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LITTER SURVEY — STATUS REPORT 1

by

Stephen N. Runkle
Research Analyst

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

Virginia Highway & Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia Department of Highways & Transportation and the University of Virginia)

Charlottesville, Virginia

March 1979
VHTRC 79-R37

2326

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ABSTRACT

At the request of the Division of Litter Control of the Department of Conservation and Economic Development, the Research Council has initiated a litter survey program at approximately 25 sites on the state highway system. The purpose of this program is to determine changes in the quantities of litter generated at these sites.

The purpose of this initial report is to discuss the final selection of the sites and to discuss the results of the initial litter survey of these sites. The initial survey results indicated a large within site variability between pickups (see Appendix D), probably due to conditioning at these sites; i.e., people may be less likely to litter at sites cleaned frequently. This result led to a change in procedure for one-half the sites remaining in the study whereby litter would not be cleaned from the sites during a survey but increases in litter from one survey period to the next would be estimated by visual counts. Also, this initial survey indicated that the proportion of paper and plastic items is probably dependent to some degree on the time intervals between pickups or surveys, with the proportion being higher for shorter time intervals. Finally, the proportion of paper and plastic items found in this initial survey was somewhat higher (about 5% to 10%) than the proportion found in the 1976 survey.

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INTRODUCTION

As a result of the Virginia Litter Control Act passed by the 1976 Session of the Virginia General Assembly the Division of Litter Control was formed within the Department of Conservation and Economic Development. The major function of this Division is to initiate or fund programs of its own or those of localities in an attempt to reduce the amount of litter being discarded along streets and highways, parks and recreational areas, industrial areas, and other public places. Several such programs were initiated in 1978.

In initiating these programs, a major concern of the Division of Litter Control was the development of a method for measuring their impact. It seemed obvious that the best method of measuring the impact would be to conduct litter surveys periodically as the programs progressed. Thus, because of his involvement in the 1976 litter survey required by the "Virginia Litter Control Act", the author was consulted with respect to additional surveys. Based on the results of the 1976 survey, it seemed the best approach was to select a fairly small number of highway sites (about 25) and to sample them frequently. The reasoning behind this approach is discussed in a letter from the author to John Jackson dated May 24, 1978, and reproduced as Appendix A.

The approach agreed on was to select about 25 sites 0.1 mile in length and to sample them 4 times each at about 2-week intervals 3 times yearly, i.e., to sample each site 12 times per year, and to determine by site the rate of litter accumulation and proportions by bottles, cans, paper and plastic, and other items. It was hoped the frequent sampling would permit a meaningful statistical analysis with respect to changes in the quantities of litter generated at the sites. Of the 25 sites, 10 were to be on the secondary system, 10 on the primary system, and 5 on the interstate system.

PURPOSE AND SCOPE

Thus far one sampling series has been completed; i.e., most sites have been cleaned 4 times at about 2-week intervals. The

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purpose of this report is to present the initial survey results and comment on possible future modifications to the survey plans. Results of the initial sampling series are presented in terms of item count as opposed to weight or volume. Future, more comprehensive reports will present the data in all three forms.

It should be mentioned that throughout this study only items of litter equal to or larger than a folded matchbook are included in the litter pickups. Also, in determining item counts certain judgments are made with regard to what constitutes an item. For instance, if several pieces of glass occurred in a small area and obviously resulted from a broken bottle, the item count would be one bottle. The same would be true for several small pieces of paper from the same paper item. Judgements of this type have not, as yet, been required frequently.

SITE DESCRIPTIONS AND DETAILED DATA

Each site included in the survey is approximately 0.1 mile in length and generally includes the area from the edge of the pavement to the ditch line in one direction of travel. Thus, the entire area along a given segment of highway is not included in the site. A total of 34 sites have been selected; 16 on the primary system, 8 on the interstate system, and 10 on the secondary system. It is anticipated that some sites, particularly some of those on the primary system, will be eliminated as the study continues.

Detailed data for the initial series of litter pickups are shown in Appendix B as Tables B-1 through B-3. Sites are identified only by site number and highway system because of the Division of Litter Control's desire to have the actual site locations remain unknown. Shown in Tables B-1 through B-3 for each site are the dates of litter pickups, the days of elapsed time since the previous pickup (unknown for the initial pickup), and the number and proportion of items in each of four categories: cans, bottles, paper and plastic items, and other items. The same data are summarized for each site showing the total for all pickups (1-4), and for all pickups excluding the initial pickup (2-4). Also computed for each site are the items per day found at the site for all pickups for which the time was known. The detailed data shown in Tables B-1 through B-3 were summarized for analysis purposes as discussed in the next section.

DATA ANALYSES AND CONCLUSIONS

For this report, basically three things were considered for analyses: a comparison of these initial results with those of the 1976 litter survey with respect to the proportion of litter by categories; an initial estimate of the variability in litter that may be expected at a given site during a short time period and any influencing factors with respect to this variability; and, for each site, a measure of the rate of litter accumulation for the purpose of possibly deleting some of the selected sites. The last of these three items will be discussed first.

Selection of Permanent Sites

Referring again to Tables B-1 through B-3, the items per day value for the total of all but the initial pickup (0.90 for Site 1, Table B-1) is considered the best measure of the rate of litter accumulation. Assuming it is desirable to retain those sites having the higher rates of litter accumulation, it would appear the permanent sites should be 2, 3, 4, 5, 6, 10, 11, 12, 13, and 15 from the primary system, sites 1, 2, 3, 5, 6, 7, and 8 from the interstate system, and sites 1 - 10, with the exception of site 6, from the secondary system. It is assumed to be desirable to select sites having the higher rates of litter accumulation since it would be difficult to measure decreases in litter accumulation at sites already having low rates.

Seven sites are included from the interstate instead of the 5 originally planned since 2 of the sites (2 and 5) are on ramp areas rather than the main line. One additional secondary system site may be chosen in order to maintain the planned 10 sites.

Utilizing the sites indicated above results in the geographic distribution of sites shown in Appendix C. It is felt the geographic coverage of the state shown is the best that can be achieved and still maintain a reasonable time schedule for coverage of the sites during the litter collection periods.

Initial Estimate of Site Variability

The major reason for the 4 litter pickups at each site during each litter collection cycle was to establish an estimate of the variability in the rate of litter accumulation at a given site during a short time interval in which it is assumed no external factors would influence the variability; i.e., seasonal changes in the weather or program efforts would not cause a change in the rate of litter accumulation. By establishing this variability measure, an estimate can be made of the magnitude of change in the rate of

litter accumulation that could be detected as being statistically significant from period to period on the basis of the present sampling plan.

The estimate of variability determined from the data shown in Tables B-1 through B-3 was the average standard deviation of items per day for all sites having 4 litter pickups. This average value was obtained by computing the standard deviation of items per day at each of these sites and then averaging the standard deviation values computed.

The average within site standard deviations for each highway system and those for all highway systems combined are shown in Appendix D. Also shown in Appendix D are the number of sites used in the calculations, the average number of items per day discarded at the sites, and the between site standard deviations (computed as the standard deviation of the average items per day for each site).

The average within site variability is larger than had been expected, and, in fact, exceeds the between site variability. This unexpected result may cause difficulties in assessing the changes at given sites because the variability is so large relative to the average items per day discarded. For instance, based on the composite values for the average items per day discarded and within site standard deviation ($\bar{X}$ = 2.99 and σ = 1.45) at least 7 to 8 litter pickups per time period at a given site would be required in order to have a 50% chance of detecting a 50% change in the quantity of litter discarded. In fact, it would appear to be easier to detect an average change for all 27 sites combined. For the 27 sites included in the computations for Appendix D an average difference of approximately 0.75 item per day, or, in other words, a change of about 25%, would have a 50% chance of being judged significant at a 95% confidence level. By choosing more similar sites in terms of items per day than are presently included, the difference to be judged significant could be reduced. Of course, it was hoped that within site variability would be small enough to allow statements about specific sites.

