER TRIPS

Traffic Generating Characteristics of Residential Districts

Residential districts in the San Juan Metropolitan Area are classified by the Planning Board as follows:

- R-1 A single dwelling unit in a 900 square meter lot.
- R-2 A single dwelling unit in a 450 sq. m. lot.
- R-3 A single dwelling unit in a 300 sq. m. lot, or duplex unit in a 450 sq. m. lot.
- R-4 A single dwelling unit in a 200 sq. m. lot.
- R-5 Low density apartments, one dwelling unit per each 100 sq. m. lot area.
- R-6 High density apartments, one dwelling unit per each 50 sq. m. lot area.

The areas restricted for residential use are indicated by type of district in the Plans for Improvement and Land Use for the San Juan Metropolitan Area shown in Figure 1. The regulations restrict the development of these residential areas to the type of district indicated. However, the type of residential district shown on the zoning maps are not completely indicative of the classification of the dwelling units existing within each district today.

In order to determine the traffic-generating characteristics of each type of residential district, the subzones of the San Juan O.D. Study

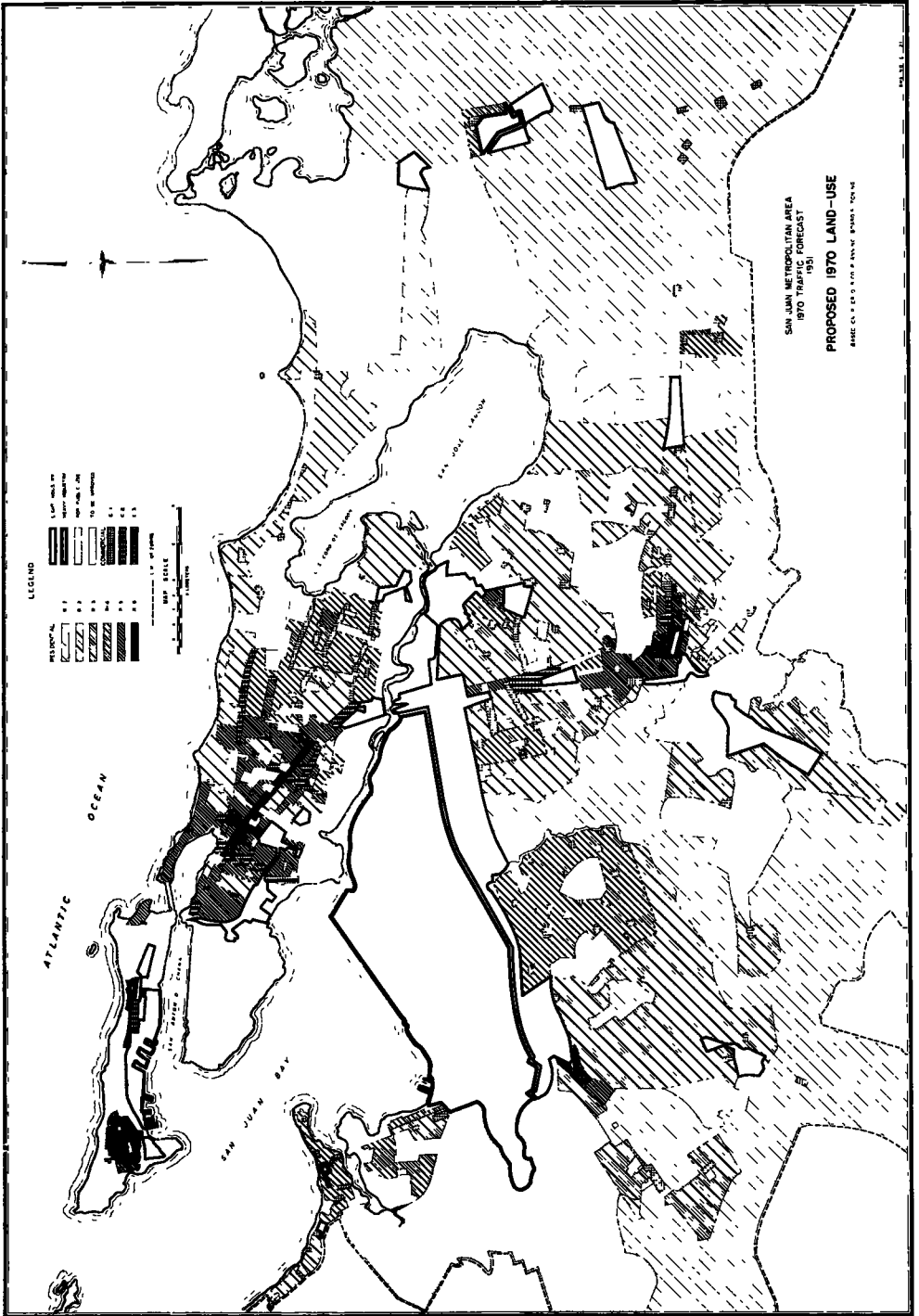


Figure 1. Plans for improvement and land use for San Juan Metropolitan Area

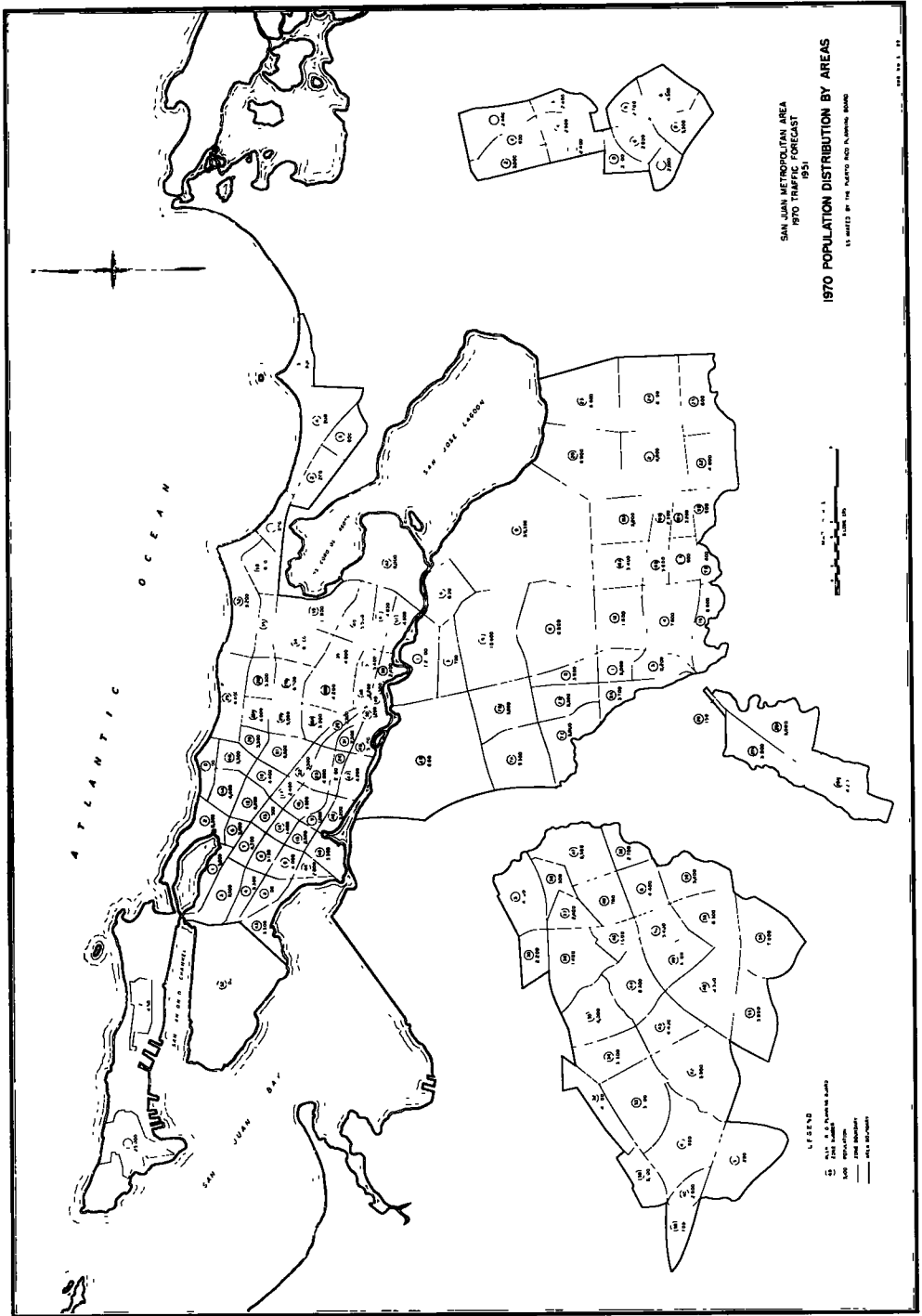


Figure 3. Estimated 1970 population distribution

were classified according to today's residential type. A general pattern of present land use is illustrated in Figure 2. The subzones were given the classification of the predominant type within each. This was done by comparing the lot sizes in the present Land Use Map and in many cases by applying the general knowledge of the residential characteristics of the area.

