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September 28, 1972

H.3.30

MEMORANDUM TO: J. R. Harbison
State Highway Engineer
Chairman, Research Committee

SUBJECT: Research Report No. 342; "Rural Recreational Travel in Kentucky;" KYP-30; HPR-1(8), Part III.

In August 1971, we submitted a report on the "Influence of Recreational Areas on the Functional Service of Highways". The study was done under Part I (Planning) of HPR-1(7) -- by previous arrangement with the Planning Division. The results obtained then were not altogether useful in the Statewide Traffic Forecasting Model project. However, we continued the study under Part III (non-participating) because we had an opportunity to obtain continuous ATR counts through an extended period of time at some specific recreational areas. A year of data has been obtained and further analyses completed. The ultimate usefulness of the findings remains to be determined by the Division of Planning.

Respectfully submitted,

Jas. H. Havens
Director of Research

JHH:gd
Attachment
cc's: Research Committee

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2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle

RURAL RECREATIONAL TRAVEL IN KENTUCKY

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Study Title: Influence of Recreational Areas on the Functional Service of Highways

16. Abstract

The purpose of this study was to develop a methodology for predicting travel patterns on routes leading to outdoor recreational areas in Kentucky. Data were collected by means of a license-plate, origin-destination survey at 160 sites within 42 recreational areas and by means of a continuous vehicle counting program at eight of these sites. Results indicate that the method of associating similar facilities is a reliable procedure for predicting traffic characteristics. Vehicle occupancy was found to depend on the type of recreational area, distance traveled, and vehicle type. Percentages of various vehicle types were also influenced by the type of recreational areas and the distance traveled. In general, trip lengths were quite short, as evidenced by the fact that 60 percent of all vehicles traveled less than 50 miles. Analysis of the distribution of traffic over time verified that recreational travel is much more highly peaked than other forms of highway travel.

17. Key Words

Recreation, Travel, Vehicle Occupancy, Vehicle Classification, Trip Lengths, Time Distribution

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342

RURAL RECREATIONAL TRAVEL IN KENTUCKY

Final Report
KYP-30, HPR-1(8), Part III

by

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Research Engineer

Division of Research
DEPARTMENT OF HIGHWAYS
Commonwealth of Kentucky

September 1972

INTRODUCTION

Kentucky has outdoor recreational development rivaling that of any state. The highway travel generated continues to mount. Favorable access routes, together with the major highway network, and attributes of the recreational area mutually invite visitation and travel. The purpose of this study was to develop methods for predicting traffic volumes on routes leading to outdoor recreational areas and also the traffic burden induced on the major highway network by existing and future recreational facilities.

A previous study dealt with the development of travel demand models for rural recreational routes *(1)*. Then, a single-equation regression model and a cross-classification model were calibrated and tested to verify their applicability as predictors. Data were obtained by means of license-plate origin-destination surveys at 42 major recreational areas (160 sites) and by continuous counting of vehicles at eight of the sites. Results from the first phase indicated that the cross-classification model was acceptable for simulating and predicting purposes and was decidedly superior to other single-equation models evaluated. From another phase of this same study, Kaltenbach *(2)* found that neither the gravity model nor the intervening opportunities model was as effective as the cross-classification model.

The objective of most previous studies of outdoor recreational travel has been to forecast annual visitation to existing or proposed recreational areas for the purpose of evaluating the economic consequences of existing or proposed investments. Techniques which have been used effectively to predict this travel demand include multiple regression models *(3, 4, 5)*, gravity models *(6, 7)*, opportunity models *(8)*, and systems theory models *(9, 10)*. There appears to be no definitive preference for any model type, and each will yield satisfactory results if applied correctly.

There has been little research on the subject of predicting seasonal travel patterns and time variations of traffic flow to outdoor recreational areas. On the other hand, considerable work has been done on the problem of estimating annual average daily traffic from short-term traffic counts *(11, 12, 13)*. Probably all highway planning agencies have procedures for estimating average daily traffic flow, but it appears that none has specifically isolated recreation-oriented traffic.

Statewide and zonal traffic-forecasting modeling depends in a large degree on the synthesis of travel desires and composing traffic volumes from the several constitutive parts. Inversely, existing traffic may be decomposed constitutively, but only in terms of vehicle classification unless interviews are conducted. From a 1970 survey of auto-utility trailer combinations (house trailers boat trailers, camper trailers, rental trailers, etc.) on various Kentucky routes, Siria (15) isolated appendant recreational vehicles. He reported an overall average of 3.48 percent. The percentage on four-lane, limited-access roads was 4.11. The percentage on I 75 was 5.53; but the percentage on I 64 was only 1.75.

Historically, an improvement in transportation has led to an increase in recreational activity, while an increase in recreational demand has often put a major strain on the transportation system. Clawson and Knetsch *(14)* have recognized the dilemna which transportation engineers are likely to fact by pointing out that a projected increase of 80 percent in the number of registered vehicles from 1959 to 1976 will bring about a proportional increase in outdoor recreational travel. Clawson and Knetsch discuss three general situations in which the effect of outdoor recreational demand upon highway facilities is felt. First, the existence of an attractive outdoor recreational area requires local access roads. The number and nature of such roads vary greatly from one recreational area to another and depends upon such factors as availability of construction funds, estimates of potential travel demand, and environmental aspects. Certainly, the structural and geometric designs should include considerations of the nature of types of vehicles peculiar to recreational travel and the preservation of natural scenic sites which constitute, in part, the attraction of the area.

Second, recreational travel of all types constitutes an important part of the total traffic volumes on major highways. In many instances, the volume of recreational traffic may be so large as to require highways of improved design and capacity. Peak volumes for most rural routes now occur on the weekends; a large percentage of this travel is for recreational purposes. Often a traveler's impression of an area or state, and his desire to return, is greatly affected by the types and conditions of the route to and from the recreational area. Recreation is a demand factor and is definitely a consideration in the planning of a highway system.

Third, recreational travel has a great effect on traffic flow on arterials leading out of and into back major urban centers. In many urban areas, the desire of the city dweller to seek weekend outdoor recreational experience brings about a Friday afternoon, Saturday, and Sunday rush to leave the city and late Sunday and early Monday rush to return to the city.

According to Matson, Smith, and Hurd *(16)*, the 30th highest hourly volume may vary from as low as 8 percent of the ADT on some urban routes to 40 percent of the ADT on highly recreational routes. The design of a roadway must be based to some extent on peak-hour traffic; but on the other hand, it is usually uneconomical to design for the highest volume hours since they occur only a small percentage of the time.

While highways should be designed and located primarily for the efficient and safe transportation of people, other secondary purposes should also be considered. The desire to isolate and designate recreational routes apparently originates from the park and recreation profession and preservationists. Indeed, idealists may envision secondary routes through scenic, historic, and cultural areas where the recreationists may drive more slowly and stop at points of interest. Likewise, some routes may be compatible with outdoor recreational activities such as hiking, bicycling, and picnicking. One cannot help but wish that outdoor recreation-oriented routes could be designed to be interesting and enjoyable for travel and also satisfy the constraints of economics.

DATA ACQUISITION

To analyze seasonal patterns and time variations of traffic flow, it was felt a comprehensive data base representing traffic flows throughout the year would be necessary. The method chosen was continuous automatic traffic recorders located at ten representative sites. Punched-tape, automatic traffic recorders, employing a wire loop embedded in the pavement, were installed in July 1970, and data were recorded through July 1971. In the analyses, the one-year traffic counts were combined with origin-destination data collected during the summer of 1970 *(1)*.

The principal criteria used in the selection of sites were: type of recreational area, geographical location, accessibility of recreational area, and facilities available. Type of recreational area, being the most stratifying, ranked as the criterion of greatest importance. Four types of recreational areas were represented; they were: 1) water-oriented resort park, 2) outdoor multiple-use resort park, 3) scenic attraction park, and 4) small fishing lake. Geographical settings and area types were selected so that similar recreational areas would be geographically dispersed. Ideally, only those areas having one access road should have been considered; but with the importance placed on area type, it was necessary to locate recorders at two sites where there were two access roads. At both of these sites, approximately 90 percent of the total traffic occurred on the road where the recorders were stationed. Facilities available were also inherently related to area type. It was felt that a wide range of types and sizes of area would be represented in the selections. The recreational areas chosen are identified by name, number, and area type in Table 1. Figure 1 shows the geographic location of each site.

Some problems were encountered in accumulating data. Due to the wide geographical distribution of the sites, it was impractical to check the recorders more often than once each month. Therefore, when recorder breakdowns did occur, it was sometimes several weeks before the problems were detected and corrected. Another problem resulted when one of the selected parks was closed for a significant period during the winter. For these reasons, data from two sites were discarded.

TABLE 1

RECREATIONAL AREA NAME, NUMBER AND TYPE

SITE NUMBER	SITE NAME	TYPE OF RECREATIONAL AREA
1	Rough River State Park	Water-Oriented Resort
2	Beaver Lake	Small Fishing Lake
3	Levi Jackson State Park	Outdoor Multiple-Use
4	Lake Barkley State Park	Water-Oriented Resort
5	Mammoth Cave National Park	Scenic Attraction
6	Boonesborough State Park	Outdoor Multiple-Use
7	Carter Caves State Park	Outdoor Multiple-Use Resort
8	Jenny Wiley State Park	Water-Oriented Resort

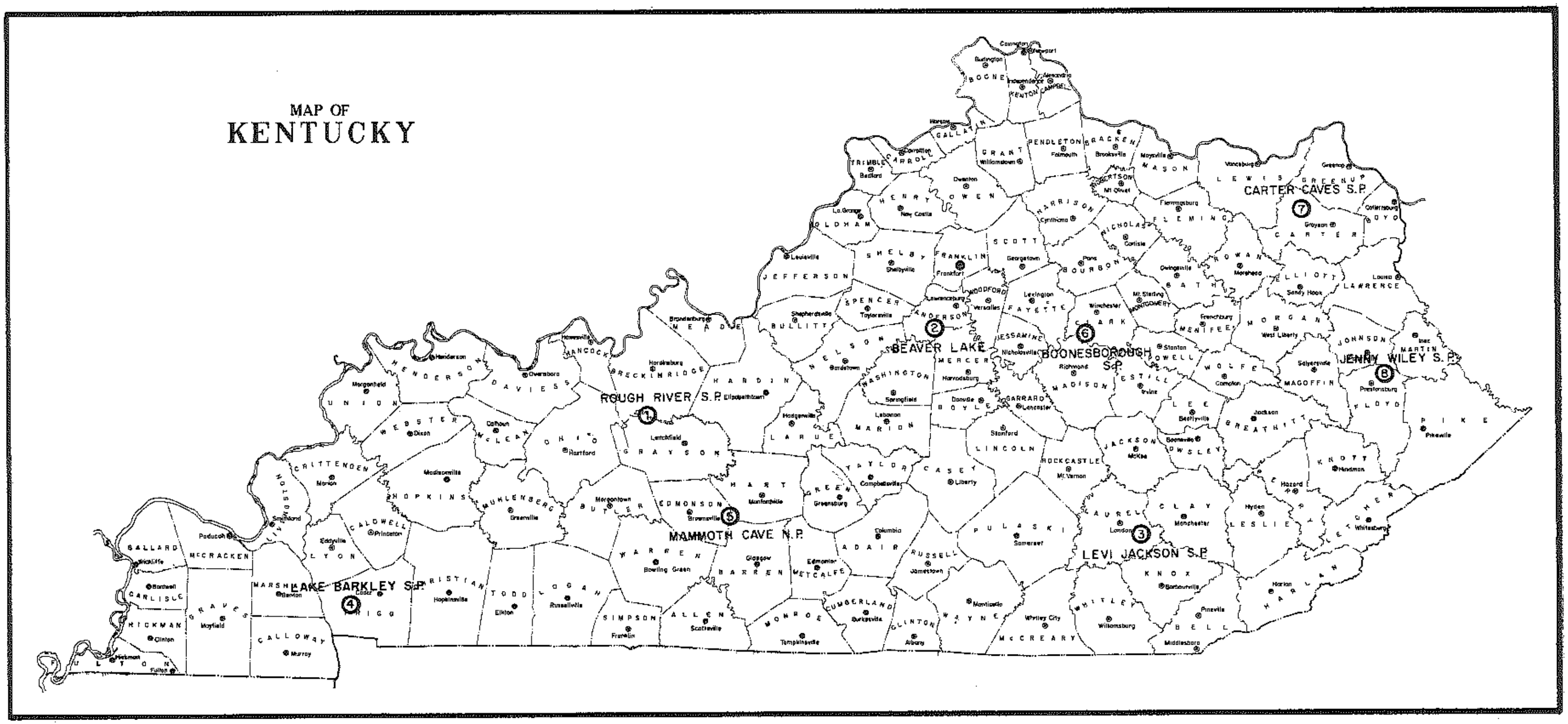

Figure 1. Location of Traffic Recorder Sites

ANALYSES

The data, originally on punched paper tape, were interpreted and presented on an easy-to-read printout. Shown on the printouts were hourly volumes for each day of the week and several peak, total, and average volumes. Computer cards with hourly volumes were also available.