It is obvious when one evaluates the data in Tables B-1 through B-3 that one reason for the relatively large within site variability is the change in the rate of litter accumulation from one litter pickup to the next; i.e., that the within site variability is not entirely random in nature. This change is clearly illustrated in Figures E-1 and E-2, which show the items per day for each site, (Figure E-1) and the average items per day for the various highway systems (Figure E-2) for the 2nd, 3rd, and 4th litter pickups. As shown in Figure E-2, the decrease in the average items per day from pickup to pickup is almost identical for each highway system.

The change in average items per day for all highway systems combined is also shown in Figure E-2. A statistical significance test was run to test the difference in the averages of the combined data as shown in the figure (4.37 for the 2nd pickup, 2.63 for the 3rd pickup, and 1.97 for the 4th pickup) with the differences in averages found to be significant at a 95% confidence level.

The reason for the decrease in average items per day for each subsequent pickup is not known, but it is believed that it may be due to conditioning at the site; i.e., people might be less likely to litter at sites that are clean due to frequent pickups. It is also felt that the decrease between pickups is not a result of seasonal influences because of the relatively short periods of time between pickups. If the decrease is due to site conditioning as discussed above, it may be desirable to alter the sampling method in an attempt to counter this effect and thus reduce the within site variability. One possible alternative would be to simply record the number of items for each litter survey date with the difference in the number of items between survey dates being considered the amount littered since the last previous survey date; i.e., to leave the litter in place. This approach will be used for about one-half the sites for the next survey period.

If one assumes it is valid to correct for the average difference in items per day by pickup, i.e., to add the difference between 4.37 and 2.65, or 1.74, to the items per day for the 3rd pickup at each site, and add the difference between 4.37 and 1.97, or 2.40, to the items per day for the 4th pickup at each site, then the average within site standard deviations would be reduced to the values shown in Appendix F. Based on the adjusted standard deviation values, changes in the amount of litter discarded would be easier to detect. Sample sizes or number of pickups required to detect changes in items per day of given magnitudes are shown in Appendix G for various levels of β, where β is the percent chance of detecting the change indicated. For instance, using the adjusted standard deviation value a sample size of approximately 4 would be required to have a 50% chance of judging a 50% change in items per day significant at a 95% confidence level. To have a 80% chance ($1 - \beta$) of detecting a change of the same magnitude would require a sample size of about 6.

Proportion of Litter by Categories

Although the major intent of the present litter surveys is to determine trends in the quantity of litter discarded it is also of interest to look at the proportion of litter by type. Summarizing the data shown in Tables B-1 through B-3 yields the proportions by

type shown in Appendix H. Also shown in Appendix H are the proportions by type as determined in the 1976 litter study.

While no statistical comparisons were made for the data in Appendix H, several things seem apparent. First, the proportion of litter by type seems to be influenced by the time interval between pickups with paper and plastic items being underestimated relative to bottles and cans for longer time intervals. The initial pickup in the present survey covered unknown time periods, but probably averaged 90 days or more. Proportions of paper and plastic items for the initial pickup ranged from 54% to 66%, depending on the highway system. For pickups after the initial pickup, which usually involved time intervals of 2 weeks or less, the proportion of paper and plastic items increased from 62% to 76%, depending on the highway system, or an increase of 8% to 10%. The effects of time intervals on proportions will continue to be studied in future surveys.

A second result that seems evident from Appendix H is that the proportion of paper and plastic items is higher based on the present survey as compared to the 1976 survey with cans representing a smaller proportion. This trend holds true for all highway systems and for either initial or other pickups. The best comparison with the 1976 survey is probably that for the initial pickup results since the 1976 results covered relatively long time intervals. No explanation is offered for this apparent change; it may be a result of the site selection process, it may be a seasonal influence, or it may represent a real change. Again, future surveys will provide additional information regarding the trends in proportions of litter by type relative to past survey results.

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N E. HARWOOD, COMMISSIONER
BUSSER, III
EPUTY COMMISSIONER AND
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DR. LESTER A. HOEL, CHAIRMAN
DEPARTMENT OF CIVIL ENGINEERING

Methods for Conducting Litter Surveys

COMMONWEALTH of VIRGINIA

HIGHWAY & TRANSPORTATION RESEARCH COUNCIL

2335

BOX 3817 UNIVERSITY STATION
CHARLOTTESVILLE, VIRGINIA 22903

IN REPLY PLEASE 27-27
REFER TO FILE NO.

DILLARD, HEAD
IA HIGHWAY & TRANSPORTATION RESEARCH COUNCIL

May 24, 1978

Memorandum
to: Mr. John Jackson

From : Steve N. Runkle

Subject: Methods for Conducting Litter Surveys

As I agreed to do in our discussion of May 15, 1978, I am indicating below possible approaches for litter surveys, and recommending what I feel is the best approach considering your requirements. As we also discussed, my comments are related to survey methods for the state highway system, which would not usually include urban areas, industrial areas, parks and other recreational areas, and high density residential areas.

With regard to your requirements I understand them to be as follows:

1. You want to measure the impact of antilitter programs as evidenced in the quantities of litter generated from year-to-year; i.e. you want to measure changes in the quantities of litter discarded from year-to-year. If possible, it also would be desirable to measure the total quantities of litter discarded annually on a statewide basis.

2. You want to measure any seasonal changes in the quantities of litter discarded to enable you to achieve the best timing for emphasis on antilitter programs.

3. You would like to measure litter by 4 classifications (bottles, cans, paper and plastic, and other) to allow an evaluation of the effectiveness of the program on the basis of specific litter items (such as bottles and cans). However, the detailed classification used in the 1976 litter survey is not required.

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4. You would like estimated costs of the proposed methods.

The majority of my discussion relates to the first requirement listed above. Once the most reasonable approach is selected to satisfy this requirement, consideration can be given to any additional survey work required to satisfy requirements 2 and 3 and the development of the costs of the surveys (requirement 4).

Basically, there are three possible approaches. One would be a record-keeping system whereby the quantities of litter collected would be recorded along with other required data such as the miles of roadway cleaned and the time elapsed since the preceding collection. This approach would give you absolute data on the quantities collected annually (which may be a good measure of the quantities discarded annually), but is probably not possible from a record-keeping standpoint on a statewide basis. Obviously, as this approach is extended beyond the state highway system the problems of record-keeping are magnified greatly. Also, this approach would not yield the information you want regarding seasonal changes or litter classification, without some specific sampling. However, as I will discuss below when considering the third approach, some record-keeping of the type discussed is probably desirable to obtain supplemental data, but would be confined to selected routes in various highway maintenance areas throughout the state.

A second approach would use a statistically based sampling plan to meet your requirements with a stated degree of precision, but probably would require too many sampling sites and, thus, too high a sampling cost. In order to determine the amount of sampling required in this approach to detect changes in litter quantities, two questions must be answered. The first is, What degree of change in quantities do you want to detect by the sampling? that is, Do you want to detect a 10% decrease, 20% decrease, or what? The second is What is the underlying variability in quantities of litter from site-to-site within a given highway system?

Obviously, you must answer the first of these questions because it is related to the cost of your program as compared to the savings or other economic utility gain resulting from various levels of decrease in the quantity of litter. In other words, How much does the quantity of litter have to decrease in order for your program to be judged a success? Related to this question are two additional considerations which are most important in determining required sample sizes (number of sites). First, What chance are you willing to take of being wrong in saying a change in the quantity of litter has occurred when it really hasn't? And, second, What chance are you willing to take of saying a stated change (say 20%) has not occurred when it really has? These two issues will be discussed below.