TABLE 1
1948 CHARACTERISTICS OF R-2 RESIDENTIAL DISTRICTS, BY ZONE OF RESIDENCE^a

O.D. Zone of Residents	Number of Dwelling Units	Number of Residents	Passenger Cars Owned	Passenger Trips Made	Persons Per Dwelling Unit	Trips Per Person	Families Per Passenger Car Owned
30	580	2800	330	5320	4.8	1.9	1.8
31	400	2110	210	3930	5.3	1.8	1.9
32	210	908	140	1540	4.3	1.7	1.5
40	525	2838	313	5515	5.4	1.9	1.7
41	520	2340	110	2450	4.5	1.0	4.7
45	550	2420	242	3090	4.4	1.5	2.3
72	645	3295	329	5825	5.1	1.8	2.0
74	91	475	61	970	5.2	2.0	1.5

^a Similar tables were prepared for each type of residential district.

TABLE 2
1948 AVERAGE CHARACTERISTICS OF RESIDENTIAL DISTRICTS

Type of Residential District	Number of Dwelling Units	Number of Residents	Passenger Cars Owned	Passenger Trips Made	Persons Per Dwelling Unit	Trips per Person	Families Per Passenger Car Owned ^a
R-1	1,196	5,095	834	9,760	4.3	1.9	1.4
R-2	3,649	17,338	1,710	29,230	4.8	1.7	2.1
R-3	5,190	24,247	1,656	35,634	4.7	1.5	3.1
R-4	19,317	99,386	2,018	109,704	5.1	1.1	9.6
R-5	1,735	7,777	973	16,091	4.5	2.1	1.8
R-6	7,999	31,642	373	25,629	4.0	0.8	21.4
Slums	24,175	126,583	462	72,979	5.2	0.6	52.3
Total	63,261	312,068	8,026	299,027	4.9	0.9	8.0

^a For comparison see definitions of types of residential district.

From a tabulation of dwelling unit information by subzones, the traffic-generating characteristics of each subzone were determined. The initial residential type classification was then checked and minor changes made. The subzones were grouped by O.D. zones and residential type and the average characteristics by residential types and O.D. zones determined, since the zone was the smallest unit by which the estimated 1970 population could be subdivided.

The traffic generating characteristics were found to vary, as expected, not only by residential type but also by location. By inspecting Table 1, it can be seen that, of the people living in the R-2 districts, those in Zone 41, which includes the C.B.D. in San-turce, make the lesser number of trips per person. Also the number of trips per person and families per car varies with the type of residential district, as shown in Table 2.

Classification of the Estimated 1970 Population

With the aid of the 1970 Population Map, Figure 3, the future population of each O.D. zone was determined. Three new zones were added and the cordon moved outward. The future population of each zone was in turn subdivided by residential type using the Plans for Improvement and Land Use, as shown in Table 3.

Determination of Passenger Trips Generated by 1970 Population

Applying the corresponding 1948 trips per person figures to the estimated 1970 population by O.D. zones and residential type, the number of passenger trips to be made by the future residents of each O.D. zone were determined. Whenever the 1970 population of an O.D. zone varied in classification from that of 1948, unit figures of an adjacent O.D. zone, having a corresponding residential classification were used.

Determination of Trips by Mode of Travel

Trips were divided by mode of travel applying percentages obtained from the original data. Refer to Tables 4 and 5.

Auto-Driver Trips by Purpose

The 1970 auto-driver trips determined in the step above were subdivided by trip purpose by applying percentages computed from the 1948 data. Auto driver trips were divided by purpose so as to have a more accurate basis for expansion factors. Specimens of 1970 auto-driver trips by purpose and of 1948 percentages are given in Tables 7 and 6, respectively.

Determination of Expansion Factors

The travel pattern of auto-driver trips by residents of a specific O.D. zone is generally

dependent upon the location of the zone with respect to commercial, recreational, and other centers of marked traffic attraction. Since trip cards for auto-driver trips made by 1948 residents of each O.D. zone were available, it was decided that, by applying corresponding

zone of residence were tabulated. Dividing the 1970 trips for each purpose, by the 1948 trip cards for the same purpose, the desired factor would result. However, while trying to obtain a factor for each trip purpose, certain difficulties arose, such as the appearance of zero and infinity factors and factors which, if carried to one decimal, had more than three digits. Further investigation was made in an effort to obviate the above difficulties and to reduce the number of factors without reducing appreciably the accuracy of the results.

TABLE 3
CLASSIFICATION OF ESTIMATED POPULATION AND ESTIMATED NUMBER OF PASSENGER TRIPS BY 1970 RESIDENTS OF EACH O.D. ZONE
(Sample Computations)

O.D. Zone of Residence	Type of Residential District	Estimated 1970 Population	1948 Trips Per Person	1970 Passenger Trips
30	R-2	4,540	1.9	8,626
	R-3	580	1.8	1,044
	R-5	11,980	2.5	29,950
31	R-2	2,000	1.9	3,800
	R-3	2,240	1.8	4,032
	R-5	2,160	2.5	5,400
32	R-2	6,880	1.7	11,696
	R-3	4,620	1.8	8,316
	R-4	8,600	0.8	6,572
33	R-3	810	1.8	1,458
	R-4	5,720	1.2	6,864
	R-5	6,070	2.0	12,140
34 ^a	R-1	1,300	1.7 ^b	2,210
	R-2	5,400	1.7 ^b	9,180

^a This is a new zone.
^b Unit figures of zone 32 applied.

Purposes were combined, first into two, and later into three groups, keeping together those more closely related. Factors were determined by dividing the 1970 trips in one group of purposes by the number of 1948 trip cards for those same purposes. Table 8 shows the 1970 trips for each purpose obtained in the analysis and the number of trips that resulted with the factors computed. The findings indicated that two factors for each zone would yield the most satisfactory results.

Trip Cards for New Zones

The original cards, with a factor to yield the desired 1970 trips, were used whenever possible. For new residential zones and for zones where the number of available cards was neither enough nor suitable, trip cards were prepared. This was accomplished by duplicating cards of an adjacent zone, altering the block of residence and the zone of origin or destination. For example, cards for auto-driver trips by residents of Zone 34 were prepared by duplicating auto-driver trip cards by residents of adjacent Zone 32, changing the block of residence, and the zone of origin or destination from 32--- to 34---.¹ Origin and destination in zones other than 32 were reproduced as such. The duplicated cards were separated by groups of purposes and the factor to go on them determined by dividing the trips obtained analytically by the now available cards. While selecting the adjacent zone from which the cards were to be duplicated, care was exercised in choosing one whose characteristics were apparently similar to those of the new zone.