Because of the various problems associated with the recorder and detector units, several periods were found to have traffic volumes which were unreasonably high or low, or completely missing. To identify and replace inaccurate or missing data, a series of computer programs were written to read the data, extract data exceeding specified limits and to synthesize those data by fitting a third degree polynomial to known points. The methodology and the computer programs for the adjustments are presented in the APPENDIX.

Time Distribution of Flow

After adjustments were made, eight sets of data were produced which contained a complete year of hourly volumes. Summarized data for each site included highest-to-lowest volume rankings and percentages of average daily traffic volumes (ADT) for the 300 highest hours, 364 days, and 52 weeks. Also included in the summaries were the highest-to-lowest volume rankings and percentages of total yearly traffic volumes for the 12 months and the four seasons.

A weekend was defined as the 48-hour period between 6 p.m. on Friday and 6 p.m. on Sunday. Seasonal periods were as follows: June 20 through September 19 -- summer, September 20 through December 19 -- fall, December 20 through March 19 -- winter, and March 20 through June 19 -- spring.

Figure 2 is a graph of the highest hourly volume versus hourly volume as a percentage of average daily traffic. Three curves are shown. The upper curve represents the maximum volumes amongst the eight sites, the middle curve represents the eight-site average volumes, and the lower curve represents the minimum volumes amongst the sites. For the maximum, average, and minimum curves, the highest hourly volumes as percentages of ADT are respectively: 121, 63, and 37. Correspondingly, the 30th highest hourly volumes as percentages of ADT are respectively: 83, 40, and 25.

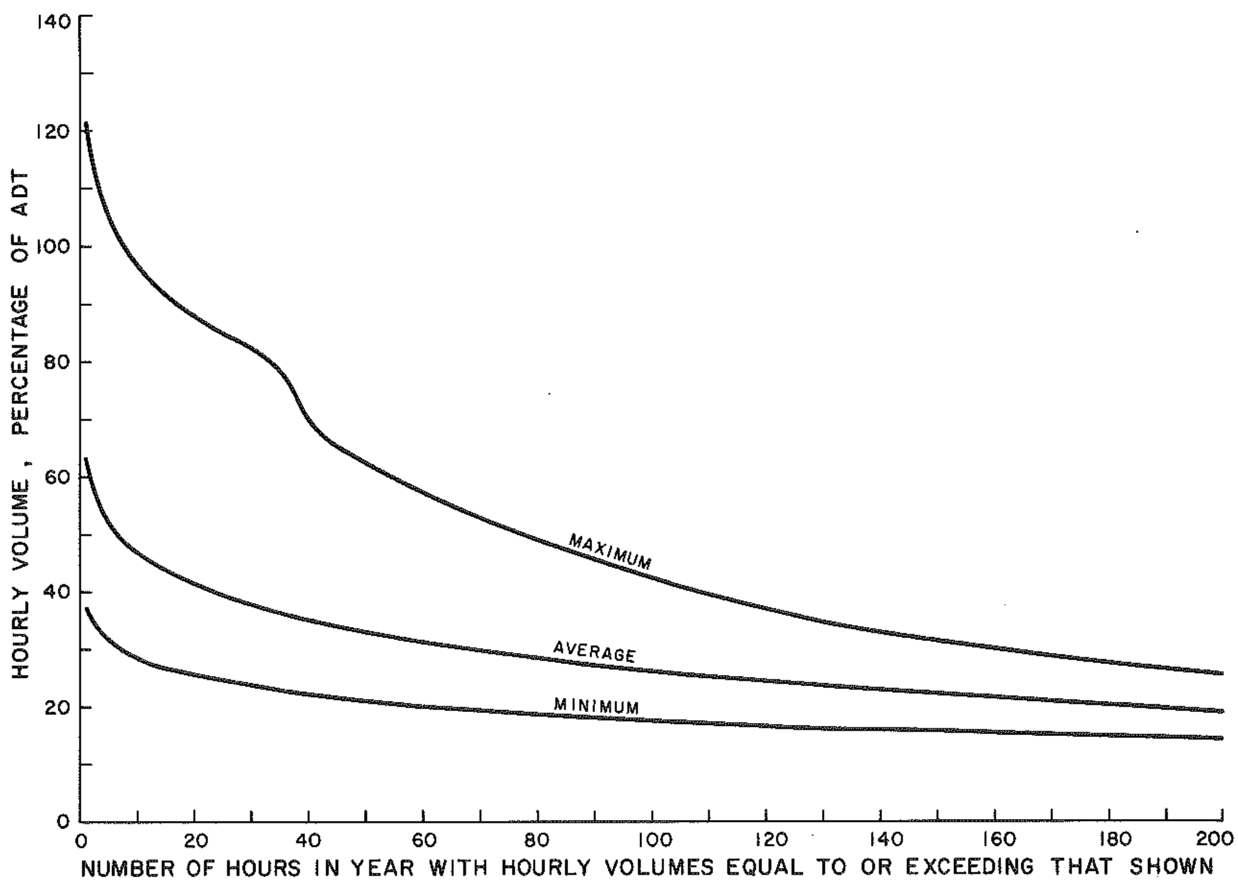

Figure 2. Highest Hourly Volumes

Daily volumes, expressed as a multiple of ADT, for the 100 highest volume days, are shown in Figure 3. The maximum daily volumes ranged from a high of 889 percent of the ADT at Boonesborough to a low of 332 percent at Beaver Lake. The high-volume days in Figure 3 were typically associated with summer Sundays, and the average summer Sunday volumes ranged from a high of 412 percent of the ADT at Boonesborough to a low of 156 percent of the ADT at Beaver Lake.

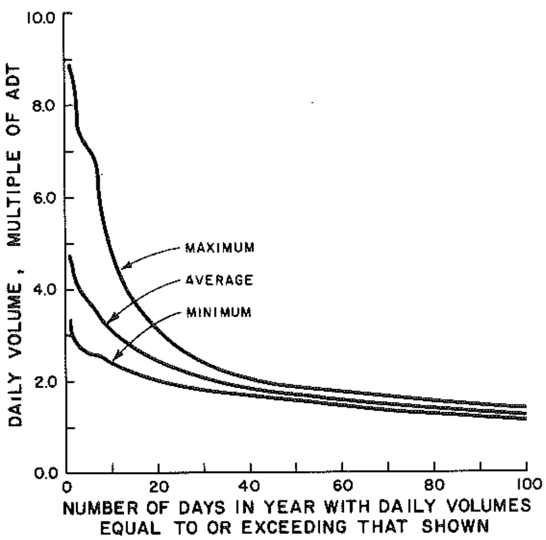

Figure 3. Highest Daily Volumes

Finally, Figure 4 shows the weekly volumes arranged in order of magnitude for the 52 weeks. A very wide range in weekly volumes was observed for the average summer weekly volumes -- from a high of 1300 percent of the ADT at Mammoth Cave to a low of 800 percent of the ADT at Beaver Lake.

Figure 2 is a typical curve relating peak traffic volumes to frequency. This type of graph is often used to determine the most equitable ratio between cost and service provided. The design volume is usually selected near the "knee of the curve", which, for most rural roads, is about the 30th highest hour *(16)*.

Hourly, Daily, Monthly, and Seasonal Variations of Flow

Cyclical variations in the time distributions were also investigated. The time periods chosen were: hours, days, months, and seasons. To define hourly cyclical variations, only summer Fridays, Saturdays, and Sundays were analyzed. Peaking within these summer days is demonstrated by Figure 5 and Table 2. As was expected, a rightward skew, identifying heavy evening traffic, occurred on Fridays. This was attributable to the fact that a significant portion of weekend visitors arrive on Friday evenings. Saturday traffic was generally spread evenly throughout the day with some peaking at midafternoon. Peaking was most prominent on Sunday afternoons from approximately 1:00 to 6:00 p.m. From Table 2, it appears a majority of individual peak summer hours were between 4:00 and 7:00 p.m. on Fridays, between 3:00 and 5:00 p.m. on Saturdays, and between 2:00 and 4:00 p.m. on Sundays.

A graph of day of week versus average daily volume as a percentage of average weekly volume is shown in Figure 6. Sunday is shown to be the peak day of the week. The next highest volume day is Saturday, and there is very little difference between other days of the week. Table 3 includes a summary of days on which the peak average volume occurs and corresponding percentages of the average weekly volume.

Seasonal and monthly cyclic variations are presented in Figures 7 and 8, respectively. In addition, the peak monthly volumes and peak seasonal volumes for each site are also given in Table 3. Monthly peaks occurred in May, June, and August, and peak monthly volume expressed as a percentage of total annual volume varied from 15 percent at Beaver Lake to 24 percent at Boonesborough State Park. Seasonal peaks occurred in spring and summer and peak seasonal volume expressed as a percentage of total annual volume varied from 36 percent at Beaver Lake to 47 percent at Mammoth Cave National Park.