With respect to the question concerning the variability in the quantities of litter from site-to-site, some limited information is available from the 1976 survey. Using data contained in the report "Litter Survey in Virginia — Detailed Results", I have computed the summary data shown in Table 1 (attached). Shown in Table 1 is the average amount of daily litter ($\bar{x}$) by item count, weight, and volume and the associated variability (σ) site-to-site (site - 0.5 mile). It is evident from Table 1 that σ is large relative to $\bar{x}$, which, in essence, means that large sample sizes (many sites) would be required to detect changes in quantities of litter. (It is also true that the size of the σ values relative to the $\bar{x}$ values probably means the underlying distributions are not truly normal, which in turn means the required sample sizes as indicated later for various conditions are probably understated.)

Using the data in Table 1, approximate sample size requirements have been computed for various assumptions and are shown in Table 2. The values computed are for the item count method of quantification, but the required sample size would be about the same if the volume method were used. If weight was the measure of interest, the required sample sizes would be slightly higher. In my opinion, the best quantification would be either item count or volume because of the better agreement of these two methods (see attached graphs) and because they probably better reflect the true impact of the type of litter your program is directed toward. (Weight reflects a larger part of the litter being automobile parts and tires, which many people may not consider to be litter.)

In Table 2, sample sizes are shown for α, the probability of concluding a change has occurred when actually no change has occurred, and β, the probability of concluding no change has occurred when actually a change equal to D has occurred. For example, assume you would like to sample so as to detect a 25% change in the quantity of litter from year-to-year as being significant for the secondary highway system. You are willing to take a 10% chance of being wrong and saying a significant change has occurred when actually no change has occurred ($\alpha = 0.10$), and wish to have no more than a 10% chance of incorrectly concluding no change has occurred when actually the change was 25% ($\beta = 0.10$, D = 25%). The required sample size from Table 2 would be 175. If you are willing to let β be 20%, the required sample size would be reduced to 125; and if you are interested in detecting only a 50% change as a significant change, the required sample size would be further reduced to 35.

It seems evident to me in looking at Table 2 that the required sample sizes (other than possibly for detecting 50% changes) are too large to permit this type of approach, particularly when you consider that the same number of samples would be required

to measure seasonal changes. Since a sampling plan would allow us to make statements with associated statistical significance about our highway systems requires too many samples, it seems the next best approach, and the final approach discussed, is to select only a few sites and sample them so we can make statements about the selected sites with some associated degree of statistical significance.

It is important to recognize that in using this approach we will be able (with stated statistical precision) to make statements about only the sites themselves. To extend statements about these sites to the highway systems in general must be done without any real knowledge of the degree of confidence that may be attached to the statements. Thus, this approach alone will not provide sufficient information to allow you to estimate and compare the total annual quantities of litter on our highway systems. Of course, it will be possible to measure and compare annual quantities of litter at these selected sites. Furthermore, I think it may be possible to supplement the site data with general information about the quantity of litter collected during routine collections from some preselected routes in most of our maintenance areas. This supplementary data should give a good indication of whether or not results based on the site data can be used to make generalized statements about the various highway systems.

In this approach, the number of sites to be used is not a statistical question, but rather a judgemental issue with respect to the number of sites you feel are required to adequately represent our highway system or the portions of the system you are interested in. I would recommend 25 sites broken down as follows:

1.	Rural Interstate	5 sites
2.	Arterial Primary	5 sites
3.	Nonarterial Primary	5 sites
4.	Secondary	10 sites

It would be desirable to disperse the sites throughout the state with, in my opinion, an attempt being made to select average or above average litter areas (excluding very high litter areas which may be the result of special problems). Data from the 1976 survey would be helpful in the selection of sites.

Once the sites are selected, the same statistical issues as discussed above for the second method must be addressed; i.e., you must designate the magnitude of the difference you want to detect as being significant from period-to-period and the associated levels of α and β error you are willing to accept. Of course, in this method the statistical issues apply to judging differences at the specific sites from period-to-period as opposed to differences for the highway systems. Unfortunately, there are no available data indicating normal within site variability from period-to-period, and thus the determination of sample sizes (number of litter pickups at a specific site) required to detect specified differences in quantities of litter is not possible. Because of the lack of data

available with respect to within site variability, I would suggest initiating a survey program at the 25 sites selected in which multiple site samples would be obtained during the early summer, fall, and winter. Specifically, I think it would be desirable to sample each site four times each season until the within site variability of the data is determined so as to permit the computation of appropriate sampling rates. Hopefully, the within site variability will be much lower than site-to-site variability and thus require much smaller sample sizes to detect period-to-period changes for a particular site than the sample sizes indicated in Table 2. However, I have no assurance this is true, and, in fact, more than 4 samples per site may be required seasonally. An appropriate sampling procedure would be to have an initial litter pickup (covering a recorded time period) followed by 3 additional litter pickups at approximately weekly intervals. Also, I think that one-tenth mile sites would be sufficient in length, and that randomly selected subportions of the litter collected could be used for classification purposes in the event the total litter sample is large.

As I indicated above, I am not sure at this point just what this final approach will permit in terms of an analysis of changes in the quantities of litter generated or an analysis of changes in the percentages of litter by classifications. However, I am confident it is the best approach considering the resources you have available for litter surveys. With respect to cost, I can only approximate, but I would estimate each litter collection and quantification would require 2 men ½ day. Thus, each seasonal survey (4 samples for 25 sites) would require about 100 man-days at an approximate cost of $50 per day (including a truck) for a total seasonal survey cost of about $5,000, and thus an annual cost of $15,000. Should it be found that more than 4 samples per site are required seasonally to detect changes of the size you would like, it may be desirable to decrease the number of sites to maintain the survey cost. Of course, the costs mentioned make no allowance for data interpretation and analysis.

Hopefully, the above discussion will help you decide what survey work should be undertaken. If I can be of additional assistance, please let me know.

S. N. Runkle
Research Analyst

SNR:ss

Attachment
cc: Mr. L. E. Busser III
Mr. J. M. Wray, Jr.
Mr. J. P. Royer, Jr.
Mr. J. H. Dillard
Mr. C. S. Hughes

TABLE 1

Average Daily Litter Quantities ($\bar{x}$) and Site-to-Site Variability (σ)

System	Item Count		Weight		Volume	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Rural Interstate	17	8	2.0	1.3	0.33	0.17
Arterial Primary	19	13	3.0	2.4	0.54	0.35
Nonarterial Primary	14	13	1.8	2.4	0.37	0.32
Secondary	22	18	3.3	3.1	0.73	0.68

TABLE 2

Sample Sizes (Number of Sites) Required for Item Count Surveys

System	D[a]	α[b]=0.05			α=0.10		
	Percent	β[c]=0.20	β=0.10	β=0.05	β=0.20	β=0.10	β=0.05
Interstate	50	15	20	25	10	15	20
	25	55	75	90	40	60	75
	10	350	465	575	275	380	480
Arterial Primary	50	30	40	50	25	30	40
	25	115	155	190	95	125	160
	10	785	1050	1296	615	850	1075
Nonarterial Primary	50	55	75	90	40	60	75
	25	215	290	360	170	235	295
	10	1225	1640	2025	960	1330	1680
Secondary	50	40	60	70	35	45	60
	25	160	220	270	125	175	220
	10	970	1295	1600	760	1050	1330

(a) D = difference to be judged as significant.
(b) α = probability of concluding a significant difference exists when no change has occurred.
(c) β = probability of concluding no significant difference exists when actually the difference is D.