TABLE 4
PERCENT BY MODE OF TRAVEL OF TOTAL PASSENGER TRIPS BY 1948 RESIDENTS OF R-2 RESIDENTIAL DISTRICTS BY O.D. ZONE OF RESIDENCE^a

O.D. Zone of Residence	Percent by Mode of Travel						Total
	Auto Driver	Auto Pass.	Bus Pass.	Taxi Pass.	Publico Pass.	Truck Pass.	
30	35.6	24.8	37.8	1.6	0.2	—	100.0
31	24.5	17.4	57.3	0.3	0.5	—	100.0
32	47.9	27.8	22.9	0.7	0.7	—	100.0
40	29.3	22.7	46.0	1.8	0.2	—	100.0
41	11.9	11.4	73.2	3.5	—	—	100.0
45	30.9	8.8	59.7	0.6	—	—	100.0
72	26.7	29.7	42.8	0.8	—	—	100.0
74	44.7	33.1	22.2	—	—	—	100.0
Average	29.6	21.8	47.2	1.2	0.2	—	100.0

^a Similar tables were made for each type of residential district.

expansion factors to these, a fairly logical travel pattern for 1970 would result. Later on, these factors would be altered to take care of unequal changes expected in certain major traffic generators.

Total 1970 auto-driver trips and total 1948 auto-driver trip cards by purpose and for each

By using this method for assigning auto-driver trips, no account is made of trips in and out of the new zone by nonresidents.

¹ A five place code indicating district, zone, subzone and block, was used in the original cards.

Checking the 1948 data, it was found that they constituted less than 25 percent of the auto-driver trips for a zone. If it is desired to account for these trips, the residential zones must be analysed to determine the relation between nonresident trips and population. Using this as

INTERNAL TAXI-PUBLICO TRIPS

A *publico* is defined as a limousine which operates as a taxi without a fixed rate or a "jitney" which plies between two fixed terminals, operating similar to a mass-transportation vehicle without a fixed schedule.

TABLE 5
ESTIMATED TRIPS BY 1970 RESIDENTS BY MODE OF TRAVEL, O.D. ZONE OF RESIDENCE AND RESIDENTIAL TYPE
(Sample Computations)

O.D. Zone of Residence	Residential Type	Mode of Travel						Total
		Auto Driver	Auto. Pass.	Bus Pass.	Taxi Pass.	Publico Pass.	Truck Pass.	
30	R-2	3,071	2,139	3,261	138	17	—	8,626
	R-3	168	187	657	32	—	—	1,044
	R-5	11,201	10,152	6,859	1,468	270	—	29,950
	Total	14,440	12,478	10,777	1,638	287	—	39,620
31	R-2	931	661	2,177	11	20	—	3,800
	R-3	649	722	2,536	125	—	—	4,032
	R-5	1,323	940	3,094	16	27	—	5,400
	Total	2,903	2,323	7,807	152	47	—	13,232
32	R-2	5,602	3,251	2,679	82	82	—	11,696
	R-3	1,339	1,489	5,230	258	—	—	8,316
	R-4	493	86	5,993	—	—	—	6,572
	Total	7,434	4,826	13,902	340	82	—	26,584
33	R-3	235	261	917	45	—	—	1,458
	R-4	535	302	5,958	69	—	—	6,864
	R-5	2,974	2,112	6,957	36	61	—	12,140
	Total	3,744	2,675	13,832	150	61	—	20,462
34	R-1	1,059	614	507	15	15	—	2,210
	R-2	4,397	2,552	2,103	64	64	—	9,180
	Total	5,456	3,166	2,610	79	79	—	11,390
Total all zones		112,152	88,250	389,619	7,807	7,703	2,293	607,824

TABLE 6
PERCENT BY TRIP PURPOSE OF TOTAL AUTO DRIVER TRIPS BY 1948 RESIDENTS OF R-2 RESIDENTIAL DISTRICTS, BY O.D. ZONE OF RESIDENCE^a

O.D. Zone of Residence	Trip Purpose									
	Home	Work	Business	Medical-Dental	School	Social-Rec.	Change Travel	Eat	Shop	Serve Pass.
30	26.7	28.9	9.6	—	—	11.8	—	11.8	6.2	5.0
31	29.8	41.2	1.3	—	—	9.8	1.2	13.5	1.2	2.0
32	27.4	39.0	5.8	1.5	—	8.8	—	10.2	4.4	2.9
40	19.9	45.6	5.9	—	2.4	21.2	—	3.5	3.5	—
41	53.7	9.7	2.5	2.4	—	17.1	—	—	9.7	4.9
45	12.0	48.0	4.0	—	8.0	18.0	—	2.0	2.0	6.0
72	10.4	28.6	19.4	—	—	29.9	—	5.2	5.2	1.3
74	26.2	26.2	7.1	—	2.5	19.0	—	11.8	7.2	—

^a Similar tables were prepared for each type of residential district.

a basis, the number of nonresident trips to the new zone can be computed and the trips assigned by transferring them from other zones. Since the total number of trips for the area as a whole can not be altered, card factors for trips transferred must be reduced.

It has been estimated that jitneys will be supplanted by regularly scheduled busses in the near future. Limousines will in all probability remain.

In the determination of 1970 trips by internal residents, 7,807 taxi-passenger and 7,703

TABLE 7
ESTIMATED AUTO DRIVER TRIPS BY 1970 RESIDENTS BY TRIP PURPOSE, O.D. ZONE OF RESIDENCE AND RESIDENTIAL TYPE
(Sample Computations)

O.D. Zone of Residence	Residential Type	Trip Purpose										
		Home	Work	Business	Medical-Dental	School	Soc.-Rec.	Change Travel	Eat	Shop	Serve Pass	Total
30	R-2	821	888	293	—	—	362	—	362	190	155	3,071
	R-3	53	55	14	2	—	17	—	23	2	2	168
	R-5	3,595	2,546	839	60	—	1,615	—	1,108	689	749	11,201
	Total	4,469	3,489	1,146	62	—	1,994	—	1,493	881	906	14,440
31	R-2	279	384	11	—	—	91	11	125	11	19	931
	R-3	206	214	52	8	—	84	—	89	8	8	649
	R-5	395	545	16	—	—	130	16	178	16	27	1,323
	Total	880	1,143	79	8	—	285	27	392	35	54	2,903
32	R-2	1,532	2,187	327	82	—	491	—	573	246	184	5,602
	R-3	423	441	108	17	—	133	—	183	17	17	1,339
	R-4	132	209	6	—	—	38	—	76	13	19	493
	Total	2,087	2,837	441	99	—	662	—	832	276	200	7,434
33	R-3	75	77	19	3	—	23	—	32	3	3	235
	R-4	144	226	7	—	—	41	—	82	14	21	535
	R-5	887	1,226	36	—	—	291	36	401	36	61	2,974
	Total	1,106	1,629	62	3	—	355	36	515	53	85	3,744
34	R-1	291	413	62	15	—	93	—	108	46	31	1,059
	R-2	1,201	1,717	257	64	—	386	—	450	193	129	4,397
	Total	1,492	2,130	319	79	—	479	—	558	239	160	5,466
	Total all zones	35,197	34,536	5,601	638	520	13,962	179	12,905	4,740	3,874	112,152

TABLE 8
ESTIMATED AUTO-DRIVER TRIPS BY 1970 INTERNAL RESIDENTS—COMPARISON OF TRIPS DETERMINED ANALYTICALLY WITH TRIPS RESULTING BY THE APPLICATION OF COMBINED FACTORS

Trip Purpose	Total ^a Trips	Ten Factors ^b		One Factor ^c		Two Factors ^d		Three Factors ^e	
		Trips	% Diff.	Trips	% Diff.	Trips	% Diff.	Trips	% Diff.
Home	35,197	34,202	-2.8	34,145	-3.0	34,983	-0.6	34,983	-0.6
Work	34,536	35,034	+1.4	34,841	+0.9	35,651	+3.2	35,651	+3.2
Soc.-Rec.	13,962	13,782	-1.3	13,568	-2.8	13,831	-0.9	13,831	-0.9
Eat	12,905	12,489	-3.2	12,340	-4.4	12,654	-1.0	12,654	-1.9
Sub-total	96,600	95,507	-1.1	94,894	-1.8	97,119	+0.5	97,119	+0.5
Business	5,601	6,886	+19.4	8,146	+45.4	6,587	+17.6	6,923	+23.6
Shop	4,740	4,900	+3.0	4,249	-10.4	3,894	-17.8	4,059	-14.4
Serve Pass	3,874	3,852	-0.6	3,716	-4.1	3,552	-8.3	3,697	-4.6
Sub-Total	14,215	15,138	+6.5	16,111	+13.3	14,033	-1.3	14,679	+3.3
Med.-Dent.	638	443	-30.6	478	-25.1	429	-32.8	303	-52.5
School	520	615	+18.3	906	+74.2	762	+46.5	383	-24.4
Change Travel	179	13	-92.7	13	-92.7	20	-88.8	35	-80.4
Sub-Total..	1,337	1,071	-19.9	1,397	+4.5	1,211	-9.4	731	-45.3
Total ...	112,152	111,716	-0.4	112,402	+0.2	112,363	+0.2	112,529	+0.3

^a Total number of trips as determined from analysis.