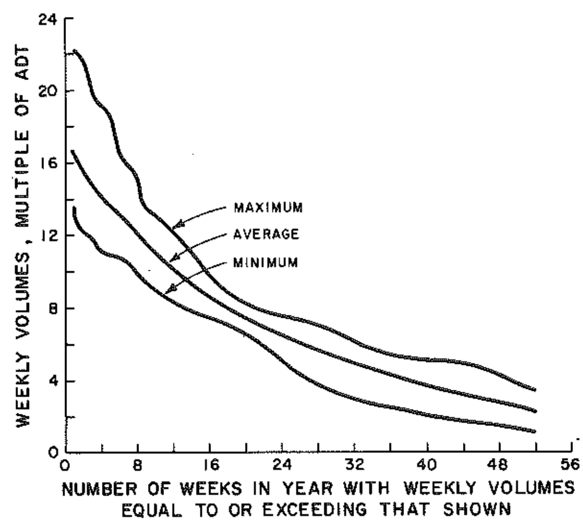

Figure 4. Highest Weekly Volumes

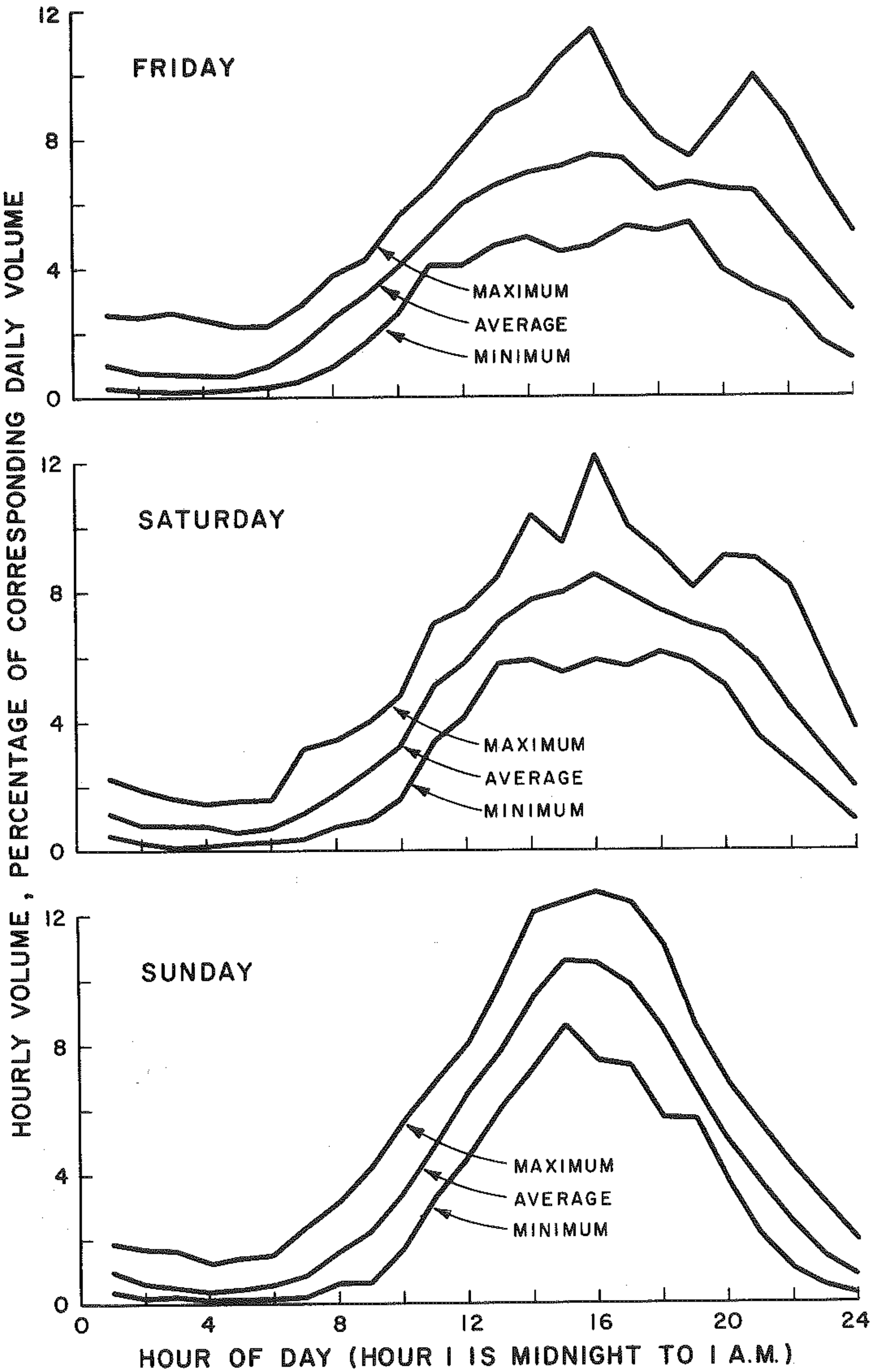

Figure 5. Volume Variations throughout Average Summer Weekend Days

TABLE 2

PEAK-HOUR VOLUMES FOR AVERAGE
SUMMER FRIDAYS, SATURDAYS, AND SUNDAYS

SITE NUMBER	HOUR OF PEAK VOLUME			PEAK HOURLY VOLUME (PERCENT OF DAILY VOLUME)		
	FRIDAY	SATURDAY	SUNDAY	FRIDAY	SATURDAY	SUNDAY
5	3-4 p.m.	3-4 p.m.	3-4 p.m.	11.41	12.17	12.68
3	8-9 p.m.	2-3 p.m.	3-4 p.m.	7.75	8.85	11.14
1	4-5 p.m.	4-5 p.m.	3-4 p.m.	8.44	8.94	9.83
6	7-8 p.m.	3-4 p.m.	2-3 p.m.	6.44	7.06	8.59
4	2-3 p.m.	3-4 p.m.	4-5 p.m.	8.37	10.05	12.39
2	8-9 p.m.	7-8 p.m.	2-3 p.m.	9.90	9.11	11.31
8	4-5 p.m.	2-3 p.m.	1-2 p.m.	7.53	9.20	12.11
7	4-5 p.m.	3-4 p.m.	1-2 p.m.	8.28	7.88	9.72
Average				8.52	9.16	10.97

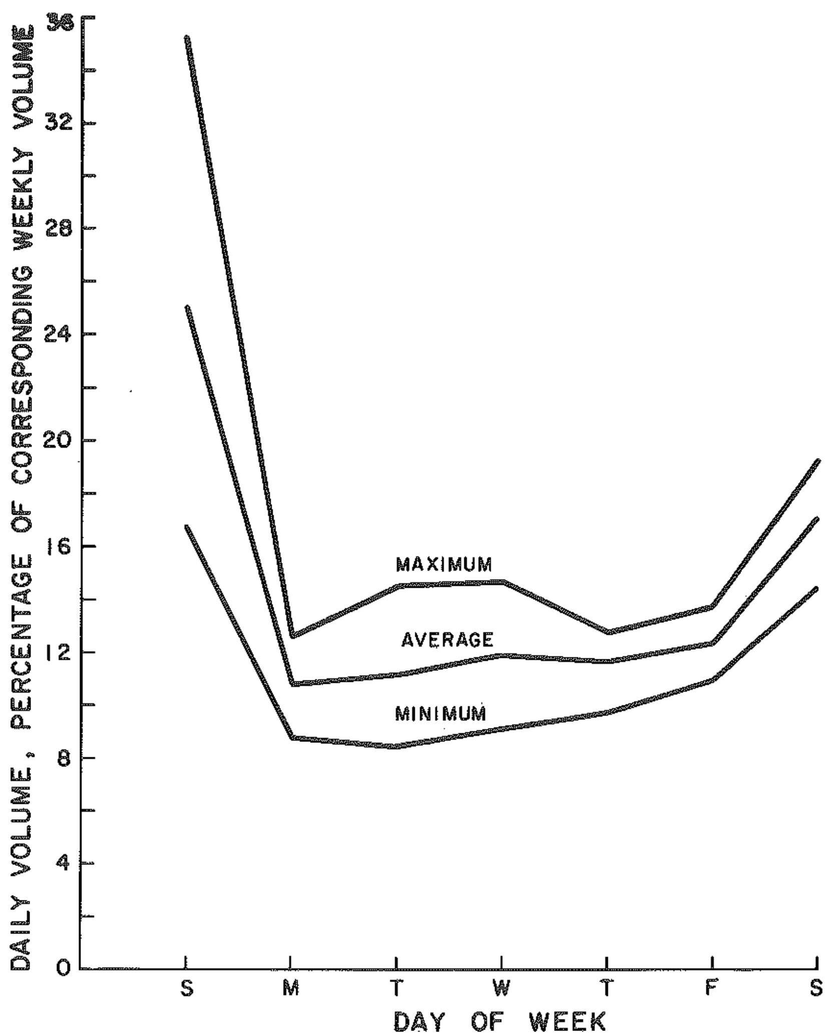

Figure 6. Volume Variations among Days throughout Average Summer Week

TABLE 3

PEAK VOLUMES FOR SEASON OF YEAR, MONTH OF YEAR, AND DAY OF AVERAGE SUMMER WEEK

SITE NUMBER	PERIOD OF PEAK VOLUME: DAY OF SUMMER WEEK	MONTH OF YEAR	SEASON OF YEAR	PEAK VOLUME: DAY (PERCENT OF AVERAGE SUMMER WEEK)	MONTH (PERCENT OF ANNUAL VOLUME)	SEASON (PERCENT OF ANNUAL VOLUME)
5	Sunday	May	Spring	26.46	16.92	38.55
3	Sunday	June	Summer	29.83	19.44	43.84
1	Sunday	August	Summer	16.82	18.51	46.41
6	Sunday	May	Spring	19.41	14.67	36.00
4	Sunday	June	Spring	35.26	23.66	42.16
2	Sunday	August	Summer	23.19	15.64	39.06
8	Sunday	August	Summer	26.30	15.39	40.54
7	Sunday	August	Summer	23.50	16.50	38.52
Average				25.09	17.59	40.64

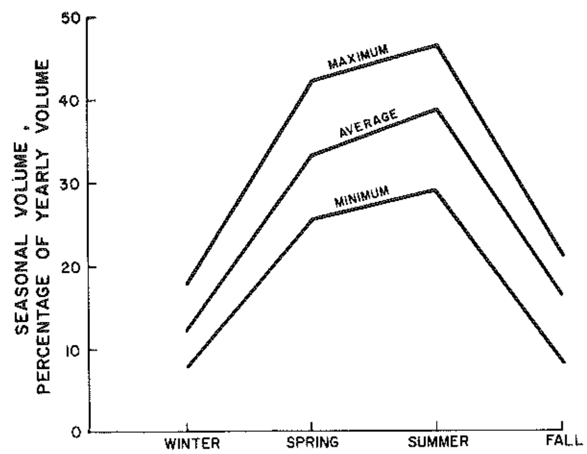

Figure 7. Volume Variations among Seasons

Figure 8. Volume Variations among Months

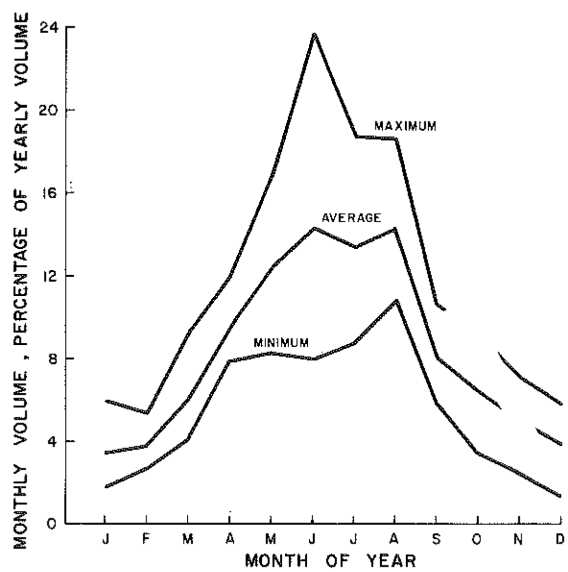

Table 4 summarizes all volume characteristics for each of the eight sites. Included are 1) all time periods which were considered significant, 2) volumes for each time period expressed as the number of vehicles counted, and 3) volumes as a multiple of ADT. Table 4 revealed that total annual volumes and average annual daily traffic flows ranged from 668,312 and 1836 at Levi Jackson State Park to 109,319 and 300 at Beaver Lake. Other information of interest to the highway designer is the 30th highest hourly volume. Expressed as a percentage of the ADT, this factor varied from 24 percent at Beaver Lake to 83 percent at Rough River State Park.

Coversion Factors

The next phase of analysis involved calculating factors to convert from measured volumes to average daily traffic (ADT) and summer Sunday traffic (SST). Conversion factors, presented in Table 5, were calculated for each day of the week during each season of the year, for each month of the year, for the average week, the average weekend, and the average ten-hour (10 a.m. - 8 p.m.) summer Sunday.

The conversion factors constitute a significant development for anyone desiring to convert short duration counts from recreational routes to average daily traffic flows. Certainly one of the most beneficial applications of these factors would be in the design of a highway leading to an existing or proposed outdoor recreational area. Trends in the conversion factors indicate that considerable variation occurs from one site to another, and careful study will be required before selecting the appropriate factor.

For very short duration counts, the 10 a.m. - 8 p.m. summer Sunday period appeared to be a very reliable unit of time from which to project traffic flows. The most apparent advantage of using this time period is that it is usually the highest volume 10-hour period of the week. Forty-eight hour counts are frequently used to obtain data from which to prepare traffic flow maps. It appears that the period from 6 p.m. Friday till 6 p.m. Sunday would be the most appropriate time to obtain peak flows. For a sample of an off-peak day, any of the other days of the week would suffice.

Greatest emphasis was placed on summer recreational travel, but Table 5 also includes factors for the other seasons of the year. At some recreational developments, spring and fall visitation exceeds summer visitation; therefore, appropriate analysis should be made to determine if peaks occur at sometime other than summer. Winter recreational travel has increased in recent years; and, in those areas where it is necessary, projections should be based on peak winter volumes.

Vehicle Occupancy

The average occupancy rate, based on 1970 surveys, was found to be 3.06 persons per vehicle. However, occupancy rate was found to be a function of type of recreational area, distance traveled, and vehicle type.

Table 6 demonstrates the effect of recreational area type and distance traveled as related to vehicle occupancy. A general trend of increasing vehicle occupancy with increasing distance traveled was established. It was also apparent that vehicle occupancy rates varied among the distinctively different recreational area types.

Table 7 summarizes data indicating the effects of both distance and vehicle type on occupancy rate. Sensitivity of occupancy rate to distance is greatest for camping vehicles and least for vehicles with boats. Despite large variability in the data, occupancy rates generally increased with increasing distance of travel. The effects were most pronounced for vehicles traveling rather short distances.

Highest occupancy rates were observed for cars pulling camper trailers, and lowest rates were for the other" vehicle category -- including primarily service trucks and motorcycles. The fact that single-unit campers had much lower occupancy rates than cars pulling camper trailers is probably due to a combination of 1) failure to detect some persons riding in the single-unit campers and 2) bias caused by extensive use of pickup campers by fishermen who usually travel in rather small groups.

Vehicle Classification

As anticipated, a large proportion of the vehicles were cars (pickups included) or cars pulling trailers (a total of 96.7 percent). The remainder were single-unit campers (2.1 percent) and motorcycles, trucks, and buses (1.2 percent). Altogether, 3.4 percent of the vehicles had camping units appended and 5.8 percent had boats. Vehicle classification was found to depend on the origin of the vehicle, or the distance traveled, as well as on the type of recreational area.