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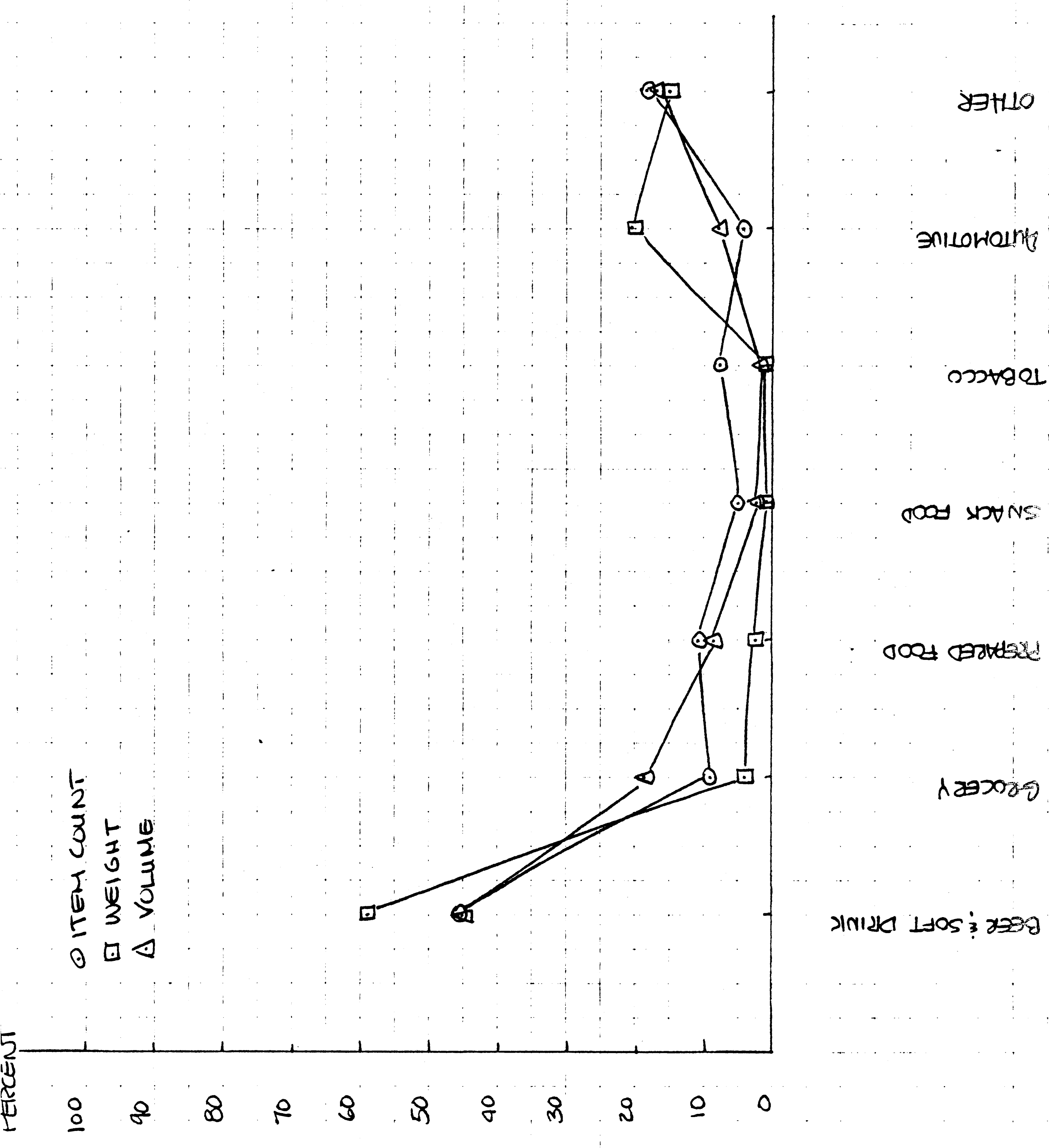
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WEIGHT
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SNACK FOOD
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AUTOMOTIVE
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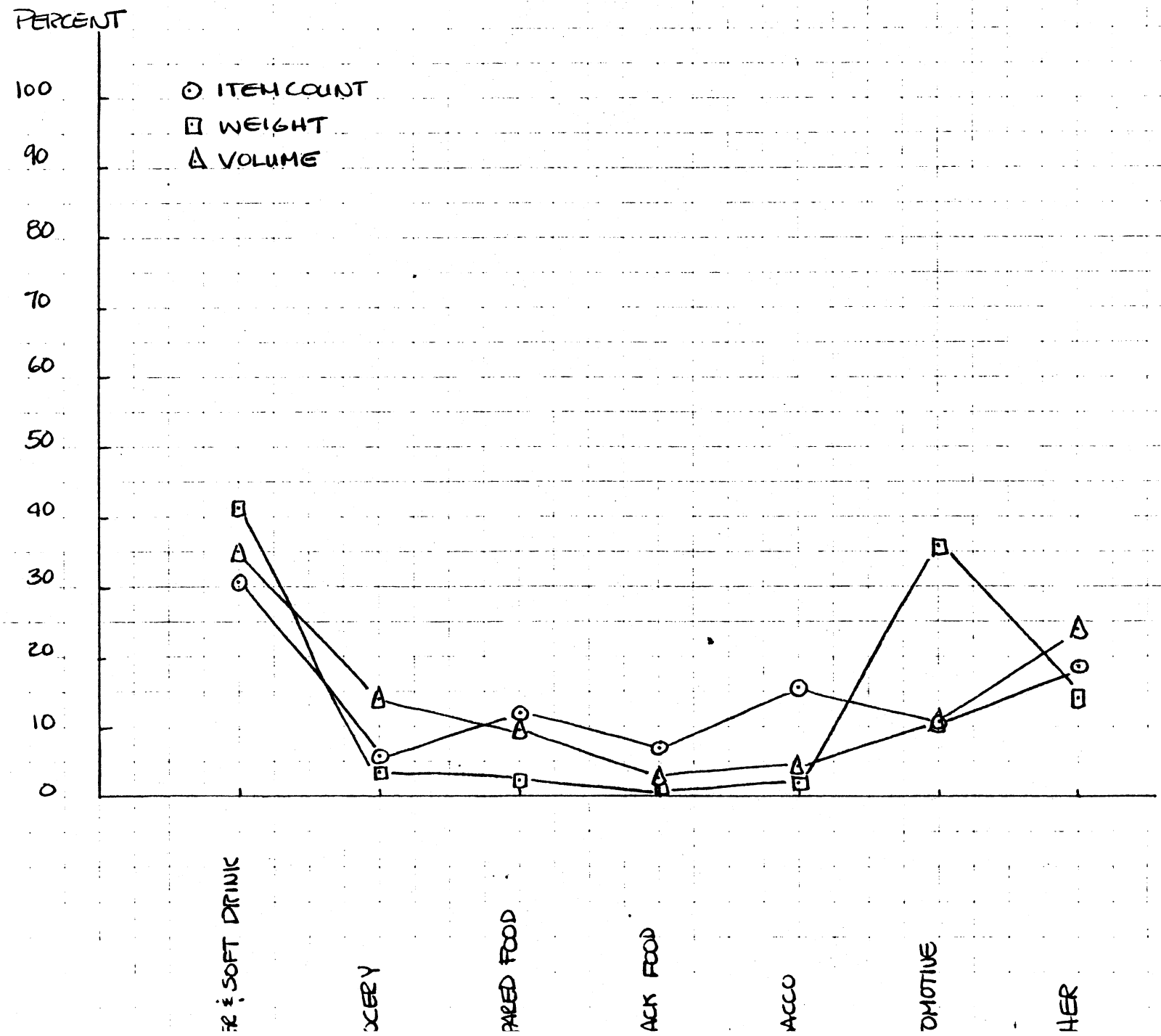
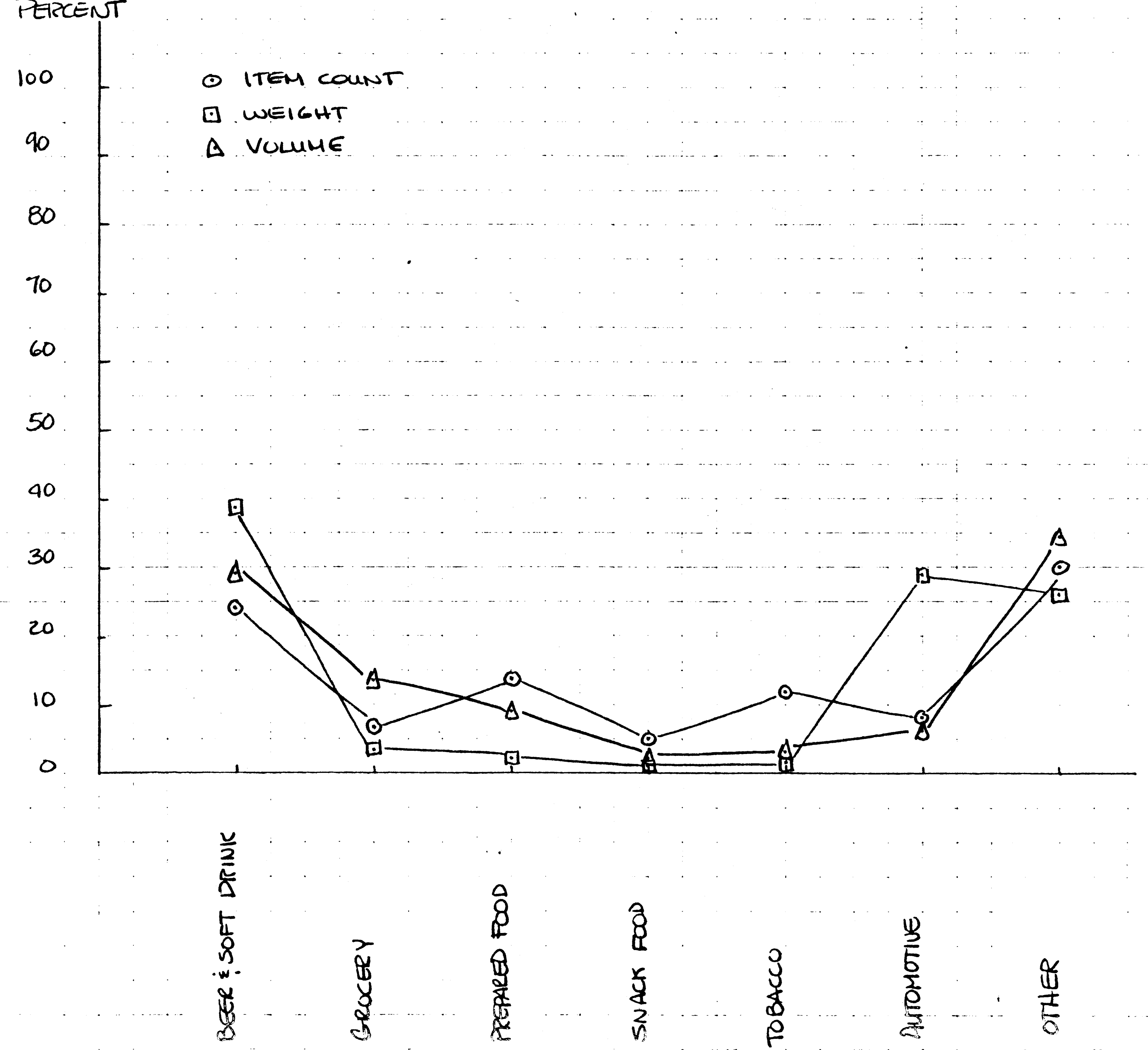
RURAL INTERSTATE