^b One factor for each purpose.

^c One average factor for all purposes.

^d One average factor for trip purposes, home, work, recreation, and eat; and one average factor for the remaining six purposes.

^e One average factor for trip purposes, home, work, recreation, and eat; one average factor for trip purposes, business, shop, and serve passenger; and one average factor for remaining trip purposes.

publico-passenger trips were obtained. In the original study, 3,426 taxi-passenger and 7,601 publico-passenger trips were reported in the

dwelling unit interviews. By dividing the first by the second, two ratios resulted. These ratios multiplied by the original factors yielded

factors, which were punched on the original taxi and limousine cards.

By using this method of expansion, it was assumed that trips by nonresidents and other trips made by these vehicles not directly connected with the servicing of the residents, will exhibit an increase similar to the one computed. Also by applying a uniform factor to all trip cards, the travel pattern was not altered. The only correlation made here between future land use and traffic generation was in the determination of total passenger trips based on future population.

More than 50 percent of taxi-publico trips are made to centers of major attraction whose traffic generating potential will increase in varying ratios. Trips to these centers were altered when the final factor was computed.

By using the original cards with a new factor, no trips with terminals in the new residential zones appeared. This did not affect seriously the final results as regards total movement within the study area.

If it is desired to account for these trips, the index of trips per person generated must be determined by comparing with similar residential zones; the trips expected, calculated; and the trips assigned by duplicating cards having terminals in an adjacent zone and making the needed changes in the origin or destination columns and in the factor. The trips assigned to these new zones must then be deducted from the total 1970 trips previously computed and the original expansion factor reduced accordingly.

INTERNAL TRUCK TRIPS

In determining the total number of internal truck trips, it was assumed that the percentage of this type of trips to total internal trips would be the same in 1970 as in 1948.

Following is a summary of related data as obtained from the 1948 O.D. Study.

Vehicle Type	Vehicles Registered in Area	Percent of Total Registration	Internal Vehicle Trips	Percent of Internal Trips
Priv. pass cars.	8,011	57.8	30,823	45.5
Taxis and publicos	1,105	8.0	13,012	19.2
Trucks	4,744	34.2	23,899	35.3
Total.	13,860	100.0	67,734	100.0

The above table indicates that the percentage of trucks to total registration was similar in 1948 to the percentage of internal truck

driver trips to total internal vehicle trips. Although there are no registration figures segregated by vehicle type for a sufficient number of years for the metropolitan area from which to determine trends, the figures for the island as a whole indicate that the percentage of trucks has increased steadily since 1916, the year in which the vehicle records show for the first time a segregation by vehicle type. The tendency seems to be for the proportion of trucks to increase for some years yet.

In the light of the above and in the absence of more statistical data, the assumption that the percentage of internal truck trips to total internal trips would be the same in 1970 as in 1948 was established. Where sufficient data are available, trends can be studied, both in truck registration and truck trips, and the future relation between internal truck trips and total internal trips established with a fair degree of certainty.

In the determination of 1970 passenger-car trips, it was estimated that there would be 112,152 auto-driver trips by residents, of which about 95,500 would be made internally. It was also estimated that taxis and publico vehicles would make 16,739 trips, making a total of 112,239 internal passenger-car trips.

Taking internal truck trips as 35.3 percent of the total, 61,237 truck trips for 1970 were estimated. In 1948 there were 23,899 internal truck trips. The ratio of 1970 to 1948 trips is therefore 2.56.

Using the population figures together with the destination trips per person for residential areas determined from the 1948 data and the 1970 data so far estimated, truck trips to have origin or destination in the three new residential zones were determined. These were assigned by duplicating truck trip cards of similar adjacent residential zones, changing the zone of origin and destination as required and punching a factor that would produce the required total.

The three new zones accounted for about 6,246 truck trips. Deducting these from the 61,237 previously determined, 54,991 remained. Dividing 54,991 by the 23,899 trips made in 1948 a ratio of 2.30 resulted, which was multiplied by the original factor on truck trip cards to produce the 1970 factor.

The original cards with this new factor produced a travel pattern similar to the existing one, except for the new zones. The trip

distribution was altered later on when the final factor was determined. The zones involved in the redistribution made by the final factor were the termini of about 50 percent of the internal truck trips in 1948.

EXTERNAL TRIPS

For the purpose of expansion, external zones were divided into three groups or rings of decreasing traffic influence thus: (a) suburbs, (b) neighboring towns and (c) remaining external zones.

Trips between Internal Area and Suburbs

Those suburban areas lying closer to the cordon were incorporated into the future internal area by the addition of new zones. Two other large suburbs remained: Puerto Nuevo-Villa Caparra and San Antón-Sabana Abajo and their surrounding areas. These suburbs are expected to have populations of 133,300 and 31,100 respectively in 1970 (planning board's figures). Refer to Figure 4.

To estimate the 1970 trips, the population of the suburbs was divided by residential types with the aid of the Plans for Improvement and Land Use. To each population segment, trips per person from similar internal zones were applied and total passenger trips to be generated by the residents obtained. These were in turn subdivided by mode of travel by applying percentages from the same similar internal zones, and then converted to vehicle trips using average car occupancy figures previously determined. In converting to vehicle trips, bus and publico passengers were assigned to busses and auto and truck passengers were disregarded.

Analyzing the trip movement of the residents of a group of internal zones that had suburban characteristics in 1948, it was determined that 85.8 percent of the trips generated crossed a theoretical cordon thrown around the zones investigated. An origin-destination study conducted in Puerto Nuevo, indicated that of all the trips in and out of this suburb, 72 percent had termini in San Juan. Therefore it was concluded that 85.8 times 72.0 or 61.8 percent of the trips generated by the residents of the suburbs would cross the inner area cordon.

Truck trips were estimated by assuming that they would constitute 21.6 percent of the total trips between the inner area and the

suburb. This percentage was determined from the data of the original study.

To the above trips were added trips to be made to and from the suburb by the internal residents or by vehicles registered internally. These were arrived at by expanding the 1948 trips of this type by the ratios determined in the estimate of internal trips.

It should be noted here that there will be a limited number of trips by the residents of the suburbs which will have both termini in internal zones and which have not been accounted for.

In order to assign internal zones of origin or destination to the trips from the suburbs, the original external trip cards of suburban zones were used with factors to yield the estimated number of trips. Factors were determined by vehicle type. Results are shown in the following table:

Trip Type	Puerto Nuevo-Villa Caparra			San Anton-Sabana Abajo		
	1970 Trips	Available Cards	1970 Factor	1970 Trips	Available Cards	1970 Factor
Auto driver...	24,824	4,552	5.5	8,863	801	11.1
Bus driver....	3,536	426	8.3	459	26	17.7
Taxi driver....	1,097	168	6.5	78	2	39.0
Truck driver..	8,116	1,440	5.6	2,590	596	4.3

Trips between Internal Area and Neighboring Towns

Of the external zones, the neighboring towns constitute the second ring of traffic influence. Four towns were considered close enough to belong to this group. These towns were: Cataño, Bayamon, Guaynabo, and Carolina. Unlike the suburbs, these towns will not be very directly affected by the growth of the area, although they will probably feel more the effect than towns lying more distant.

The method used for expanding 1948 vehicle trips to and from these towns to 1970 was: first, determine the total 1948 vehicle trips between each town and the internal area; second, divide these trips by vehicle type into two groups—(1) those made by residents or by vehicles registered in the internal area and (2) other; third, to expand the trips in Group 1 using the ratios determined in the 1970 internal area analysis by vehicle type; and, fourth, to expand the trips in Group 2 by the 1970 to 1948 population ratio of the town in question.