TABLE 4

TRAFFIC VOLUME CHARACTERISTICS

TIME PERIOD	TYPE OF VOLUME	COUNTED VOLUMES (VEHICLES)								
		SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7	SITE 8	AVERAGE
Year	Total	268,976	109,319	668,312	324,781	617,044	387,337	234,786	395,602	376,020
Week	Maximum	14,117	4,031	28,701	12,774	29,751	23,678	9,483	16,910	17,431
Week	4th highest	12,664	3,287	22,321	11,650	24,648	20,221	8,615	13,936	14,668
Week	8th highest	10,322	3,146	20,334	10,116	22,256	16,187	7,831	10,631	12,603
Week	Summer Average	9,071	2,414	20,081	7,369	22,030	12,429	7,322	11,721	11,555
Week	Annual Average	5,173	2,102	12,852	6,246	11,866	7,449	4,515	7,608	7,226
Weekend	Maximum	8,655	1,848	13,036	5,903	10,617	15,715	7,418	6,168	8,670
Weekend	4th highest	7,307	1,594	10,130	4,940	9,557	12,005	4,149	6,252	6,992
Weekend	8th highest	5,645	1,354	9,304	4,161	7,384	8,557	3,678	5,012	5,637
Weekend	Summer Average	4,645	991	9,072	3,151	7,514	6,540	3,379	5,223	5,064
Weekend	Annual Average	2,580	901	5,975	2,664	4,473	4,184	2,157	3,323	3,282
Day	Maximum	4,887	998	6,377	3,321	5,930	9,464	3,227	3,997	4,775
Day	5th highest	4,068	780	5,374	2,600	4,620	7,518	2,381	3,093	3,804
Day	10th highest	3,015	728	4,746	2,134	4,378	5,354	1,951	2,684	3,124
Day	Summer Sunday Average	2,706	469	4,657	1,950	3,704	4,382	1,925	2,755	2,819
Day	Annual Average	739	300	1,836	892	1,695	4,064	645	1,087	1,407
Hour	Maximum	620	149	1,124	384	630	1,290	435	462	637
Hour	15th highest	445	82	569	312	447	971	267	384	435
Hour	30th highest	372	72	522	270	430	882	255	319	390
Hour	50th highest	303	64	481	249	410	667	237	275	336
Hour	100th highest	237	53	398	217	377	430	188	232	267
		VOLUME EXPRESSED AS A MULTIPLE OF AVERAGE DAILY TRAFFIC								
Year	Total	364.0	364.4	364.0	364.1	364.0	364.0	364.0	364.9	364.2
Week	Maximum	19.1	13.4	15.6	14.3	17.6	22.3	14.7	15.6	16.6
Week	4th highest	17.1	11.0	12.2	13.1	14.5	19.0	13.4	12.8	14.1
Week	8th highest	14.0	10.5	11.1	11.3	13.1	15.2	12.1	9.8	12.1
Week	Summer Average	12.3	8.1	10.9	8.3	13.0	11.7	11.4	10.8	10.8
Week	Annual Average	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Weekend	Maximum	11.7	6.2	6.9	6.6	6.3	14.8	9.6	6.8	8.6
Weekend	4th highest	9.9	5.3	5.5	5.5	5.6	11.3	6.4	5.8	6.9
Weekend	8th highest	7.6	4.5	5.1	4.7	4.4	8.0	5.7	4.6	5.6
Weekend	Summer Average	6.3	3.3	4.9	3.5	4.4	6.2	5.2	4.8	4.8
Weekend	Annual Average	3.5	3.0	3.3	3.0	2.6	3.9	3.3	3.1	3.2
Day	Maximum	6.6	3.3	3.5	3.7	3.5	8.9	5.0	3.7	4.8
Day	5th highest	5.5	2.6	2.9	2.9	2.7	7.1	3.7	2.9	3.8
Day	10th highest	4.1	2.4	2.6	2.4	2.6	5.0	3.0	2.5	3.1
Day	Summer Sunday Average	3.7	1.6	2.5	2.2	2.2	4.1	3.0	2.5	2.7
Day	Annual Average	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Hour	Maximum	0.8	0.5	0.6	0.4	0.4	1.2	0.7	0.4	0.6
Hour	15th highest	0.6	0.3	0.3	0.4	0.3	0.9	0.4	0.4	0.5
Hour	30th highest	0.5	0.2	0.3	0.3	0.3	0.8	0.4	0.3	0.4
Hour	50th highest	0.4	0.2	0.3	0.3	0.2	0.6	0.4	0.3	0.3
Hour	100th highest	0.3	0.2	0.2	0.2	0.2	0.4	0.3	0.2	0.3

TABLE 5

FACTORS TO CONVERT FROM MEASURED VOLUMES TO AVERAGE DAILY TRAFFIC AND SUMMER SUNDAY TRAFFIC

FACTORS TO CONVERT FROM MEASURED VOLUMES TO AVERAGE DAILY TRAFFIC AND SUMMER SUNDAY TRAFFIC

TIME	PERIOD	LOCATION 1 AVG VOL	LOCATION 1 ADT FACTOR	LOCATION 1 SST FACTOR	LOCATION 2 AVG VOL	LOCATION 2 ADT FACTOR	LOCATION 2 SST FACTOR	LOCATION 3 AVG VOL	LOCATION 3 ADT FACTOR	LOCATION 3 SST FACTOR	LOCATION 4 AVG VOL	LOCATION 4 ADT FACTOR	LOCATION 4 SST FACTOR
FALL	SUNDAY	1293	1.311	2.912	2007	0.915	2.282	583	1.268	4.345	807	1.318	5.175
	MONDAY	731	2.320	5.153	1047	1.754	4.376	264	2.801	9.599	256	4.155	16.318
	TUESDAY	816	2.077	4.613	1098	1.671	4.170	258	2.860	9.799	249	4.278	16.797
	WEDNESDAY	829	2.045	4.543	1030	1.783	4.447	295	2.508	8.592	243	4.379	17.196
	THURSDAY	820	2.067	4.591	1042	1.763	4.398	297	2.491	8.535	265	4.022	15.793
	FRIDAY	963	1.760	3.910	1324	1.387	3.461	327	2.263	7.753	303	3.515	13.802
	SATURDAY	1015	1.671	3.711	1546	1.188	2.963	404	1.831	6.274	437	2.433	9.553
	WEEKEND	2543	0.667	1.481	4118	0.446	1.112	1103	0.670	2.296	1307	0.814	3.197
	10-HR SUN	919	1.844	4.095	1500	1.224	3.054	430	1.719	5.889	721	1.477	5.799
	WEEKLY	6885	0.246	0.547	9085	0.202	0.504	2564	0.288	0.988	2644	0.402	1.580
WINTER	SUNDAY	935	1.814	4.028	1534	1.197	2.986	312	2.368	8.115	690	1.543	6.059
	MONDAY	656	2.582	5.736	852	2.155	5.375	292	2.534	8.682	258	4.131	16.220
	TUESDAY	680	2.491	5.534	979	1.875	4.678	308	2.402	8.231	246	4.320	16.965
	WEDNESDAY	626	2.709	6.016	935	1.963	4.899	311	2.377	8.145	236	4.512	17.718
	THURSDAY	698	2.430	5.398	1006	1.825	4.552	344	2.149	7.364	264	4.027	15.813
	FRIDAY	744	2.280	5.063	1201	1.529	3.814	459	1.610	5.516	307	3.465	13.607
	SATURDAY	918	1.847	4.102	1334	1.377	3.435	334	2.215	7.589	398	2.672	10.494
	WEEKEND	2010	0.844	1.874	3446	0.533	1.329	737	1.002	3.435	1189	0.895	3.515
	10-HR SUN	716	2.367	5.257	1101	1.667	4.159	145	5.106	17.494	569	1.871	7.346
	WEEKLY	5264	0.322	0.715	7867	0.233	0.582	2426	0.305	1.044	2543	0.418	1.643
SPRING	SUNDAY	2634	0.644	1.430	3447	0.533	1.329	1861	0.397	1.360	4461	0.239	0.937
	MONDAY	1617	1.048	2.329	1428	1.286	3.208	549	1.347	4.615	984	1.081	4.267
	TUESDAY	1585	1.069	2.375	1531	1.199	2.993	600	1.231	4.219	974	1.093	4.290
	WEDNESDAY	1583	1.071	2.379	1487	1.235	3.081	673	1.098	3.763	1006	1.058	4.153
	THURSDAY	1624	1.044	2.318	1560	1.177	2.935	735	1.006	3.447	1165	0.913	3.586
	FRIDAY	1838	0.923	2.049	1970	0.932	2.326	895	0.826	2.829	1447	0.736	2.889
	SATURDAY	2568	0.660	1.466	2702	0.679	1.695	1496	0.494	1.693	2331	0.457	1.793
	WEEKEND	5562	0.305	0.677	6971	0.263	0.657	3681	0.201	0.688	7303	0.146	0.572
	10-HR SUN	2036	0.833	1.850	2721	0.675	1.683	1517	0.487	1.669	4052	0.263	1.031
	WEEKLY	12817	0.132	0.294	13691	0.134	0.335	6641	0.111	0.381	11721	0.091	0.357
SUMMER	SUNDAY	3765	0.450	1.000	4581	0.401	1.000	2532	0.292	1.000	4179	0.255	1.000
	MONDAY	2669	0.635	1.411	2222	0.826	2.061	792	0.933	3.196	1121	0.950	3.729
	TUESDAY	3203	0.529	1.175	2475	0.742	1.851	903	0.818	2.803	1044	1.020	4.004
	WEDNESDAY	3243	0.523	1.161	2295	0.800	1.996	929	0.796	2.727	1134	0.939	3.686
	THURSDAY	2801	0.605	1.344	2443	0.751	1.875	941	0.786	2.692	1205	0.883	3.468
	FRIDAY	3017	0.562	1.248	2536	0.724	1.806	1054	0.701	2.401	1365	0.779	3.061
	SATURDAY	3455	0.491	1.090	3393	0.541	1.350	1656	0.446	1.529	2062	0.516	2.026
	WEEKEND	7724	0.219	0.487	8930	0.206	0.513	4550	0.162	0.556	6568	0.162	0.636
	10-HR SUN	3007	0.564	1.252	3532	0.520	1.297	2092	0.353	1.210	3659	0.291	1.142
	WEEKLY	22711	0.075	0.166	21096	0.087	0.217	8756	0.084	0.289	12074	0.088	0.346
	OCTOBER	32998	0.051	0.114	40131	0.046	0.114	12494	0.059	0.203	13244	0.080	0.315
	NOVEMBER	22309	0.076	0.169	40858	0.045	0.112	8040	0.092	0.315	9607	0.111	0.435
	DECEMBER	19883	0.085	0.189	33294	0.055	0.138	8816	0.084	0.287	6334	0.168	0.660
	JANUARY	20515	0.083	0.183	33006	0.056	0.139	8113	0.091	0.312	6845	0.155	0.610
	FEBRUARY	19819	0.085	0.190	28380	0.065	0.161	9948	0.074	0.254	10918	0.097	0.383
	MARCH	32540	0.052	0.116	42406	0.043	0.108	13593	0.054	0.186	17119	0.062	0.244
	APRIL	56654	0.030	0.066	59496	0.031	0.077	21102	0.035	0.120	37098	0.029	0.113
	MAY	59195	0.029	0.064	66113	0.028	0.069	31416	0.023	0.081	60816	0.017	0.069
	JUNE	90560	0.019	0.042	78968	0.023	0.058	52293	0.014	0.048	91663	0.012	0.046
	JULY	91010	0.019	0.041	90024	0.020	0.051	50285	0.015	0.050	62526	0.017	0.067
	AUGUST	114227	0.015	0.033	104507	0.018	0.044	34937	0.021	0.072	48605	0.022	0.086
	SEPTEMBER	57334	0.030	0.066	51129	0.036	0.090	17939	0.041	0.141	22562	0.047	0.185