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ITEM COUNT
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SNACK FOOD
TOBACCO
AUTOMOTIVE
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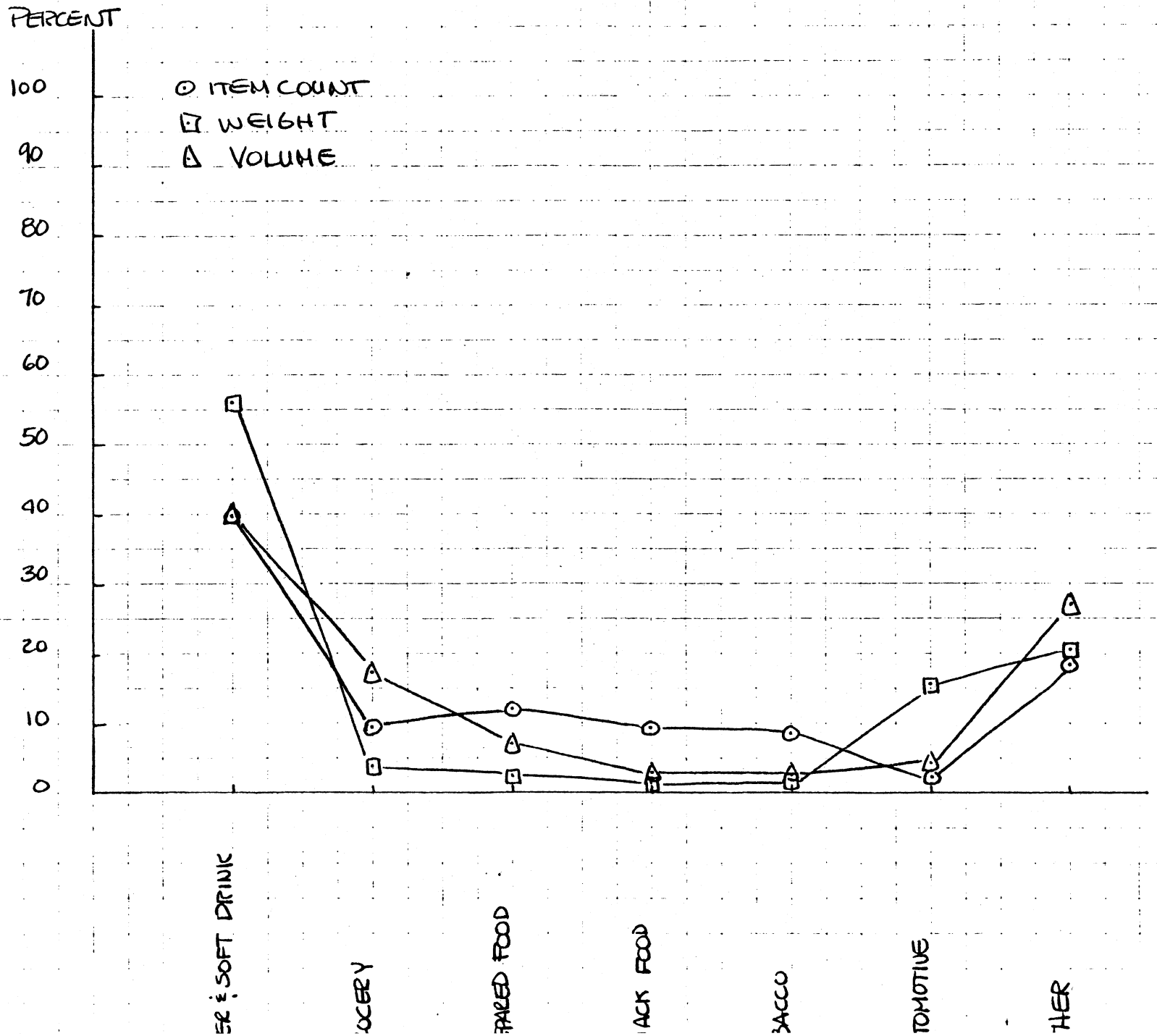
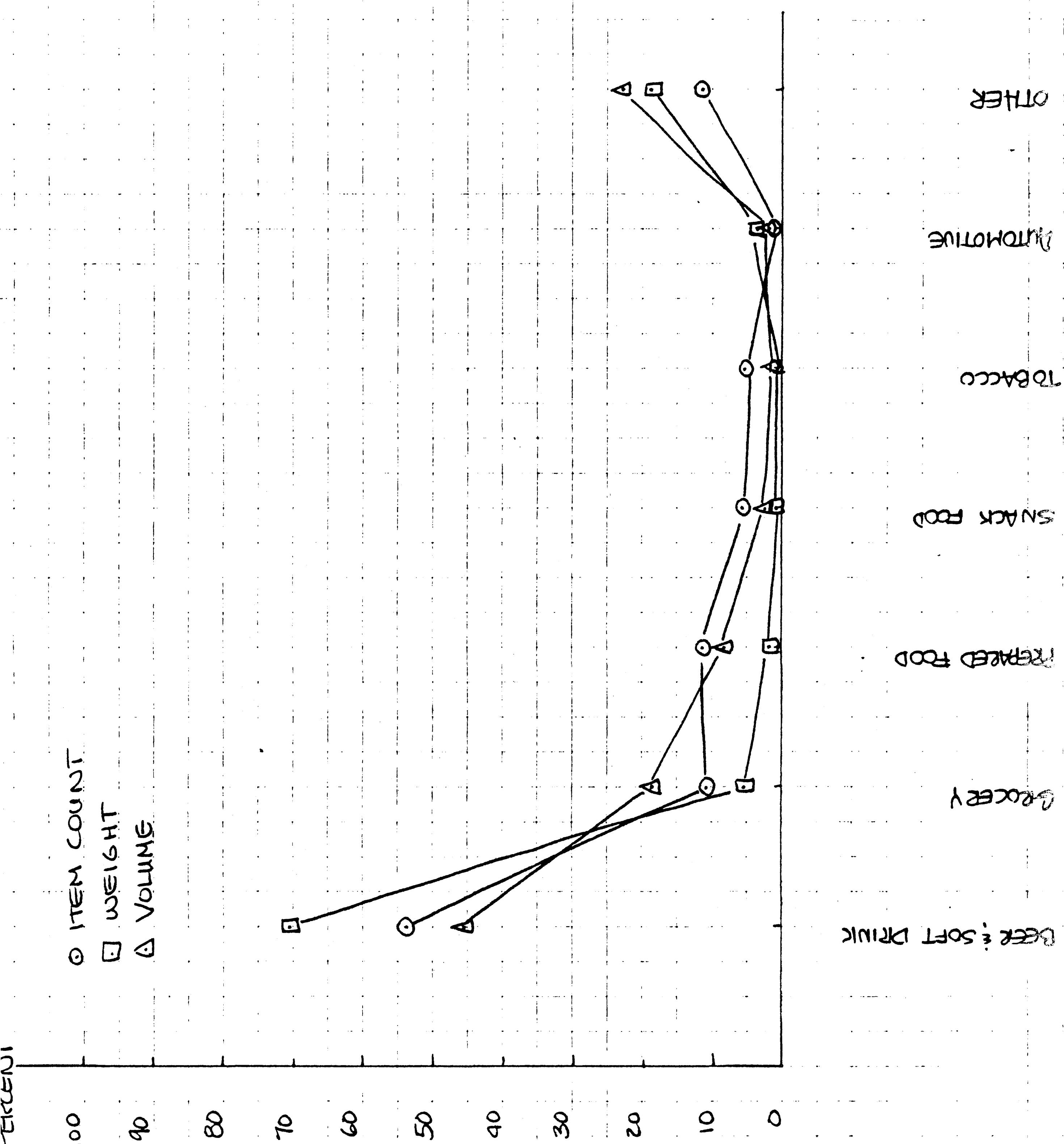
NONARTERIAL PRIMARY