It is difficult to foresee how the traffic-generating characteristics of these towns will develop. It is reasonable to assume that as the population of the town increases its commercial and recreational facilities will also increase, thus causing an increase in internal trips. However, since these towns are small and are suburban in nature, the greatest number of vehicle trips are made to the big city. With all this in mind, the population ratio was decided upon for expanding 1948 to 1970 trips in Group 2 above.

Following is an example of the computations for determining 1970 trips between San Juan and Cataño:

(1) Available Data:

(a) Population in 1948: 9,979; in 1970: 46,900

(b) Population ratio 1970 to 1948: 4.7

(c) Internal trip ratios, for auto driver: 3.15; for truck: 2.56.

(2) The 1948 trips expanded to 1970:

	Trips by Internal Vehicles			Trips by Other Vehicles			Totals	
	1948	Factor	1970	1948	Factor	1970	1948	1970
Auto	192	3.15	605	376	4.7	1767	568	2372
Publico				125	4.7	588	125	588
Taxi				10	4.7	47	10	47
Truck	211	2.56	540	213	4.7	1001	424	1541
Bus				91	4.7	428	91	428
Total..	403		1145	815		3831	1218	4976

Using the number of available trip cards as a base, the following factors for obtaining 1970 trips between San Juan and Cataño were determined and punched in two new columns:

Vehicle Type	1970 Trips	Available Cards	Factor
Auto	2372	368	6.4
Publico	588	95	6.2
Taxi	47	8	5.9
Truck	1541	263	5.9
Bus	428	59	7.3

Trips between Internal Area and Remaining External Zones

As part of the original study, a traffic forecast for the island as a whole was made. This forecast was based on vehicle registration, gasoline consumption, population-vehicle ratio and other allied information. Some of the outstanding data used follows: (1) estimated

1970 population—2,809,000, 130 percent of 1949; (2) estimated 1970 vehicle registration—117,000, 213 percent of 1949; (3) estimated 1970 population vehicle ratio—24, it was 39 in 1949; and (4) estimated 1970 gasoline consumption 124 million gallons, 279 percent of 1949.

From this forecast it was estimated that the 1970 traffic in the island as a whole would be 1.8 times that of 1949. This factor was used for expanding trips between San Juan and the remaining external zones.

Using the available trip cards as a base the following 1970 factors were computed and punched in two new columns:

Vehicle Type	Trips 1948 × 1.8 = 1970		Available Cards	1970 Factor
Private auto	6,572	11,830	4,606	2.6
Publico	4,178	7,520	3,094	2.4
Panel or pick-up	2,145	3,861	1,479	2.6
2-axle single tire	395	711	280	2.5
2-axle dual tire	3,361	6,050	2,361	2.6
3-axle single unit	159	286	109	2.6
Combination	185	333	124	2.7
Bus	479	862	323	2.7
Taxi	82	148	60	2.5
Total.	17,556	31,601	12,436	2.5

Trips between External Zones (through)

Through trips were expanded by a factor equal to the average of the two factors corresponding to the zones in which the termini of the trips were located. The two suburbs and the four adjacent towns, plus the remaining external zones make up seven groups of zones for which seven different expansion factors have already been computed. Through trips may have termini in either two of these seven, or they may have both origin and destination in the group of zones classed as "remaining."

As an example, let's take the through trips whose termini were in Cataño and one of the zones classed as "remaining." In 1948 there were 28 of these. The 1970-1948 trip ratio previously determined for Cataño was 4.1 and the one for remaining external zones was 1.8, therefore, the expansion factor applied to the 28 trips was 2.9 or the arithmetical average of 4.1 and 1.8.

There was a total of 753 through trips in 1948. As a result of the expansion made in the manner above outlined, 2,157 through trips were obtained for 1970.

REDISTRIBUTION OF FUTURE TRIPS

The total 1970 vehicle trips by vehicle type and purpose, both internal and external have been determined. If trip attraction is considered a measure of service rendered, the total required size of future commercial, industrial and recreational areas and other areas equipped to serve the future population have thus been indirectly determined. However, 1970 trips have not been equitably distributed, since we have them going to the same places as in 1948, thus assuming that the present service centers will all grow in the same ratio.

Studies conducted by the planning board together with present building limitations, both physical and regulatory, lead to the conclusion that industrial and commercial activities are definitely redistributing themselves. Centers of marked activity which are expected to have major changes in the future are the following: (1) airport facilities, (2) port facilities, (3) industrial areas, (4) central business districts, and (5) government center.

In order to have a more rational trip distribution, trips having origin or destination in these centers were reassigned.

Airport Facilities

A new international airport is under construction east of Santurce in the area commonly known as Isla Verde. It is expected that this airport will practically supplant the existing one at Isla Grande. It was estimated that 3,776 trips would have destination in Zone 20 where the present airport is located. About 2,556 of these were accounted for by the airport activities, which means that the future airport would generate about 5,100 trips daily.

From data collected by the Bureau of Public Roads at 14 airports in cities of various populations, it was determined that airports generate about 3,500 trips daily in cities of 500,000 and about 4,000 trips in cities of 700,000.

The CAA estimated that the 968,000 airplane passengers expected in 1970 in the new international airport would generate 4,500 vehicle trips daily.

By comparison with the last two estimates, our determination of 5,100 trips appears high. However, our estimate was used because the existing trip cards which are to yield this total already have zones of origin.

These trips were transferred to the new airport by duplicating all cards having origin or destination in Subzones 200 and 201, where the present airport lies, and changing the origins and destinations to 90,233, which is the code for the new location. The original cards were destroyed.

Port Facilities

The existing port in San Juan handled approximately 1,408,000 tons of cargo in 1948-49. The total demand for 1970 has been estimated at 2,338,000 tons. Of the cargo handled in 1948-49, about 300,000 tons, 200,000 of which were sugar cargo, were transported to and from the port by railroad. Studies indicate that the present port has been working above its normal capacity which is estimated to be 1,000,000 tons.

Allowing 1,000,000 for the existing port, additional facilities for 1,338,000 tons will be required in 1970. This is to be provided by a new port area to be developed on the southeastern shore of San Juan Bay. The railroad into San Juan will be definitely discontinued. Assuming that 338,000 tons will be transported by railroad into the new port area, 2,000,000 tons remain to be distributed evenly between the two port facilities.

The analysis yielded 3,725 trips having destination in the port area. These were reassigned evenly between the two port areas by reducing by half the factor on all cards having origin or destination in the existing port and duplicating all these cards with the half factor, changing the code of origin or destination to the code for the new port. Both sets of cards were used.

Industrial Areas

According to the planning board, the only new industrial area of any consequence to be developed by 1970 will lie south of the new port area. This area will cover about 175 net acres and will employ about 7,000 people.

Subzone 502 with a net area of 23.7 acres today constitutes a homogeneous industrial area. This subzone attracted 12.5 trips per acre in 1948, 5.5 passenger car and 7.0 truck.

Applying these unit figures to the new area, about 2,200 destination trips were obtained. Since the total number of all types of trips were originally determined, trips to

the new industrial area were assigned by transferring them from other similar internal areas.

The same method of reducing the factor in the original cards and duplicating these with a complementary factor and a changed code of origin or destination was used. Trips were transferred in varying ratios according to the vehicle type.

Central Business Districts

Today there are three main business districts within the study area, one each in San Juan, Santurce, and Rio Piedras. The San Juan business district is almost homogeneous and covers practically all of Zones 00, 01 and 02. The one in Santurce is more sparse and, although it definitely merits the classification of a central business district, a good number of recreational and residential establishments is present within the zones which comprise the district. The business district in Rio Piedras, although small, is compact and covers most of Zone 81.

Because of the disproportionate size of the noncommercial activities within the zones in which the business districts lie, and because of their location with respect to the center of population, their relative size cannot be determined solely on the basis of trips attracted. Certain trip types had to be assumed as being attracted by commercial activities in order to be able to redistribute future traffic in accordance with the proportionate increase expected in each district.