TIME	PERIOD	LOCATION 5 AVG VOL	LOCATION 5 ADT FACTOR	LOCATION 5 SST FACTOR	LOCATION 6 AVG VOL	LOCATION 6 ADT FACTOR	LOCATION 6 SST FACTOR	LOCATION 7 AVG VOL	LOCATION 7 ADT FACTOR	LOCATION 7 SST FACTOR	LOCATION 8 AVG VOL	LOCATION 8 ADT FACTOR	LOCATION 8 SST FACTOR
FALL	SUNDAY	1108	0.805	1.734	403	0.745	1.141	1169	0.930	2.396	792	0.814	2.357
	MONDAY	492	1.815	3.910	204	1.475	2.260	676	1.608	4.143	424	1.522	4.408
	TUESDAY	514	1.734	3.735	194	1.549	2.374	736	1.476	3.804	408	1.581	4.578
	WEDNESDAY	611	1.459	3.143	201	1.495	2.291	724	1.501	3.868	381	1.692	4.899
	THURSDAY	620	1.439	3.098	205	1.466	2.247	720	1.510	3.891	378	1.706	4.941
	FRIDAY	737	1.211	2.607	213	1.413	2.166	752	1.445	3.725	443	1.456	4.217
	SATURDAY	886	1.007	2.169	364	0.825	1.264	894	1.216	3.134	602	1.072	3.105
	WEEKEND	2080	0.429	0.924	796	0.377	0.578	2314	0.470	1.210	1496	0.431	1.249
	10-HR SUN	847	1.053	2.269	303	0.992	1.520	883	1.231	3.172	624	1.034	2.994
	WEEKLY	5199	0.172	0.370	1809	0.166	0.254	5818	0.187	0.481	3605	0.179	0.518
WINTER	SUNDAY	619	1.440	3.102	198	1.513	2.319	971	1.119	2.885	313	2.064	5.976
	MONDAY	352	2.533	5.456	151	1.987	3.044	642	1.694	4.366	188	3.423	9.911
	TUESDAY	376	2.375	5.116	155	1.936	2.966	670	1.622	4.179	210	3.066	8.878
	WEDNESDAY	358	2.490	5.363	156	1.920	2.943	687	1.581	4.075	208	3.101	8.980
	THURSDAY	416	2.144	4.617	158	1.903	2.916	721	1.507	3.883	203	3.185	9.224
	FRIDAY	464	1.923	4.141	174	1.724	2.642	853	1.274	3.283	218	2.954	8.554
	SATURDAY	571	1.562	3.363	167	1.795	2.751	964	1.127	2.904	241	2.681	7.765
	WEEKEND	1359	0.657	1.415	427	0.703	1.078	2192	0.496	1.278	636	1.015	2.939
	10-HR SUN	476	1.875	4.039	119	2.518	3.858	727	1.495	3.852	252	2.562	7.420
	WEEKLY	3211	0.278	0.599	1191	0.252	0.386	5501	0.198	0.509	1613	0.400	1.158
SPRING	SUNDAY	2297	0.388	0.837	723	0.415	0.636	2043	0.532	1.371	1526	0.423	1.224
	MONDAY	1099	0.812	1.748	349	0.861	1.320	766	1.419	3.657	488	1.323	3.830
	TUESDAY	1101	0.811	1.746	337	0.892	1.366	807	1.346	3.469	517	1.247	3.610
	WEDNESDAY	1154	0.773	1.665	351	0.855	1.310	797	1.364	3.516	526	1.226	3.549
	THURSDAY	1166	0.765	1.648	320	0.938	1.437	813	1.337	3.446	581	1.111	3.217
	FRIDAY	1189	0.751	1.617	356	0.843	1.292	990	1.098	2.829	772	0.836	2.421
	SATURDAY	1650	0.541	1.165	582	0.516	0.791	1371	0.792	2.042	1140	0.566	1.638
	WEEKEND	4156	0.215	0.462	1323	0.227	0.348	3581	0.303	0.782	2859	0.226	0.653
	10-HR SUN	1844	0.484	1.042	431	0.696	1.067	1448	0.751	1.935	1300	0.496	1.437
	WEEKLY	9661	0.092	0.199	2997	0.100	0.154	7427	0.146	0.377	5381	0.120	0.347
SUMMER	SUNDAY	1922	0.464	1.000	460	0.653	1.000	2801	0.388	1.000	1868	0.345	1.000
	MONDAY	851	1.049	2.259	281	1.067	1.636	1315	0.826	2.130	749	0.861	2.494
	TUESDAY	845	1.056	2.275	274	1.097	1.681	1308	0.831	2.141	739	0.873	2.527
	WEDNESDAY	939	0.950	2.047	323	0.928	1.423	1361	0.798	2.058	857	0.753	2.181
	THURSDAY	873	1.022	2.202	303	0.990	1.517	1375	0.790	2.037	854	0.755	2.188
	FRIDAY	834	1.070	2.304	309	0.971	1.488	1530	0.710	1.830	915	0.705	2.042
	SATURDAY	1028	0.868	1.869	435	0.690	1.058	2136	0.509	1.311	1300	0.496	1.436
	WEEKEND	3144	0.284	0.611	958	0.313	0.480	5195	0.209	0.539	3402	0.190	0.549
	10-HR SUN	1694	0.527	1.134	296	1.013	1.552	2102	0.517	1.332	1601	0.403	1.167
	WEEKLY	7383	0.121	0.260	2545	0.118	0.181	12310	0.088	0.228	7558	0.085	0.247
	OCTOBER	26027	0.034	0.074	10041	0.030	0.046	27128	0.040	0.103	18627	0.035	0.100
	NOVEMBER	18818	0.047	0.102	6539	0.046	0.070	21839	0.050	0.128	16660	0.039	0.112
	DECEMBER	12335	0.072	0.156	6253	0.048	0.074	23083	0.047	0.121	5233	0.123	0.357
	JANUARY	12210	0.073	0.157	2256	0.133	0.204	23523	0.046	0.119	5805	0.111	0.322
	FEBRUARY	11902	0.075	0.161	4363	0.069	0.105	21179	0.051	0.132	6195	0.104	0.301
	MARCH	19548	0.046	0.098	13036	0.030	0.046	27353	0.040	0.102	9702	0.066	0.192
	APRIL	34014	0.026	0.056	13066	0.023	0.035	35080	0.031	0.080	20097	0.032	0.093
	MAY	54942	0.016	0.035	16036	0.019	0.029	32435	0.033	0.086	30415	0.021	0.061
	JUNE	41292	0.022	0.046	3643	0.035	0.053	35884	0.030	0.078	35506	0.018	0.053
	JULY	28242	0.032	0.068	12855	0.023	0.036	41127	0.026	0.068	29763	0.022	0.063
	AUGUST	35253	0.025	0.054	12711	0.024	0.036	65261	0.017	0.043	36135	0.018	0.052
	SEPTEMBER	30198	0.029	0.064	6520	0.04	0.071	41710	0.026	0.067	20648	0.031	0.090

To illustrate the effect of origin, 2.1 percent of the Kentucky vehicles had camping units and 6.0 percent had boats; respective percentages for Michigan vehicles were 10.4 percent and 3.9 percent. These and similar data are summarized in Table 8 for the eight primary states contributing to Kentucky recreational travel. Origin effects are most probably due in large part to the intervening distances (Figure 9). Decreasing percentage of cars with increasing distance reflects the increasingly greater use of single-unit campers over the longer distances. As distance increases, a greater percentage of recreationists use camping vehicles. Boat usage peaks in the distance range of 60 to 90 miles.

The effects of recreation-facility type on vehicle usage are quite clear. A high percentage of vehicles with boats were observed at water-based facilities (a high of 12.3 percent at Corps of Engineers' facilities compared to a low of 0.6 percent at the national parks). The percentage of vehicles with camping units depended in large part on the nature of available camping facilities (a high of 11.2 at the Land-Between-the-Lakes compared to a low of 3.0 percent at state parks). Table 9 summarizes these data.

Trip-Length Distribution

Examination of trip origins revealed that most of the recreationists came from Kentucky. This suggested that travel to Kentucky outdoor recreational facilities is predominantly of the short-distance type. The average trip length for all vehicles was found to be 109 miles. However, 60 percent of all vehicles traveled distances less than 50 miles, and 72 percent traveled less than 100 miles.

Trip lengths were found to be a function of the type and location of the recreational area. Figure 10 shows trip-length distributions for the following three state parks: Cumberland Falls, My Old Kentucky Home, and Jenny Wiley. Mean trip lengths for Cumberland Falls, My Old Kentucky Home, and Jenny Wiley were 182, 140 and 57 miles, respectively. Corresponding percentages of trips having lengths less than 50 miles were 28.2, 39.5, and 79.5 percent, respectively.

Also of considerable interest was the influence of vehicle type on the distribution of trip lengths. Figure 11 demonstrates this effect. Cars pulling camper trailers generally traveled the greatest distances. Single-unit campers traveled somewhat shorter distances due, in part, to the considerable use of single-unit campers by fishermen. Cars without either boats or trailers generally traveled the shortest distances.

TABLE 6

EFFECT OF RECREATIONAL AREA TYPE AND DISTANCE TRAVELED ON VEHICLE OCCUPANCY RATES

SITE NUMBER	DISTANCE INTERVAL (MILES) 1-20	21-40	41-60	61-80	81-100	101-150	151-250	251-400	401-700	701-1300	1301-3000	AVERAGE (ALL DISTANCES)
1	2.68	3.30	3.02	3.10	3.02	2.86	2.80	2.93	2.74	2.96	3.00	2.70
2	2.23	2.98	3.56	2.00	2.00	3.00	2.67	0.0*	3.00	2.50	0.0*	2.00
3	2.49	2.91	3.00	2.44	2.85	2.87	3.14	2.87	3.27	3.52	3.75	2.76
4	2.46	2.91	2.99	3.34	3.16	3.16	3.05	3.48	3.34	3.21	3.74	2.90
5	2.73	3.57	3.27	3.85	3.76	3.71	3.54	3.55	3.67	3.26	2.70	3.13
6	3.12	3.29	3.43	3.32	3.78	3.25	3.34	3.69	3.42	3.17	4.30	3.18
7	2.92	3.69	3.82	3.41	3.76	3.81	4.04	3.80	3.52	3.42	2.67	3.24
8	2.95	3.22	3.08	3.09	3.03	3.35	3.32	3.11	3.45	3.25	4.22	3.01
AVERAGE (ALL SITES)	2.70	3.23	3.27	3.07	3.17	3.25	3.24	2.93	3.30	3.16	3.05	2.87

*No observations within this distance interval

TABLE 7

EFFECTS OF DISTANCE AND VEHICLE TYPE ON AVERAGE VEHICLE OCCUPANCY

VEHICLE TYPE	DISTANCE INTERVAL (MILES) 1-20	21-40	41-60	61-80	81-100	101-150	151-250	251-400	401-700	701-1300	1301-3000	AVERAGE (ALL DISTANCES)
Car	2.78	3.02	3.28	3.27	3.31	3.29	3.20	3.45	3.39	3.25	3.11	3.07
Car with Boat and Trailer	3.02	3.14	3.12	3.25	3.13	3.15	3.45	3.19	3.16	3.18	3.60	3.16
Car with Boat on Top	2.72	3.14	3.05	2.79	3.00	3.09	3.92	3.31	3.00	2.50		3.04
Car with Camper Trailer	3.06	3.20	3.28	3.45	3.44	3.61	3.63	3.86	4.06	3.60	3.82	3.63
Single-Unit Camper	2.70	2.55	2.83	3.11	3.06	3.00	2.92	2.99	3.39	3.48	3.36	2.97
Single-Unit Camper with Boat	2.75	2.79	2.71	2.71	2.70	3.27	2.65	3.38	2.94	3.30	4.25	2.96
Other	2.16	1.61	1.92	2.19	5.30	1.63	1.69	4.78	1.57	1.75	20.50	2.67
Average (All Vehicles)	2.78	3.02	3.26	3.25	3.30	3.28	3.21	3.45	3.41	3.26	3.28	3.06

TABLE 8

EFFECT OF LOCATION OF ORIGIN ON PERCENTAGES OF VARIOUS VEHICLE TYPES

ORIGIN	CAR	CAR WITH BOAT AND TRAILER	CAR WITH BOAT ON TOP	CAR WITH CAMPER TRAILER	SINGLE UNIT CAMPER	SINGLE UNIT CAMPER WITH BOAT	OTHER
Kentucky	90.89	5.27	.40	.61	1.08	.37	1.38
Ohio	86.46	5.34	.63	3.35	2.62	.62	.97
Indiana	87.57	4.51	.62	2.38	3.15	.87	.90
Illinois	88.11	3.36	.88	3.20	2.72	.86	.88
Tennessee	90.99	3.44	.32	1.59	1.62	1.05	.99
Michigan	85.74	2.28	.70	6.08	3.33	.94	.94
Missouri	88.67	4.03	.77	2.82	2.63	.51	.58
W. Virginia	88.51	2.31	.79	5.61	1.45	.46	.86
All Origins	89.95	4.91	.46	1.36	1.58	.48	1.26

TABLE 9

EFFECT OF TYPE OF RECREATIONAL AREA ON PERCENTAGES OF VARIOUS VEHICLE TYPES

TYPE OF FACILITY	PERCENTAGE OF CARS[a]	PERCENTAGE OF CAMPING VEHICLES[b]	PERCENTAGE OF VEHICLES WITH BOATS
State Parks	97.36	2.95	3.22
National Parks	95.56	6.51	0.58
Corps of Engineers Facilities	95.71	3.29	12.31
Kentucky Lake (TVA)	96.31	3.81	6.14
Land-Between-The-Lakes (TVA)	90.84	11.24	12.02
Daniel Boone National Forest	96.22	2.99	3.25
Other Areas	97.84	2.59	7.15
All Areas	96.67	3.42	5.84

[a]Includes cars with boat and camper trailers.

[b]Includes cars with camper trailers and single-unit campers.