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GROCERY
PREPARED FOOD
SNACK FOOD
TOBACCO
AUTOMOTIVE
OTHER

Appendix B

Detailed Data for Initial Series of Pickups

Table B-1. Detailed Data by Item Count

Primary System

Site	Date	Days	Cans		Bottles		Paper/ Plastic		Auto/ Other		Total	Items/ Day
			No.	%	No.	%	No.	%	No.	%		
	9-29		19	22	3	4	62	73	1	1	85	
	10-12	13	6	29	4	19	11	52	0	0	21	1.62
1	10-27	15	1	11	3	33	5	56	0	0	9	0.60
	11-8	12	1	17	0	0	5	83	0	0	6	0.50
	Total (1-4)		27	22	10	8	83	69	1	1	121	
	Total (2-4)	40	8	22	7	20	21	58	0	0	36	0.90
	9-22	-	32	34	12	13	43	46	6	7	93	-
	10-2	10	4	11	5	14	24	67	3	8	36	3.60
2	10-10	8	2	6	0	0	27	84	3	10	32	4.00
	10-16	6	1	8	0	0	11	92	0	0	12	2.00
	Total (1-4)		39	22	17	10	105	61	12	7	173	
	Total (2-4)	24	7	9	5	6	62	78	6	7	80	3.33
	9-22		61	43	29	21	43	30	9	6	142	-
	10-2	10	15	29	4	8	32	63	0	0	51	5.10
3	10-10	8	8	20	3	8	28	70	1	2	40	5.00
	10-16	6	8	21	5	13	25	66	0	0	38	6.33
	Total (1-4)		92	34	41	15	128	47	10	4	271	
	Total (2-4)	24	31	24	12	9	85	66	1	1	129	5.38
	9-22		54	23	39	17	131	57	6	3	230	-
	10-2	10	6	11	5	9	44	77	2	3	57	5.70
4	10-10	8	5	12	1	3	34	85	0	0	40	5.00
	10-16	6	3	12	2	7	21	80	0	0	26	4.33
	Total (1-4)		68	19	47	14	230	65	8	2	353	
	Total (2-4)	24	14	11	8	7	99	80	2	2	123	5.12
	9-26	-	74	39	18	9	94	50	4	2	190	
	10-5	9	7	14	2	4	39	76	3	6	51	5.67
5	10-18	13	2	6.5	2	6.5	26	84	1	3	31	2.38
	11-1	14	8	38	0	0	13	62	0	0	21	1.50

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Table B-1 (cont.)

Site	Date	Days	Cans		Bottles		Paper/ Plastic		Auto/ Other		Total	Items/ Day
			No.	%	No.	%	No.	%	No.	%		
	Total (1-4)		91	31	22	7	172	59	8	3	293	
	Total (2-4)	36	17	16	4	4	78	76	4	4	103	2.86
	9-26	-	25	14	1	1	150	83	4	2	180	
	10-5	9	9	14	8	13	47	73	0	0	64	7.11
6	10-18	13	2	2.5	2	2.5	75	95	0	0	79	6.08
	11-1	14	6	15	6	15	29	70	0	0	41	2.93
	Total (1-4)		42	11	17	5	301	83	4	1	364	
	Total (2-4)	36	17	9	16	9	151	82	0	0	184	5.11
	10-18	-	17	12	15	10	111	78	0	0	143	
7	11-1	14	4	10	5	12	32	76	1	2	42	3.00
	11-15	14	0	0	3	13	19	83	1	4	23	1.64
	Total (1-3)		21	10	23	11	162	78	2	1	208	
	Total (2-3)	28	4	6	8	12	51	79	2	3	65	2.52
	9-28	-	6	7	10	12	63	78	2	3	81	
	10-11	13	0	0	3	7	40	93	0	0	43	3.31
8	10-26	15	1	5	3	15	16	80	0	0	20	1.33
	11-8	13	2	9	3	13	18	78	0	0	23	1.77
	Total (1-4)		9	6	19	11	137	82	2	1	167	
	Total (2-4)	41	3	4	9	10	74	86	0	0	86	2.10
	10-18		18	16	7	6	83	73	6	5	114	
	11-1	14	3	14	3	14	12	58	3	14	21	1.50
9	11-15	14	4	13	2	7	24	77	1	3	31	2.21
	Total (1-3)		25	15	12	7	119	72	10	6	166	
	Total (2-3)	28	7	13	5	10	36	69	4	8	52	1.86
	9-26	-	47	22	26	12	135	64	3	2	211	
	10-5	9	8	22	5	13	21	57	3	8	37	4.11

Table B-1 (cont.)