The following trip types were redistributed:

(1) auto driver trips to work, to business and to shop; (2) external truck trips; (3) internal truck trips, adjusted; and (4) taxi-publico trips, adjusted.

The 1948 trips of the types above having destination in the three business districts were tabulated, and the truck and taxi-publico trips to Santurce and Rio Piedras adjusted using those to the San Juan district as a guide. The resulting relative sizes as regards trips attracted were: San Juan 53, Santurce 37 and Rio Piedras 10.

By tabulating 1970 trips and making the adjustments, the resulting relative sizes of 1970 business districts were: San Juan 46, Santurce 36, and Rio Piedras 18. These are

the sizes resulting before the redistribution of trips.

According to the planning board the commercial floorspace was distributed as follows in 1948:

San Juan	1,480,000 sq. ft.
Santurce	2,010,000 sq. ft.
Rio Piedras	No estimate.

Estimating the area of the Rio Piedras district on the basis of average number of trips attracted by the other two districts per 1,000 sq. ft., 105,000 sq. ft. resulted.

From the forecast it was determined that 56,169 destination trips for commercial purposes will be made in 1970. San Juan attracted 10,946 of the same type of trips, Santurce 7,523 and Rio Piedras 1,988 for a total of 20,457 in 1948. Although it has been estimated that the available commercial floor space in San Juan will increase by 25 percent from 1948 to 1970, traffic can increase by about 40 percent if traffic operation is improved. On the basis of a 40 percent increase, San Juan will attract 10,946 times 1.4 or 15,325 commercial trips in 1970.²

The Santurce district is expected to have 5,140,000 sq. ft. of commercial floor space in 1970. This represents an increase of 160 percent over 1948. As the district becomes more compact and floor space is utilized more fully, it is logical to assume that it will attract as many trips per 1,000 sq. ft. of commercial floor space as the other districts. The average for the three districts in 1948 was 5.7 destination trips per 1,000 sq. ft. and in 1970 it is expected to be 6.4.

Determining the number of destination trips on the basis of 6.4 trips per 1,000 sq. ft. of floor space, the Santurce district should attract 32,900 commercial trips in 1970.

Of the 56,169 destination commercial trips estimated for 1970, 15,325 were assigned to San Juan and 32,900 to Santurce. The remaining 7,944 should go to Rio Piedras. On this basis, the 1970 relative size of the C.B.D.'s based on trips attracted would be 27, 59 and 14 for San Juan, Santurce and Rio Piedras, respectively.

² It is generally accepted that the present traffic in the business district of San Juan would increase if congestion could be effectively reduced.

TABLE 9
TRIPS TRANSFERRED TO THE SANTURCE BUSINESS DISTRICT FROM BUSINESS DISTRICTS
IN SAN JUAN AND RIO PIEDRAS

Business District	Trip Type	1970 Trips Obtained with 1st Factor	1970 Trips After Redistribution	Trips to be Transferred	Multiplier ^a
San Juan	Auto internal	10,272	4,849	-5,423	0.472
	Auto external	3,776	2,253	-1,523	0.597
	Total	14,048	7,102	-6,946	
	Truck internal	5,497	3,456	-2,041	0.623
	Truck external	1,318	829	-489	0.629
	Total	6,815	4,285	-2,530	
Santurce	Taxi-publico int.	3,612	1,910	-1,702	0.529
	Taxi-publico ext.	1,414	748	-666	0.529
	Total	5,026	2,658	-2,368	
	Auto internal	7,933	14,229	+6,296	
	Auto external	3,200	5,045	+1,845	
	Total	11,133	19,274	+8,141	
Rio Piedras	Truck internal	12,674	15,063	+2,389	
	Truck external	2,551	3,300	+749	
	Total	15,225	18,363	+3,138	
	Taxi-publico int.	2,645	4,347	+1,702	
	Taxi-publico ext.	361	1,027	+666	
	Total	3,006	5,374	+2,368	
San Juan	Auto internal	4,048	3,175	-873	0.784
	Auto external	1,491	1,169	-322	0.784
	Total	5,539	4,344	-1,195	0
	Truck internal	1,620	1,272	-348	0.785
	Truck external	1,209	949	-260	0.785
	Total	2,829	2,221	-608	
Rio Piedras	Taxi-publico int.	2,726	2,726	0	1.000
	Taxi-publico ext.	3,467	3,467	0	1.000
	Total	6,193	6,193	0	

^a Number by which first 1970 factor was multiplied in order to reduce the number of trips to the desired total. On the duplicated cards the factor punched was equal to one minus this multiplier, times the original 1970 factor.

A summary of the trip distribution is shown below:

C.B.D.	1948		1970		Ratio 1970 to 1948
	Trips	Rel. Size	Trips	Rel. Size	
San Juan.	10,946	53	15,325	27	1.4
Santurce .	7,523	37	32,900	59	4.4
Rio Piedras	1,988	10	7,944	14	4.0
Total	20,457	100	56,169	100	2.7

The original 1970 analysis yielded 25,889 destination trips of the types under discussion to the San Juan business district; 20,199 to the Santurce district and 10,081 to the Rio Piedras district. Since we desired to distribute trips in the ratios previously determined, trips

were transferred from San Juan and Rio Piedras to Santurce. This was accomplished by reducing proportionally the factor on trip cards having origin or destination in San Juan and Rio Piedras; then, duplicating the original cards to produce a second set with a factor complementary to the reduced factor and with the codes of origin or destination changed from those corresponding to the San Juan and Rio Piedras business districts to that corresponding to the Santurce business district.

Transfer operations were carried out separately for each vehicle type. Trips transferred are shown in Table 9.

Before determining transfer factors, 1,280 additional auto driver destination trips were deducted from the San Juan Area and added