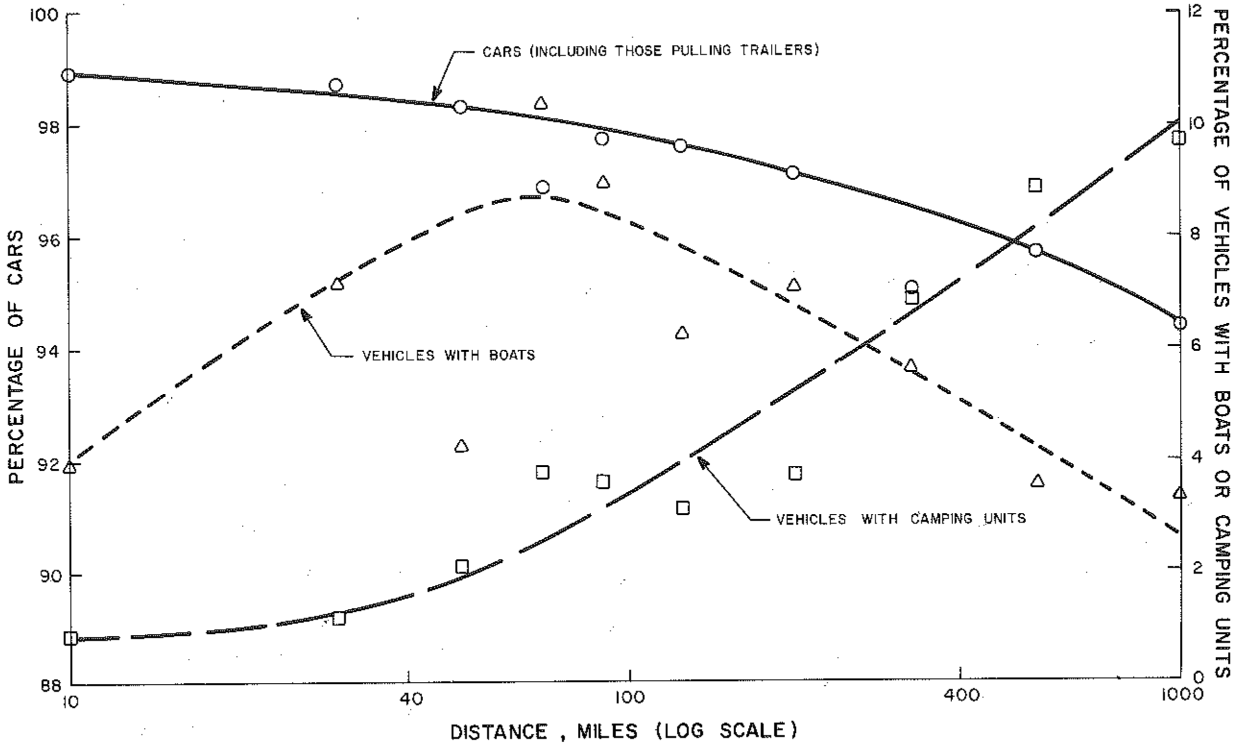

Figure 9. Effect of Distance on Percentage of Various Vehicle Types

TABLE 10

RECREATIONAL CLASSIFICATION OF RECORDER SITES

LAKE[a]	DAY USE FACILITIES[b]	OVERNIGHT FACILITIES[c]	RECREATIONAL AREA NAME & NO.	TOTAL ANNUAL VOLUME	AVERAGE ANNUAL DAILY VOLUME	10-HOUR SUMMER SUNDAY VOLUME	SUMMER SUNDAY AVERAGE VOLUME	WATER ACRES	NO. OF PICNIC TABLES	NO. OF OVERNIGHT FACILITIES	GOLF HOLES	OUTDOOR DRAMA SEATS	SWIMMING POOL OR BEACH[d]
LARGE	L	L	Jenny Wiley S.P. (8)	395,607	1087	2102	2801	1,100	245	66	9	900	SP
			Lake Barkley S.P. (4)	324,781	892	1694	1922	58,000	100	133	18		SP, SB
			Rough River S.P. (1)	268,076	730	2092	2532	5,100	144	105			SP, SB
		M											
		S											
	M	L											
		M											
		S											
	S	L											
		M											
		S											
SMALL	L	L											
		M											
		S	Carter Caves S.P. (7)	230,786	645	1601	1068	36	331	126	9		SP, SB
	M	L											
		M											
		S											
	S	L											
		M											
		S	Beaver Lake (2)	142,565	392	296	460	170	8	10			
NONE	L	L	Levi Jackson S.P. (3)	666,312	1036	3532	4581		400	200			SP
		M											
		S											
	M	L	Mammoth Cave N.P. (5)	617,044	1655	3007	3766		50	293			SP
		M	Fort Boonesborough S.P. (6)	387,337	1064	3659	4170		104	95			SB
		S											
	S	L											
		M											
		S											

[a] Large ≥ 500 acres

[b] L ≥ 150 picnic tables or availability of golf course; M = 1-150 picnic tables and no golf course; S = no picnic tables and no golf course

[c] L ≥ 50 units (cottages + lodge rooms + camping sites); M < 50 units and ≥ 15 units; S < 15 units

[d] SP = swimming pool; SB = swimming beach

PREDICTING RECREATIONAL TRAFFIC VOLUMES

The foregoing results may be used as a basis for a predictive criterion. This may be done most simply by association. Certainly, limitations and constraints must be respected inasmuch as only eight facilities were studied. However, the time period covered by data collection was rather extensive; indeed, few traffic surveys cover a full year.

Assume that traffic volumes or travel patterns are needed for a proposed, new, or existing recreational area. Regardless of the kind of information desired, the initial step should be to select a similar facility from the facility classification scheme shown in Table 10. To utilize Table 10, the following attributes of the recreational area must be known or assumed water acreage, number of picnic tables, number of overnight facilities (lodge rooms, cottages, camp sites), number of golf holes, number of outdoor drama seats, and availability of a swimming pool or beach. These attributes, plus two additional ones (miles of horseback and hiking trails), were used in the first phase of this study *(1)* to estimate attraction factors with considerable accuracy (squared correlation coefficient R^2 = 0.93). Traffic volumes may be estimated from Table 4 by choosing a comparable recreational site. Other traffic characteristics in Table 4 are directly applicable to highway planning and design processes. Table 11 summarizes the available information and lists the figure or table from which a specific statistic can be read. Traffic flows may be estimated for any recreational route in the Kentucky area.

SUMMARY AND CONCLUSIONS

Significant findings and results were:

1. A simplified method of predicting travel patterns to outdoor recreational areas has been defined. Most of the data base is valid only for recreational travel in Kentucky or in areas similar thereto.

2. To investigate time variations in recreational traffic flow, it is desirable to conduct long-term, continuous volume surveys. A method was developed and applied herein to detect and correct erroneous data from the long-term, continuous, traffic recorders. With minor modifications, this method should prove useful in all long-term, continuous, vehicle counting programs.

3. Time variations of flow for recreational traffic depends on the type of recreational area and the location of the area in relation to population centers. Recreational travel seems much more variable timewise than other forms of highway travel. Evidence of this peaking is presented in terms of highest hourly volumes, highest daily volumes, and highest weekly volumes.

4. The maximum hourly volumes averaged 63.2 percent of the average daily traffic (ADT) while the 30th highest hourly volumes averaged 38.8 percent of the ADT. The 30th highest hourly volume criterion appears in many cases to be inadequate for the design of recreational access roads. A more practical basis for design would be the peak-hour volume on the average summer Sunday. This volume on the average corresponds with the 70th to 75th highest hourly volume. It should be emphasized, however, that proper selection of a design hour volume is complicated by desire and economic analyses and may vary from situaion to situation. During the summer weeks, hourly volumes averaged 1080 percent of the ADT; during the summer weekends, they averaged 480 percent; on summer Sundays, they averaged 270 percent.

5. The peak seasonal volume averaged 40.6 percent of the total annual volume and occurred in either May, June, or August. Sunday was always the peak day of the summer week, except for holidays; and, on the average, 25.1 percent of the weekly volume was observed on Sunday. The peak hourly volume on summer Sundays occurred within the interval of 1 to 5 p.m. and averaged 11 percent of the 24-hour Sunday flows.

6. Short-duration counts used to project traffic volumes on recreational routes should include 10-hour summer Sunday volumes (10 a.m. - 8 p.m.) and 48-hour summer weekend volumes (6 p.m. Friday - 6 p.m. Sunday). These two time periods were representative of high-volume, short-period counts; and they appear to be reliable for long-term projections.

7. Vehicle occupancy averaged 3.06 persons per vehicle and was a function of type of recreational area, vehicle type, and distance traveled. Low occupancy rates were generally associated with day-use areas. Highest occupancy rates were observed in cars pulling camper trailers. Sensitivity of occupancy rate to distance was greatest for camping vehicles and least for vehicles with boats.

8. Vehicle classification was dependent upon type of recreational area and distance traveled. A decreasing percentage of cars with increasing distance suggested a greater use of single-unit campers over longer distances. Boat usage was associated with day-use activity in Kentucky and peaked in the range of 60 to 90 miles. In many cases, type of recreational area and available facilities determined vehicle classification.

9. With the exception of a few major attractors having large regional impact, most outdoor recreational areas in Kentucky attract visitors from relatively short distances. The average trip length for all vehicles was found to be 109 miles. Moreover, 60 percent of all vehicles traveled less than 50 miles and 72 percent traveled less than 100 miles.

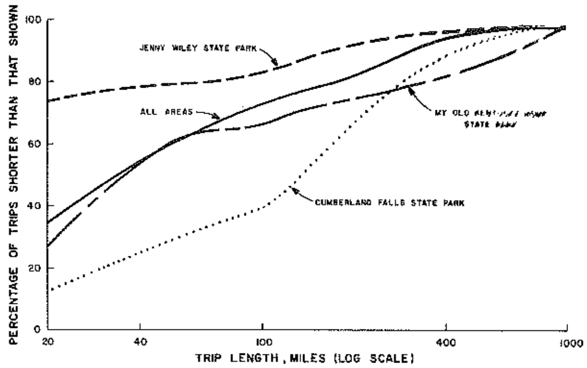

Figure 10. Trip-Length Distribution for Different Recreational Areas

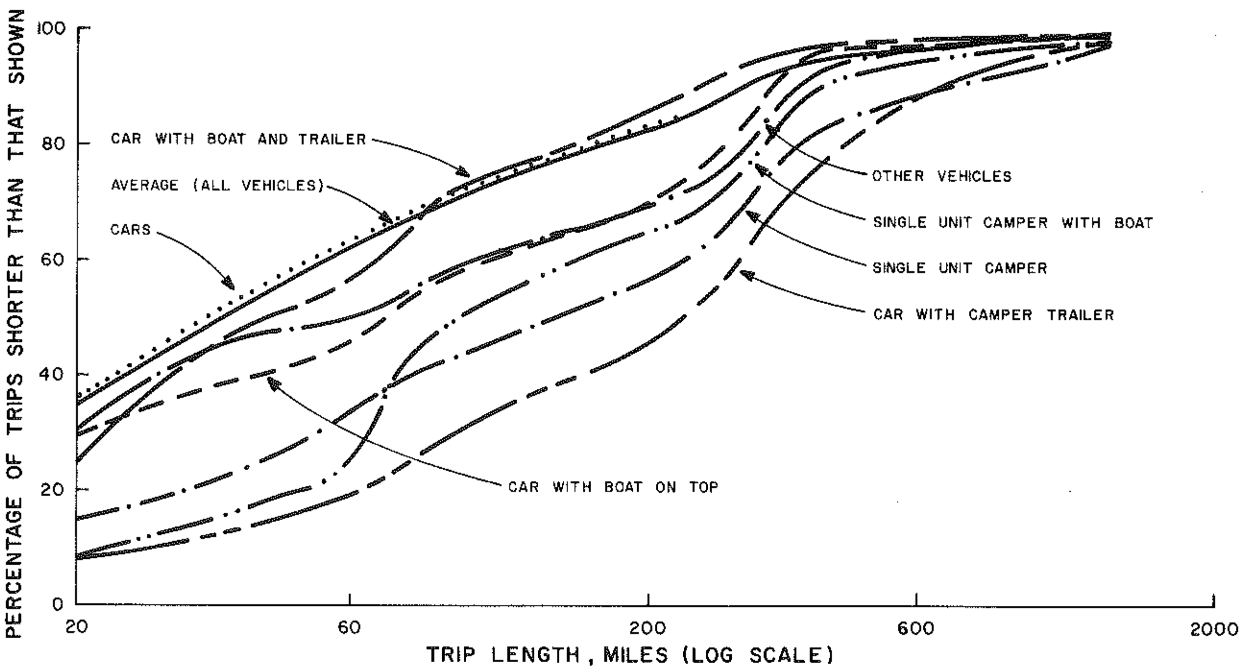

Figure 11. Trip-Length Distribution for Different Vehicle Types

TABLE 11

SUMMARY OF AVAILABLE OUTPUT

DESIRED OUTPUT	FIGURE	TABLE
1. Volume for any time period (number of vehicles counted)		4
2. Volume for any time period (multiple of ADT)		4
3. Summer, hourly cyclical variations of flow for Fridays	5	
4. Summer, hourly cyclical variations of flow for Saturdays	5	
5. Summer, hourly cyclical variations of flow for Sundays	5	
6. Summer, peak-hour occurrences on Friday, Saturday, and Sunday		2
7. Peak average hourly volume (percentage of the average Friday, Saturday, or Sunday volume)		2
8. Summer, daily cyclical variations of flow	6	
9. Summer day in which peak average volume occurs		3
10. Monthly cyclical variations of flow	7	
11. Month in which peak volume occurs		3
12. Seasonal cyclical variations of flow	8	
13. Season in which peak volume occurs		3
14. Factors to convert from measured 10-hour Sunday, daily, weekend, weekly, and monthly volumes to average daily traffic and summer Sunday traffic flows		5
15. 30th highest hourly (or any other hour) volume (percentage of ADT)	2	
16. Highest daily volume (multiple of ADT)	3	
17. Highest weekly volume (multiple of ADT)	4	
18. Average trip lengths for various vehicle types	11	
19. Vehicle occupancy rates as a function of recreational area type and distance traveled		6
20. Relationship between vehicle type and location of origin		7
21. Relationship between vehicle type and recreational area type		8
22. Vehicle occupancy rate as a function of vehicle type and distance traveled		9

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APPENDIX

DATA ADJUSTMENT PROCEDURE

DATA ADJUSTMENT PROCEDURE

Step 1

Interpretations and summaries performed in Step 1 are part of he standard procedures used by the Division of Planning to process data from permanent traffic counters. Data were retrieved in the form of hourly volumes recorded on punched paper tape. Paper tape data were mechanically interpreted and transferred to punch cards; the card format is shown in Figure A-1. A computer program, available from the Division of Planning, was used to summarize and tabulate the data in a convenient form as shown in Figure A-2.