Site	Date	Days	Cans		Bottles		Paper/ Plastic		Auto/ Other		Total	Items/ Day
			No.	%	No.	%	No.	%	No.	%		
10	10-19	14	5	20	2	8	16	64	2	8	25	1.79
	11-2	13	6	25	4	17	14	58	0	0	24	1.85
	Total (1-4)		66	22	37	12	186	63	8	3	297	
	Total (2-4)	36	19	22	11	13	51	59	5	6	86	2.39
	10-19	-	30	15	10	5	160	79	2	1	202	
	11-2	14	8	18	11	25	23	53	2	4	44	3.14
11	11-13	11	1	3	2	7	26	90	0	0	29	2.64
	Total (1-3)		39	14	23	8	209	76	4	2	275	
	Total (2-3)	25	9	12	13	18	49	67	2	3	73	2.92
	10-6	-	26	26	3	3	61	62	9	9	99	
	10-19	13	2	3	5	7	63	89	1	1	71	5.46
12	11-3	15	3	17	1	5	14	78	0	0	18	1.20
	11-14	11	1	5	4	20	15	75	0	0	20	1.82
	Total (1-4)		32	15	13	6	153	74	10	5	208	
	Total (2-4)	39	6	6	10	9	92	84	1	1	109	2.79
	10-4	-	15	14	6	6	77	74	6	6	104	
	10-13	9	1	1	5	6	69	89	3	4	78	8.67
13	10-23	10	2	14	1	7	10	72	1	7	14	1.40
	10-31	8	2	29	0	0	4	57	1	14	7	0.88
	Total (1-4)		20	10	12	6	160	79	11	5	203	
	Total (2-4)	27	5	5	6	6	83	84	5	5	99	3.67
	10-13	-	19	15	23	18	75	59	11	8	128	
	10-23	10	2	6	11	36	16	52	2	6	31	3.10
14	10-31	8	4	31	1	7.5	7	54	1	7.5	13	1.62
	11-14	14	6	20	3	10	21	70	0	0	30	2.14
	Total (1-4)		31	15	38	19	119	59	14	7	202	
	Total (2-4)	32	12	16	15	20	44	60	3	4	74	2.31

Table B-1 (cont.)

Site	Date	Days	Cans		Bottles		Paper/ Plastic		Auto/ Other		Total	Items/ Day
			No.	%	No.	%	No.	%	No.	%		
	9-28	-	12	7	6	3	165	89	2	1	185	
	10-11	13	2	3	2	3	70	94	0	0	74	5.69
15	10-26	15	20	21	27	28	48	51	0	0	95	6.33
	11-8	13	4	9	3	7	37	84	0	0	44	3.38
	Total (1-4)		38	10	38	10	320	80	2	0	398	
	Total (2-4)	41	26	12	32	15	155	75	0	0	213	5.20
	10-26	-	6	21	2	7	18	62	3	10	29	
	11-9	14	3	19	2	12	11	69	0	0	16	1.14
16	11-17	8	1	17	0	0	5	83	0	0	6	0.75
	Total (1-3)		10	19	4	8	34	67	3	6	51	
	Total (2-3)	22	4	18	2	9	16	73	0	0	22	1.00

Detailed Data by Item Count

Interstate System

Site	Date	Days	Cans		Bottles		Paper/ Plastic		Auto/ Other		Total	Items/ Day
			No.	%	No.	%	No.	%	No.	%		
	9-26	-	45	33	8	6	54	40	29	21	136	
	10-5	9	7	28	1	4	14	56	3	12	25	2.78
1	10-18	13	1	6	1	6	14	88	0	0	16	1.23
	11-1	14	1	14	1	14	5	72	0	0	7	0.50
	Total (1-4)		54	29	11	6	87	47	32	18	184	
	Total (2-4)	36	9	19	3	6	33	69	3	6	48	1.33
	10-19	-	17	9	19	10	157	80	1	1	194	
2	11-2	14	17	20	12	14	57	66	0	0	86	6.14
	11-13	11	0	0	2	4	44	96	0	0	46	4.18
	Total (1-3)		34	11	33	10	258	79	1	0	326	
	Total (2-3)	25	17	13	14	11	101	76	0	0	132	5.28
	9-26		59	35	6	5	66	58	2	2	113	
	10-5	9	6	13	7	15	29	63	4	9	46	5.11
3	10-19	14	9	16	5	9	40	71	2	4	56	4.00
	11-2	14	4	21	1	5	14	74	0	0	19	1.36
	Total (1-4)		58	25	19	8	149	64	8	3	234	
	Total (2-4)	37	19	16	13	11	83	68	6	5	121	3.27
	9-22	-	8	10	3	4	57	69	14	17	82	
	10-6	14	3	18	0	0	13	76	1	6	17	1.21
4	10-20	14	4	31	1	8	8	61	0	0	13	0.93
	11-3	14	1	9	0	0	9	82	1	9	11	0.79
	Total (1-4)		16	13	4	3	87	71	16	13	123	
	Total (2-4)	42	8	20	1	2	30	73	2	5	41	0.98

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Table B-2 (cont.)

Site	Date	Days	Cans		Bottles		Paper/ Plastic		Auto/ Other		Total	Items/ Day
			No.	%	No.	%	No.	%	No.	%		
	10-13	-	35	15	11	4	191	80	2	1	239	
	10-23	10	3	5	4	6	55	89	0	0	62	6.20
5	10-31	8	1	5	2	9	18	86	0	0	21	2.62
	11-14	14	10		3		34		0	0	47	3.36
	Total (1-4)		49	13	20	5	298	81	2	1	369	
	Total (2-4)	32	14	11	9	7	107	82	0	0	130	4.00
	10-4	-	11	16	3	4	50	74	4	6	68	
	10-15	9	3	8	1	3	32	86	1	3	37	4.11
6	10-23	10	1	8	0	0	11	84	1	8	13	1.30
	10-31	8	0	0	0	0	7	100	0	0	7	0.88
	Total (1-4)		15	12	4	3	100	80	6	5	125	
	Total (2-4)	27	4	7	1	2	50	88	2	3	57	2.11
	9-28	-	6	10	1	1.5	54	87	1	1.5	62	
	10-11	13	3	10	1	3	22	71	5	16	31	2.38
7	10-26	15	7	21	0	0	25	74	2	5	34	2.27
	11-8	13	5	25	0	0	13	65	2	10	20	1.54
	Total (1-4)		21	14	2	1	114	78	10	7	147	
	Total (2-4)	41	15	18	1	1	60	71	9	10	85	2.07
	10-26	-	23	21	40	37	45	42	0	0	108	
8	11-9	14	2	13	1	7	12	80	0	0	15	1.07
	11-17	8	0	0	2	12	14	88	0	0	16	2.00
	Total (1-3)		25	18	43	31	71	51	0	0	139	
	Total (2-3)	22	2	6	3	10	26	84	0	0	31	1.41

Detailed Data by Item Count

Secondary System

Site	Date	Days	Cans		Bottles		Paper/ Plastic		Auto/ Other		Total	Items/ Day
			No.	%	No.	%	No.	%	No.	%		
	9-20	-	39	28	21	15	80	57	0	0	140	
	10-12	13	6	14	4	9	33	77	0	0	43	3.31
1	10-27	15	1	5	2	10	18	85	0	0	21	1.40
	11-8	12	5	19	4	15	17	66	0	0	26	2.17
	Total (1-4)		51	22	31	14	148	64	0	0	230	
	Total (2-4)	40	12	13	10	11	68	76	0	0	90	2.25
	9-22	-	60	38	39	25	53	34	5	3	157	
	10-2	10	5	16	4	13	20	62	3	9	32	3.20
2	10-10	8	2	8	3	11	20	77	1	4	26	3.25
	10-16	6	0	0	2	13	13	87	0	0	15	2.50
	Total (1-4)		67	29	48	21	106	46	9	4	230	
	Total (2-4)	24	7	10	9	12	53	73	4	5	73	3.00
	10-2	-	121	36	56	17	157	47	1	0	335	
	10-10	8	17	30	5	9	34	59	1	2	57	7.12
3	10-16	6	11	42	9	35	6	23	0	0	26	4.33
	10-30	14	7	29	2	8	15	63	0	0	24	1.71
	Total (1-4)		156	35	72	16	212	48	2	1	442	
	Total (2-4)	28	35	33	16	15	55	51	1	1	107	3.82
	9-26	-	14	9	2	1.5	131	88	2	1.5	149	
	10-5	9	26	36	1	1	44	60	2	3	73	8.11
4	10-18	13	5	13	2	5	31	82	0	0	38	2.92
	11-1	14	4	34	1	8	7	58	0	0	12	1.17
	Total (1-4)		49	18	6	2	213	78	4	2	272	
	Total (2-4)	36	35	28	4	3	82	67	2	2	123	3.42

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Table B-3 (cont.)