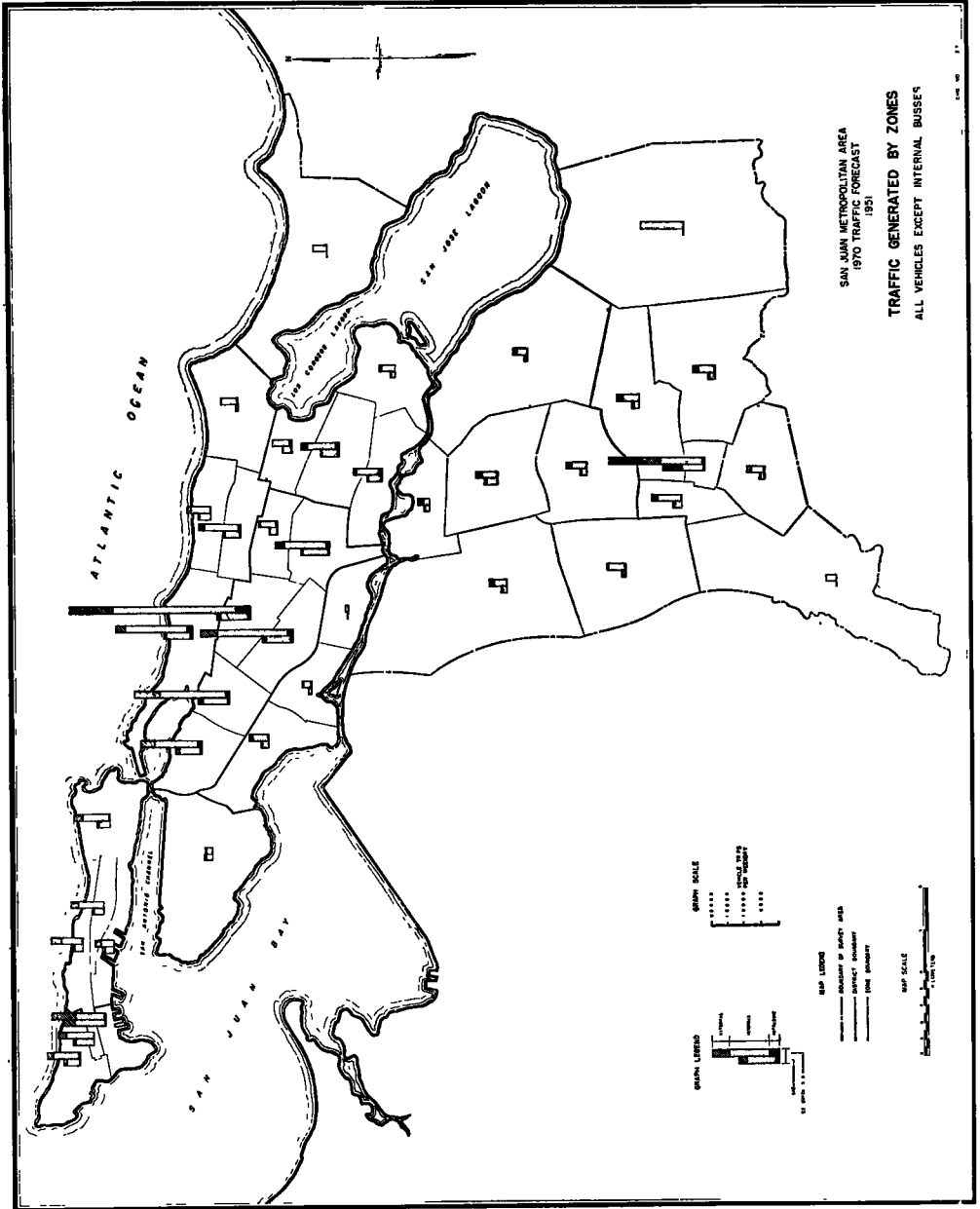


Figure 5. Traffic generated by zones.

to Santurce. These trips correspond to the government center which is expected to be transferred.

Government Center

There were 3,112 insular government employees in San Juan and 3,777 in Santurce in 1948; the total for the two being 6,889.

TABLE 10
TOTAL 1948 AND 1970 TRIPS AND INCREASE
RATIOS BY TRIP TYPE

Trip Type	1970 Trips	1948 Trips	1970 to 1948 Ratio
Auto	95,501	30,823	3.1
Truck	61,252	23,899	2.6
Taxi-publico	16,755	13,012	1.3
Total internal	173,508	67,734	2.6
Auto	54,554	13,511	4.0
Truck	37,274	10,653	3.5
Taxi-publico	14,375	7,047	2.0
Total external..	106,203	31,211	3.4

TABLE 11
COMPARATIVE TRIP DATA FOR MAJOR AREAS
WITHIN THE CORDON LINE

Trip Termini	1970 Trips	1948 Trips	1970 to 1948 Ratio
San Juan-San Juan	6,620	4,594	1.4
San Juan-Santurce	29,993	16,800	1.8
San Juan-Rio Piedras	8,837	5,032	1.8
San Juan-Externals	22,534	8,658	2.6
Total for San Juan	67,984	35,084	1.9
Santurce-Santurce	83,069	28,795	2.9
Santurce-San Juan	29,993	16,800	1.8
Santurce-Rio Piedras	30,738	7,674	4.0
Santurce-Externals	51,566	11,116	4.6
Total for Santurce	195,366	64,385	3.0
Rio Piedras-Rio Piedras	17,751	4,838	3.7
Rio Piedras-San Juan	8,837	5,032	1.8
Rio Piedras-Santurce	30,738	7,674	4.0
Rio Piedras-Externals	29,946	10,684	2.8
Total for Rio Piedras	87,272	28,228	3.1
Crossing San Antonio Channel	60,598	30,490	2.0
Crossing Martin Peña Channel	59,346	19,047	3.1

The insular government agencies now in San Juan are expected to move to Santurce to a new government center to be built somewhere in Zone 42. It is estimated that the government agencies will have 11,170 employees in 1970.

From a tabulation of employees making auto driver trips to work, using the occupation

and industry columns as a guide, it was determined that the insular government employees made 535 trips to work in San Juan in 1948 or 0.172 trips per employee. Following the normal rate of expansion, approximately 4,000 of the 11,170 government employees expected for 1970 should be in San Juan.

In the entire area there were 0.03 auto-driver trips to work per person in 1948 and from the 1970 analysis it was determined that there should be 0.056 auto-driver trips to work per person in 1970. Assuming that the auto-driver trips to work by government employees should show the same rate of increase, there should be 0.32 auto-driver trips per employee in 1970.

The 4,000 government employees expected in San Juan in 1970 should make 4,000 times 0.32 or 1,280 auto-driver trips to work. Since all government agencies are expected to be moved to Santurce, 1,280 auto driver trips were transferred from Zones 00, 01 and 02 in San Juan to Zone 42 in Santurce. These trips were transferred together with commercial trips of a similar type and were included in the trips deducted from San Juan while computing the factors for the commercial areas.

GENERAL RESULTS

From the forecast it was estimated that 279,711 trips will take place within the cordon line in 1970. The original study yielded a total of 98,945 for 1948. According to the screen line check, the original study was on the average of 83 percent accurate. Although the true overall increase for the period under study cannot be estimated with a great degree of certainty, the ratios shown in Table 10 can be used for comparative purposes.

The forecast figures show that external trips will increase in a greater ratio than internal trips, which seems logical since suburbs are developing at an unprecedented rate. This expansion is reflected on the traffic crossing the cordon from the west, where volumes have increased from 12,754 in 1948 to 30,000 vehicles per day in September 1951, a 135 percent increase in three years.

Also an unequal rate of increase for trips by different vehicle types resulted, auto driver trips exhibiting the greatest increase. This is to be expected in this island where the economy is slowly lifting itself from the low levels of the past.

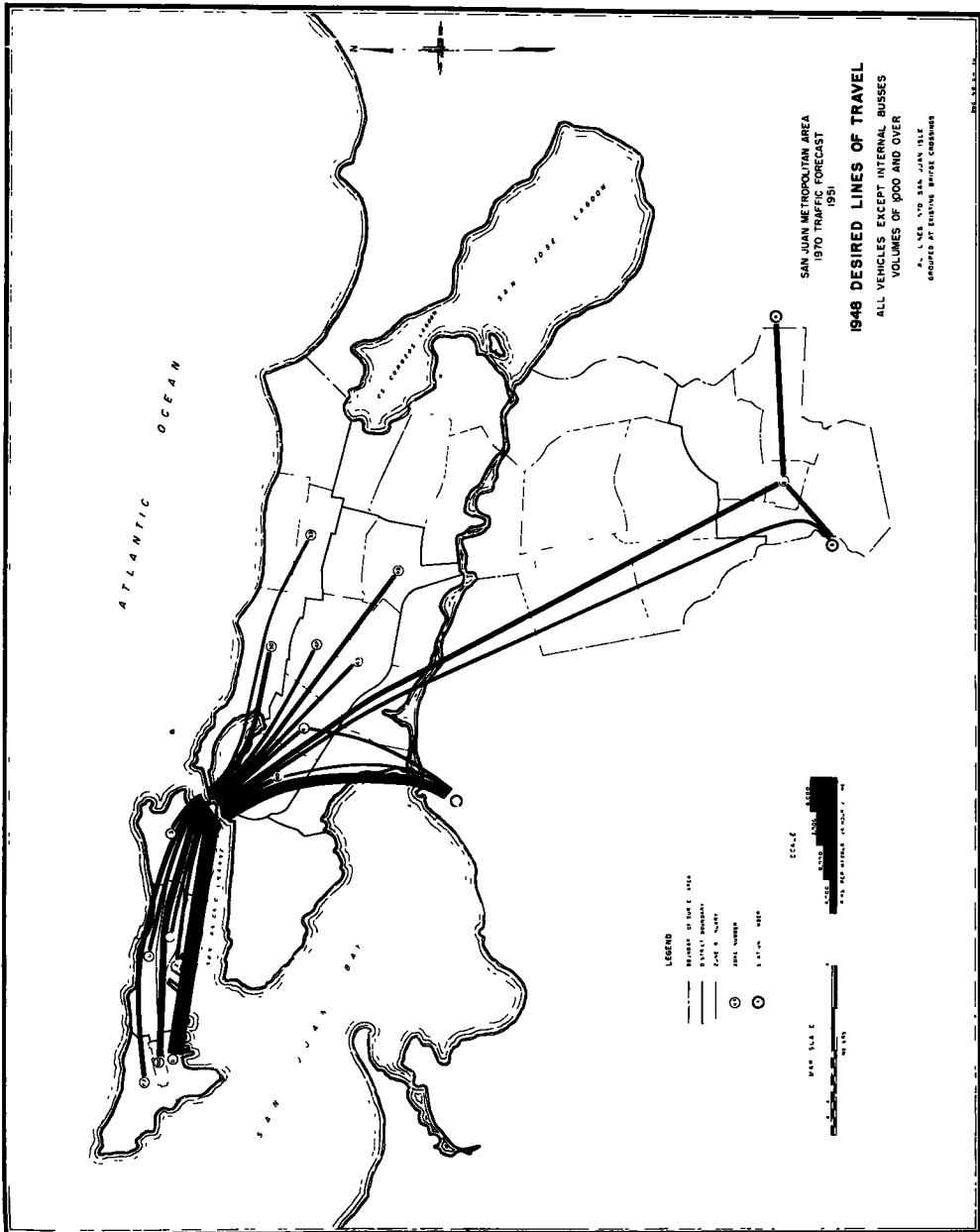


Figure 7. 1948 desired lines of travel, 1000 trips and over.