Step 2

A computer program (Figure A-3), requiring hourly volumes for each site as input, was written. Output from this program was a weekly tabulation printout and card deck which included site location number, year, month, day, day of week, and hourly volumes for each day. Missing data in this output could be detected by blank spaces (representing missing hours of a day) or by weeks having less than seven days (representing a full day of missing data).

Step 3

Data were rearranged so that the first card contained data for the first day of the fall period, September 20. Output from the program prepared to do this ordering included a printout and new card deck of location number, week of year (numbered with September 20 as the first day of week No. 1), day of week, card number (necessary because two cards were required for each 24 hours of data), and hourly volumes for each day. For entire days of missing data, two cards were inserted with location number, week of year, day of week, and card number. Partial days of missing data were represented by blank spaces. A listing of this computer program is presented in Figure A-4.

Step 4

Using card output from Step 3, computer programming was prepared to detect errors and adjust suspected erroneous data. The logic supporting this procedure was based on the premise 1) that hourly volumes at a given location for a particular hour of the day and a particular day of the week should demonstrate much consistency throughout the year and 2) that such volumes should reach a minimum in the winter months and a maximum in the spring or summer months. All hourly volume data for a given site were therefore rearranged into 168 groups of 52 volumes each. Each group represented a particular hour of a particular day and was analyzed independently of other groups. Each of the 52 hourly volumes corresponded to a particular week of the year. Figure A-5 is a plot of one such group of data for Levi Jackson State Park

Error detection proceeded as follows: Let V_i represent the hourly volume corresponding to the ith week and AV represent the average of the 52 hourly volumes. First, grossly inaccurate data were identified when either of the following two sets of inequalities was satisfied:

$$V_i < 0.05 \text{ AV and } /V_i - \text{AV}/ > 80$$

or

$$V_i > 6.0 \text{ AV and } /V_i - \text{AV}/ > 80$$

Erroneous data so identified were automatically removed from the data set and seven-item moving averages (MAV_i) were calculated. The second comparison to detect erroneous data were based on the following two sets of inequalities which relate each hourly volume with the corresponding moving average:

$$V_i < 0.2 \text{ MAV}_i \text{ and } /V_i - \text{MAV}_i/ > 20$$

or

$$V_i > 2.0 \text{ MAV}_i \text{ and } /V_i - \text{MAV}_i/ > 20.$$

Figure A-5 shows, for the group of data at Levi Jackson State Park, four erroneous volumes that were detected in this way.

After identifying the set of "correct" data, it was necessary to provide more reasonable estimates of the "incorrect" data. This was accomplished by fitting a third-degree ploynomial to the correct data and obtaining the desired estimates by interpolation. Figure A-5 also shows such a polynomial used to make the required four estimates for this group of data.

The procedure for error detection and correction was found to be invaluable to this study even though there was some risk that all erroneous data were not detected and some lesser risk that some correct data were identified as being erroneous. Identical procedures may be used for other types of hourly volume data collected on an annual basis if suitable modifications are made to the limiting constants in the above inequalities. The text of the computer program used to identify erroneous data is presented in Figure A-6. The program used to fit a third-degree polynomial to the correct data so that erroneous data could be replaced is given in Figure A-7.

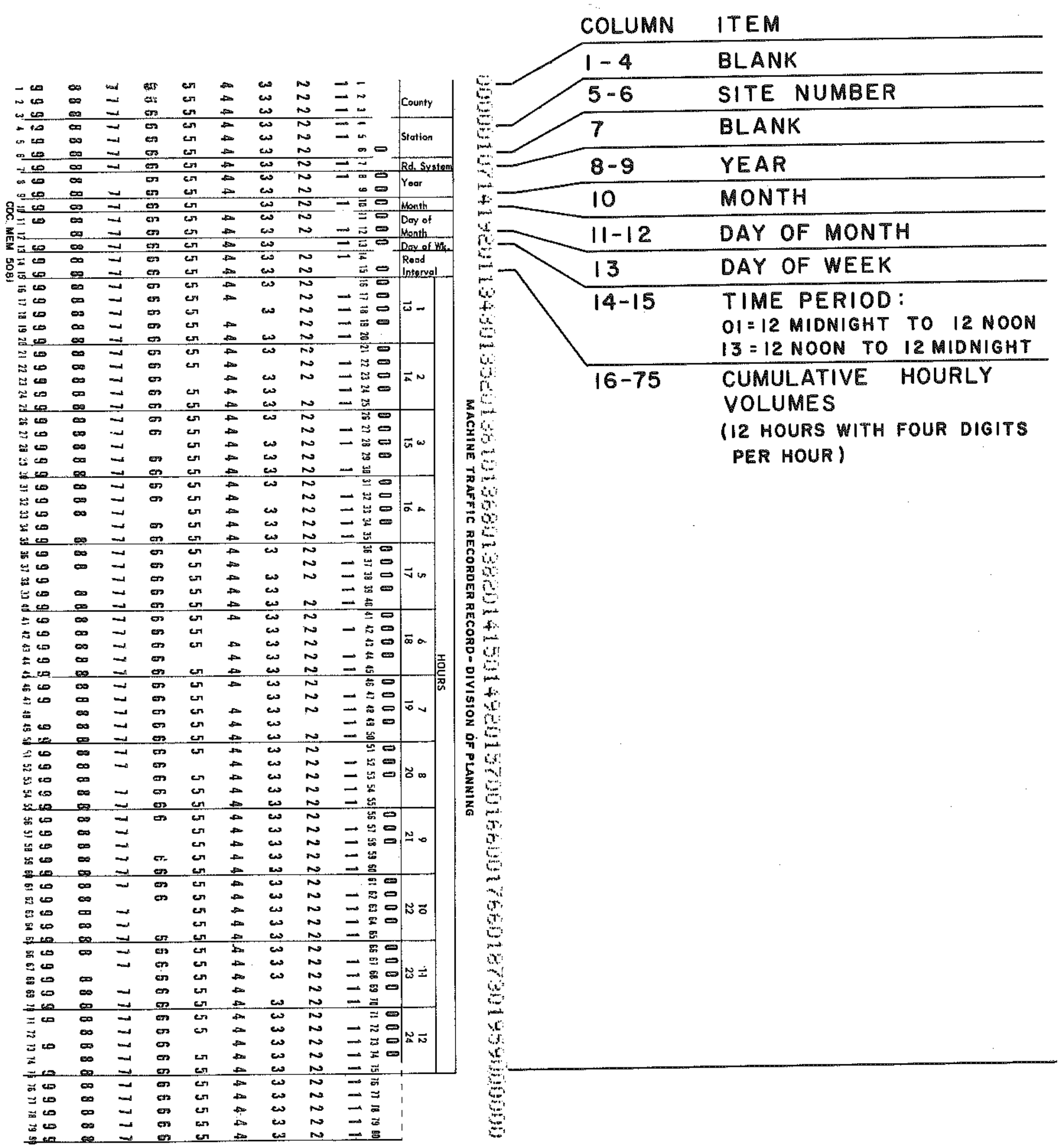

Figure A-1. Format of Traffic Recorder Data on Punch Cards

KENTUCKY AUTOMATIC TRAFFIC RECORDER REPORT

ROUTE PARK LEVI JACKSON COUNTY STA --2

WEEK SEP 13 TO SEP 19 1970

DATE	13	14	15	16	17	18	19	
DAY HOUR	SUN	MON	TUE	WED	THU	FRI	SAT	TOTAL
01	540	200	220	250	190	200	400	2000
02	140	100	130	80	160	100	160	870
03	160	110	100	130	90	90	130	810
04	170	120	110	100	70	70	110	750
05	110	90	120	100	80	90	90	680
06	110	130	190	130	150	100	140	950
07	120	220	250	280	250	220	150	1490
08	310	700	780	710	680	650	450	4280
09	360	540	580	470	520	470	470	3410
10	710	510	360	350	360	410	590	3290
11	860	650	590	470	460	490	690	4210
12	1440	620	560	610	520	510	940	5200
13	2780	580	550	810	620	380	1090	6810
14	3640	500	540	570	390	550	1060	7250
15	3980	570	420	510	450	630	1130	7690
16	3880	810	1040	800	880	860	1140	9410
17	3060	700	950	920	870	720	1010	8230
18	2450	800	810	750	780	650	1270	7510
19	2190	910	1010	860	940	910	1630	8450
20	1880	970	1160	860	1060	1370	2310	9610
21	1110	700	950	990	1030	1150	1580	7510
22	770	790	660	860	880	1180	1440	6580
23	750	470	540	650	620	1040	1340	5410
24	390	350	370	410	600	970	990	4080
	31910	12140	12990	12670	12650	13810	20310	116480

AVERAGE DAY OF WEEK 16640

PEAK HOUR 3980 SUN BETWEEN 2 3 PM

Figure A-2. Summary Format of Data Taken from Paper Tape

```
FORTRAN IV G LEVEL  20.1                 MAIN                DATE = 72032          16/43/27              PAGE 0001

0001              INTEGER STA,PREC.YR,MO,DAY,DOW.    AC(24),R(24).PPREC(7)
0002              INTEGER LOC1,LOC2,LOC3,AND,COUNT,A(80),BLANK,ZERO,ROUTE,JGP
0003              DATA BLANK.ZERO,ROUTE.JGP/' ','0','R','P'/
0004              CALL REREAD
0005            4 I=0
0006            5 READ(5,110) A
0007          110 FORMAT(80A1)
0008              IF(A(1).EQ.JGP) GO TO 999
0009              IF(A(1).EQ.ROUTE) GO TO 80
0010              IF(A(1).EQ.ZERO) GU TO 85
0011              IF(A(2).EQ.BLANK) GO TO 90
0012           80 I=0
0013              WRITE(99,110) A
0014              READ(99,100) STA,PREC,LOC1,LOC2,LOC3
0015          100 FORMAT(13X,I2,I5,3A4)
0016              GO TO 6
0017           85 IF(A(14)-NE.ZERO) GO TO 9
0018              WRITE(99,110) A
0019              READ(99,200) STA,YR,MO.DAY,DOW.(R(N),N=1,12)
0020              GO TO 5
0021            9 WRITE(99,110) A
0022              READ(99,200) STA,YR,MO,DAY,DOW,(R(N),N=13,24)
0023          200 FORMAT(4X,I2,1X,I2,A1,I2,I1,2X,12I5)
0024              GO TO 7
0025           90 WRITE(99,110) A
0026              READ(99,205) AND,COUNT
0027          205 FORMAT(A1,14X,I5)
0028              GO TO 5
0029            6 CONTINUE
0030              WRITE(6,150) STA,PREC,LOC1,LOC2,LOC3
0031          150 FORMAT(1H0,5X,'STATION',1X,I2,3X,'PREVIOUS COUNT ',I5,3X,'LOCATION
                 1',1X,3A4)
0032              WRITE(6,250)
0033          250 FORMAT(1X,'STA ','YR ','MO ','DAY ','DOW ',2X,'1 ',2X,'2 ',2X,'3 '
                 1,2X,'4 ',2X,'5 ',2X,'6 ',2X,'7 ',2X,'8 ',2X,'9 ',' 10 ',' 11 ',' 1
                 22 ',' 13 ',' 14 ',' 15 ',' 16 ',' 17 ',' 18 ',' 19 ',' 20 ',' 21 '
                 3,' 22 ',' 23 ',' 24 ')
0034              GO TO 5
0035            7 I=I+1
0036              DO 40 K=1,24
0037           40 CONTINUE
0038              DO '50 K=1,23
0039              IF(R(K+1).LT.R(K)) R(K+1)=R(K+1)+10000.
0040              AC(K+1)=R(K+1)-R(K)
0041           50 CONTINUE
0042              IF(I.EQ.1)      GO TO 99
0043              PPREC(I)  =R(24)
0044              IF(R(1).LT.PPREC(I-1)) R(1)= R(1)+10000.
0045              AC(1)=R(1)-PPREC(I-1)
0046              GO TC 1C1
0047           99 IF(R(1).LT.PREC) R(1)= R(1)+10000.
0048              AC(1)=R(1)-PREC
0049              PPREC(I)=R(24)
0050          101 WRITE(6,300) STA,YR,MO,DAY,DOW,(AC(M),M=1,24)
0051          300 FORMAT(2X,I2,1X,I2,2X,A1,2X,I2,2X,I1,2X,24I4)
0052              WRITE(7,400) STA,YR,MO,DAY,DOW,(AC(M),M=1,24)
0053          400 FORMAT(2I3,A3,2I3,16I4,/,15X,8I4)
0054              IF(I.EQ.7) GO TO 4

FORTRAN IV G LEVEL  20.1                 MAIN                DATE = 72032          16/43/27              PAGE 0002

0055              GO TO 5
0056          999 STOP
0057              END
```

Figure A-3. Data Adjustment Program No. 1

```
FORTRAN IV G LEVEL  20.1              MAIN              DATE = 72033          09/46/02             PAGE 0001

            DIMENSION A(15),B(16)
            DATA ZERO,FOUR/'0','4'/
            DATA AST,ZEROS/'****','0000'/
            DO 10 I=1,52
            DO 20 J=1,7
            DO 30 K=1,2
            READ(5,100,END=99) LOC,B
        100 FORMAT(I3,12X,16A4)
            IF(LOC.EQ.0) LOC=1
            DO 50 L=1,16
         50 IF(B(L).EQ.AST)  B(L)=ZEROS
            WRITE(6,110) LOC,I,J,K,B
        110 FORMAT(2I3,2I2,16A4)
            WRITE(7,110) LOC,I,J,K,B
         30 CONTINUE
         20 CONTINUE
         10 CONTINUE
         99 STOP
            END
```

Figure A-4. Data Adjustment Program No. 2

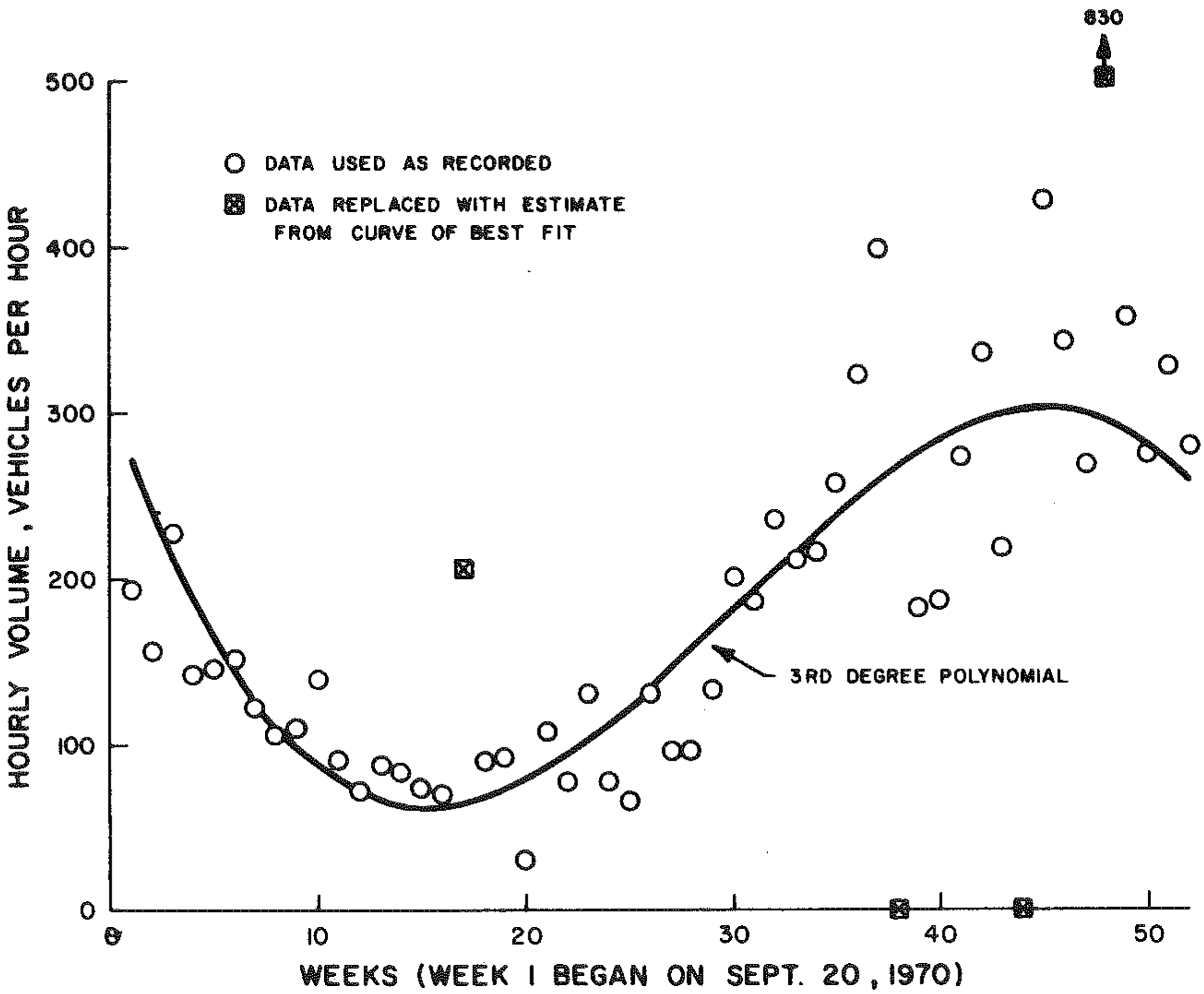

Figure A-5. Fluctuation of Hourly Volumes throughout the Year for the hour of 12 Noon- 1 p.m. on Sundays at Levi Jackson State Park

```
FORTRAN IV G LEVEL  19                MAIN              DATE = 72012         12/25/08           PAGE 0001

           INTEGER LOC,       V(58,7,24),        M(58,7,24),AST,BLANK
           INTEGER WK(55),DAY(7),A(55,24)
           DATA AST,BLANK/'*',' '/
           DO 20 I=4,55
           DO 10 J=1,7
           READ(5,100,END=400) LOC,WK(I),DAY(J),(V(I,J,K),K=1,24)
       100 FORMAT(2I3,I2,2X,16I4,/,10X,8I4)
        10 CONTINUE
        20 CONTINUE
           DO 60 J=1,7
           DO 5 L=1,24
           DO 6 JGP=1,55
           A(JGP,L)= BLANK
         6 CONTINUE
         5 CONTINUE
           DO 50 K=1,24
           V(1,J,K)=V(53,J,K)
           V(2,J,K)=V(54,J,K)
           V(3,J,K)=V(55,J,K)
           V(56,J,K)=V(4,J,K)
           V(57,J,K)=V(5,J,K)
           V(58,J,K)=V(6,J,K)
        50 CONTINUE
           DO 500 K=1,24
           AVG = 0.
           DO 505 I=4,55
       505 AVG = AVG + V(I,J,K)
           AVG = AVG/52.
           DO 510 I=4,55
           DIFF = V(I,J,K) - AVG
           DIFF = ABS(DIFF)
           IF(DIFF.LE.80.) GO TO 510
           DIFF = V(I,J,K) - AVG
           DIFF = DIFF/AVG
           Z = -0.95
           IF(DIFF.LT.Z.OR.DIFF.GT.5.) V(I,J,K) = -V(I,J,K)
       510 CONTINUE
       500 CONTINUE
           DO 515 K=1,24
           DO 520 I=4,55
           IF(V(I,J,K).LT.0) GO TO 535
           AVG = 0.
           D = 0.
           DO 525 JD=1,7
           N = I + JD - 4
           IF(V(N,J,K).LT.0.) GO TO 525
           D = D + 1.
           AVG = AVG + V(N,J,K)
       525 CONTINUE
           AVG = AVG/D
           DIFF = V(I,J,K) - AVG
           DIFF = ABS(DIFF)
           IF(DIFF.LT.20.) GO TO 520
           DIFF = V(I,J,K) - AVG
           DIFF = DIFF/AVG
           Z = -0.8
           IF(DIFF.LT.Z.OR.DIFF.GT.1.0) GO TO 530
           GO TO 520
```

```
FORTRAN IV G LEVEL  19                MAIN              DATE = 72012         12/25/08           PAGE 0002

       535 V(I,J,K) = -V(I,J,K)
       530 A(I,K) = AST
       520 CONTINUE
       515 CONTINUE
           DO 160 I=4,55
           WRITE(6,200) LOC,WK(I),DAY(J),(V(I,J,K),A(I,K),K=1,24)
       200 FORMAT(2I3,I2,24(I4,A1))
           IF(I.EQ.55) GO TO 300
           GO TO 160
       300 WRITE(6,201)
       201 FORMAT(1H1)
       160 CONTINUE
           DO 170 JAD = 4,55
           DO 175 K=1,24
           IF(A(JAD,K).EQ.AST) V(JAD,J,K) = -1
       175 CONTINUE
           WRITE(7,100) LOC,WK(JAD),DAY(J),(V(JAD,J,K),K=1,24)
       170 CONTINUE
        60 CONTINUE
       400 STOP
           END
```

Figure A-6. Data Adjustment Program No. 3

```
      REAL V(52),W(52)
      REAL Y(52),X(52,4),Z(4,52),A(4,4),B(4,4),C(4,52),D(4)
      REAL E(4)
      REAL VOL(52,7,24),PRED(52),VN(104),WN(104)
      INTEGER BADWK(52)
      INTEGER NVOL(52,7,24)
      DO 101 J=1,7
      DO 101 I=1,52
  101 READ(5,100)LOC,(VOL(I,J,K),K=1,24)
  100 FORMAT(I3,7X,16F4.0/10X,8F4.0)
      DO 400 K=1,24
      DO 400 J=1,7
      NG=0
      NB=0
      DO 201 I=1,52
      IF(VOL(I,J,K).GE.0.) GO TO 301
      NB=NB+1
      BADWK(NB)=I
      GO TO 201
  301 NG=NG+1
      V(NG)=VOL(I,J,K)
      W(NG)=I
  201 CONTINUE
      IF(NG.EQ.52) GO TO 43
      IF((NG/2)*2.EQ.NG) GO TO 40
      IT=((52-NG)/2)+1
      GO TO 41
   40 IT=(52-NG)/2
      DO 501 I=1,IT
      V(NG+I)=V(I)
      W(NG+I)=W(I)+52
  501 CONTINUE
      JA=53-IT
      DO 6 I=JA,52
      V(I)=V(I-(2*IT))
      W(I)=W(I-(2*IT))-52
    6 CONTINUE
      GO TO 42
   41 JB=IT-1
      DO 51 I=1,JB
      V(NG+I)=V(I)
      W(NG+I)=W(I)+52
   51 CONTINUE
      JC=53-IT
      DO 61 I=JC,52
      V(I)=V(I-(2*IT)+1)
      W(I)=W(I-(2*IT)+1)-52
   61 CONTINUE
   42 CONTINUE
      IDIV=NB/2
      DO 2 I=1,52
      WN(I+IDIV)=W(I)
    2 VN(I+IDIV)=V(I)
      DO 3 I=1,IDIV
      WN(I)=W(53-I)
    3 VN(I)=V(53-I)
      DO 4 I=1,52
      W(I)=WN(I)
    4 V(I)=VN(I)
      DO 1 I=1,4
      E(I) = 1.
    1 CONTINUE
      JD=52
      DO 15 I=1,JD
      Y(I) = V(I)
   15 CONTINUE
      DO 20 I=1,JD
      X(I,1) = 1.
      X(I,2) = W(I)
      X(I,3) = W(I)*W(I)
      X(I,4) = X(I,3)*W(I)
   20 CONTINUE
      DO 25 I=1,JD
      DO 25 L=1,4
      Z(L,I)=X(I,L)
   25 CONTINUE
      NI = 4
      NJ = JD
      NK = 4
      NN = JD
      CALL MAMULT(Z,X,A,NI,NJ,NK,NN)
      N = 4
      M = 0
      NN = 4
      CALL MATINV (A,N,E,M,DET,NN)
      DO 30 I=1,4
      DO 30 L=1,4
      B(I,L)=A(I,L)
   30 CONTINUE
      NI = 4
      NJ = 4
      NK = JD
      NN = JD
      CALL MAMULT(B,Z,C,NI,NJ,NK,NN)
      NI = 4
      NJ = JD
      NK = 1
      NN = JD
      CALL MAMULT(C,Y,D,NI,NJ,NK,NN)
      DO 200 JZ=1,NB
      DO 200 I=1,52
      PRED(JZ)=D(1)+D(2)*BADWK(JZ)+D(3)*BADWK(JZ)**2+D(4)*BADWK(JZ)**3
      IF(PRED(JZ).LT.0.) PRED(JZ)=0.
      IF(I.EQ.BADWK(JZ)) VOL(I,J,K)=PRED(JZ)
  200 CONTINUE
   43 CONTINUE
  400 CONTINUE
      DO 302 J=1,7
      DO 302 I=1,52
      DO 302 K=1,24
      NVOL(I,J,K)=VOL(I,J,K)
  302 CONTINUE
      DO 303 J=1,7
      DO 303 I=1,52
      WRITE(7,304)LOC,I,J,(NVOL(I,J,K),K=1,24)
  304 FORMAT(2I3,I2,2X,16I4/10X,8I4)
  303 WRITE(6,300) LOC,I,J,(NVOL(I,J,K),K=1,24)
  300 FORMAT(' ',2I3,I2,24I5)
      CALL EXIT
      END
```

Figure A-7. Data Adjustment Program No. 4