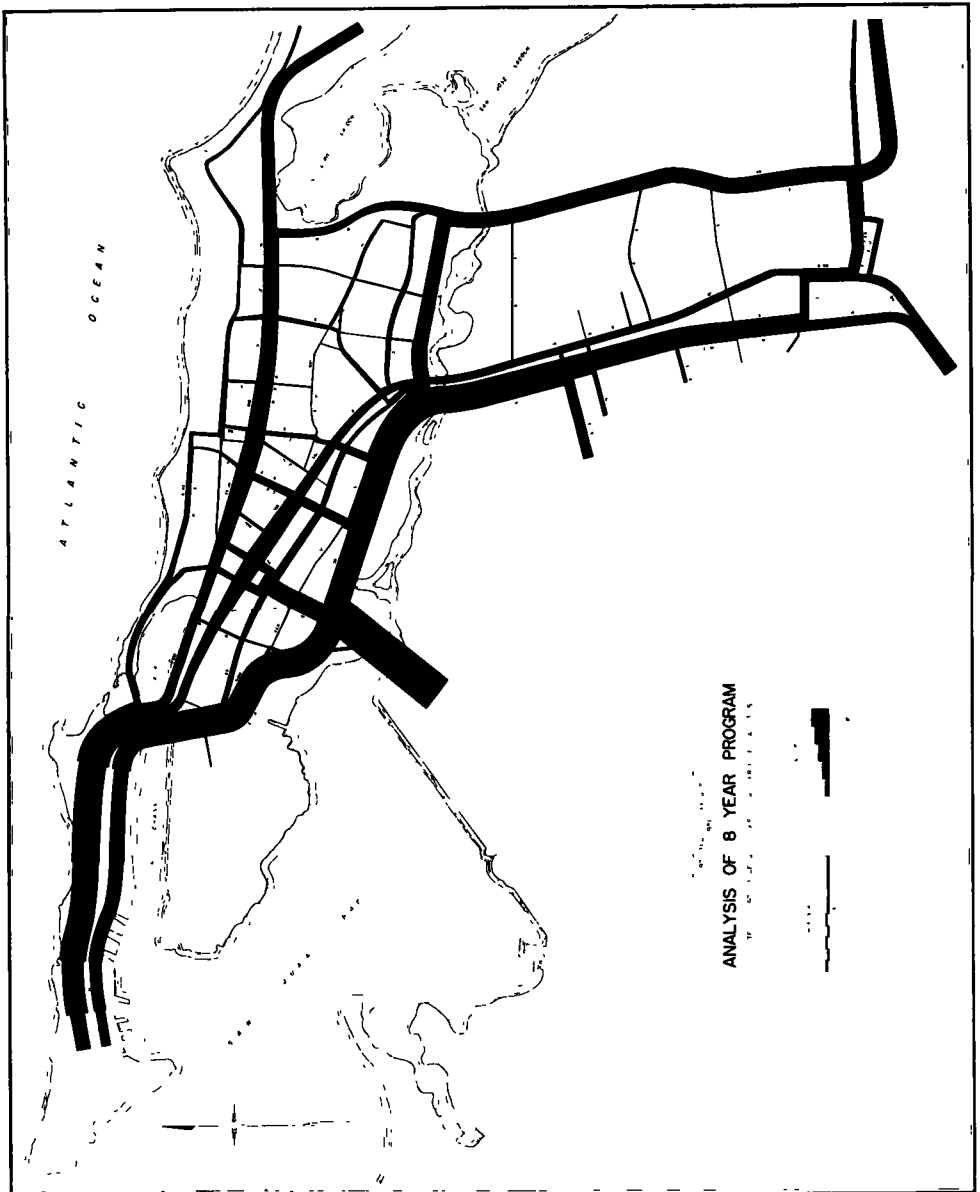


Figure 8. Potential 1970 traffic on existing and proposed facilities.

Within the cordon line there are three major areas: San Juan, the westernmost; Santurce, the central; and, Rio Piedras lying to the southeast. San Antonio Channel separates the first two, while the latter are divided by Martin Peña Channel. San Juan, completely waterbound and well developed, cannot expand physically although the activities taking place within it are still increasing. Santurce, not so fully developed, has room for expansion, while Rio Piedras has unlimited potentialities. As a result of the physical makeup of the three areas, their traffic generating activities are not expected to expand in equal ratios. The data included in Table 11 indicates that the increase ratios obtained from the forecast follow closely the expected expansion and

TABLE 12
COMPARISON OF ANTICIPATED 1948 AND 1970
TRAFFIC VOLUMES AND INCREASE RATIOS ON
VARIOUS SECTIONS OF PROPOSED FACILITIES

Facility and Section	24-Hr. Traffic Volumes		Increase Ratio
	1948	1970	
Expressway			
Westernmost Section	16,700	39,300	2.35
Central Section ..	16,700	42,100	2.52
Easternmost Section...	5,100	19,700	3.86
North Avenue			
Westernmost Section	6,200	12,900	2.08
Central Section ..	7,700	24,900	3.23
Easternmost Section...	4,900	18,300	3.73

development. Traffic counts made during the last three years at the San Antonio and Martin Peña Channel crossings revealed that traffic has increased 15 percent and 32 percent respectively at these locations.

Many other examples of the results obtained can be cited to demonstrate the validity of the expansion method used. Figures 5, 6, and 7 are included for those who desire to look further into the results.

ROUTE ANALYSIS

The need for assigning future traffic to a proposed 8-year program of additional highway facilities prompted the making of the forecast. The analysis for assigning traffic to these facilities served as a practical application of the results of the projection.

Since all traffic data was already punched in I.B.M. cards, analysis by mechanical means was possible. A process similar to the one developed by the Michigan State Highway Department was adopted. This consisted mainly in assigning the trips between subzones and stations through numbered intersections in the route network in accordance with certain basic assumptions.

The results obtained in the analyses with the forecast data and with the original data are illustrated in Figures 8 and 9. Internal bus trips, which are not accounted for in the analysis, were obtained by expanding 1948 trips by factors proportionate to the increase in bus passenger trips for zones served by bus routes. These trips were added to the facilities affected. The resulting traffic volumes for the various sections of highways accentuate the difference between the expansion by the use of a uniform factor and the expansion in which land use plays a part.

There is no need for entering into a lengthy discussion of the results of the analyses. However, another example which demonstrates the importance of the land-use method will be cited. On Table 12 are shown anticipated traffic volumes and increase ratios for two of the east-west facilities proposed. The 1970 to 1948 trip ratios vary from 2.35 to 3.86 on the expressway and from 2.08 to 3.73 on North Avenue. The trip ratios increase as we move east toward the area of expected greater development

CONCLUSIONS

The land-use forecast method yielded results compatible with the accuracy expected in any long term projection. This method lends itself to analysis by mechanical means, which is a decided advantage considering the large volume of traffic data usually attached to O.D. surveys.

The outlined procedures are considered a sound base on which to ultimately build a refined method of expansion. Inasmuch as there are so many complex factors involved in traffic generation and tendencies may tend to strike a balance, general assumptions usually suffice, since they cover most of the cases.