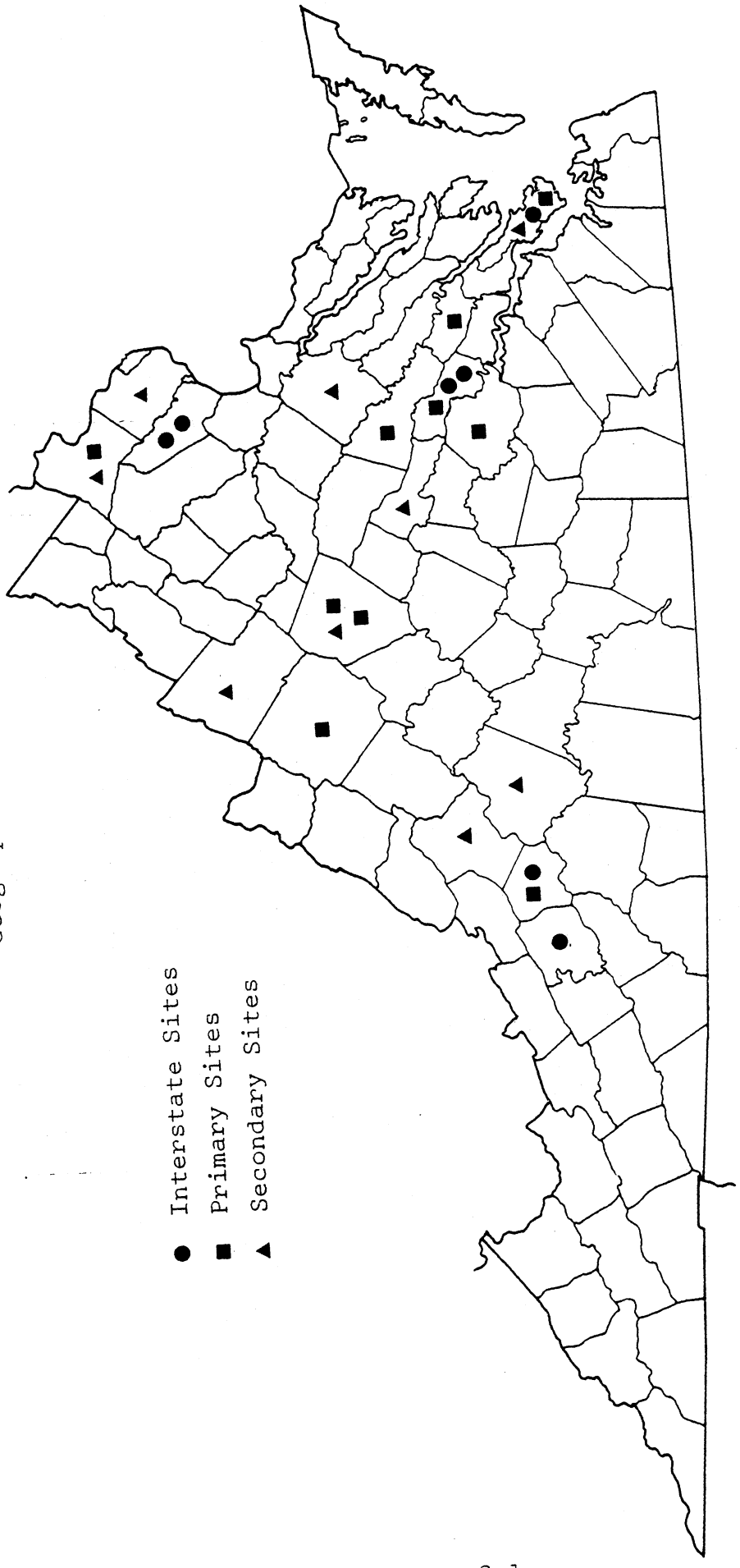
Site	Date	Days	Cans		Bottles		Paper/ Plastic		Auto/ Other		Total	Items/ Day
			No.	%	No.	%	No.	%	No.	%		
	9-25	-	21	24	4	4	64	72	0	0	89	
	10-6	11	7	19	2	6	25	69	2	6	36	3.27
5	10-20	14	19	29	8	12	37	57	1	2	65	4.64
	11-3	14	13	27	13	27	22	46	0	0	48	3.43
	Total (1-4)		60	25	27	12	148	62	3	1	258	
	Total (2-4)	39	39	26	23	16	84	56	3	2	149	3.82
	10-6	-	22	44	11	22	16	32	1	2	50	
	10-19	13	5	36	1	7	8	57	0	0	14	1.08
6	11-3	15	2	50	1	25	1	25	0	0	4	0.27
	11-17	14	0	0	1	14	6	86	0	0	7	0.50
	Total (1-4)		29	37	14	19	31	41	1	1	75	
	Total (2-4)	42	7	28	3	12	15	60	0	0	25	0.60
	10-4	-	7	8	5	6	71	84	2	2	85	
	10-13	9	0	0	0	0	27	96	1	4	28	3.11
7	10-23	10	0	0	2	15	11	85	0	0	13	1.30
	10-31	8	1	7	2	14	11	79	0	0	14	1.75
	Total (1-4)		8	6	9	6	120	86	3	2	140	
	Total (2-4)	27	1	2	4	7	49	89	1	2	55	2.08
	10-4	-	22	32	20	29	27	39	0	0	69	
	10-18	9	4	15	8	30	13	48	2	7	27	3.00
8	10-23	10	5	23	5	23	11	50	1	4	22	2.20
	10-31	8	2	25	1	12	5	63	0	0	8	1.00
	Total (1-4)		33	26	34	27	56	44	3	3	126	
	Total (2-4)	27	11	19	14	25	29	51	3	5	57	2.11

Table B-3 (cont.)

Site	Date	Days	Cans		Bottles		Paper/ Plastic		Auto/ Other		Total	Items/ Day
			No.	%	No.	%	No.	%	No.	%		
	9-27	-	37	39	24	25	35	36	0	0	96	
	10-5	8	16	41	7	18	16	41	0	0	39	4.88
9	10-23	18	7	23	7	23	15	50	1	4	30	1.67
	11-2	10	4	40	0	0	6	60	0	0	10	1.00
	Total (1-4)		64	37	38	22	72	41	1	0	175	
	Total (2-4)	36	27	34	14	18	37	47	1	1	79	2.19
	10-26	-	95	32	43	15	156	53	1	0	295	
	11-8	12	20	44	7	16	17	38	1	2	45	3.75
10	11-16	8	10	29	1	3	24	68	0	0	35	4.38
	Total (1-3)		125	33	51	14	197	53	2	0	375	
	Total (2-3)	20	30	38	8	10	41	51	1	1	80	4.00

Appendix C

Geographic Location of Sites



Appendix D

Within and Between Site Standard Deviation Values

Highway System	Number of Sites	Avg. Items Per Day	Avg. Within Site Standard Deviation	Between Site Standard Deviation
terstate	6	2.37	1.24	1.18
imary	12	3.48	1.57	1.47
condary	9	2.75	1.43	1.19
l Systems	27	2.99	1.45	1.36

Summary Data on Items Collected Per Day

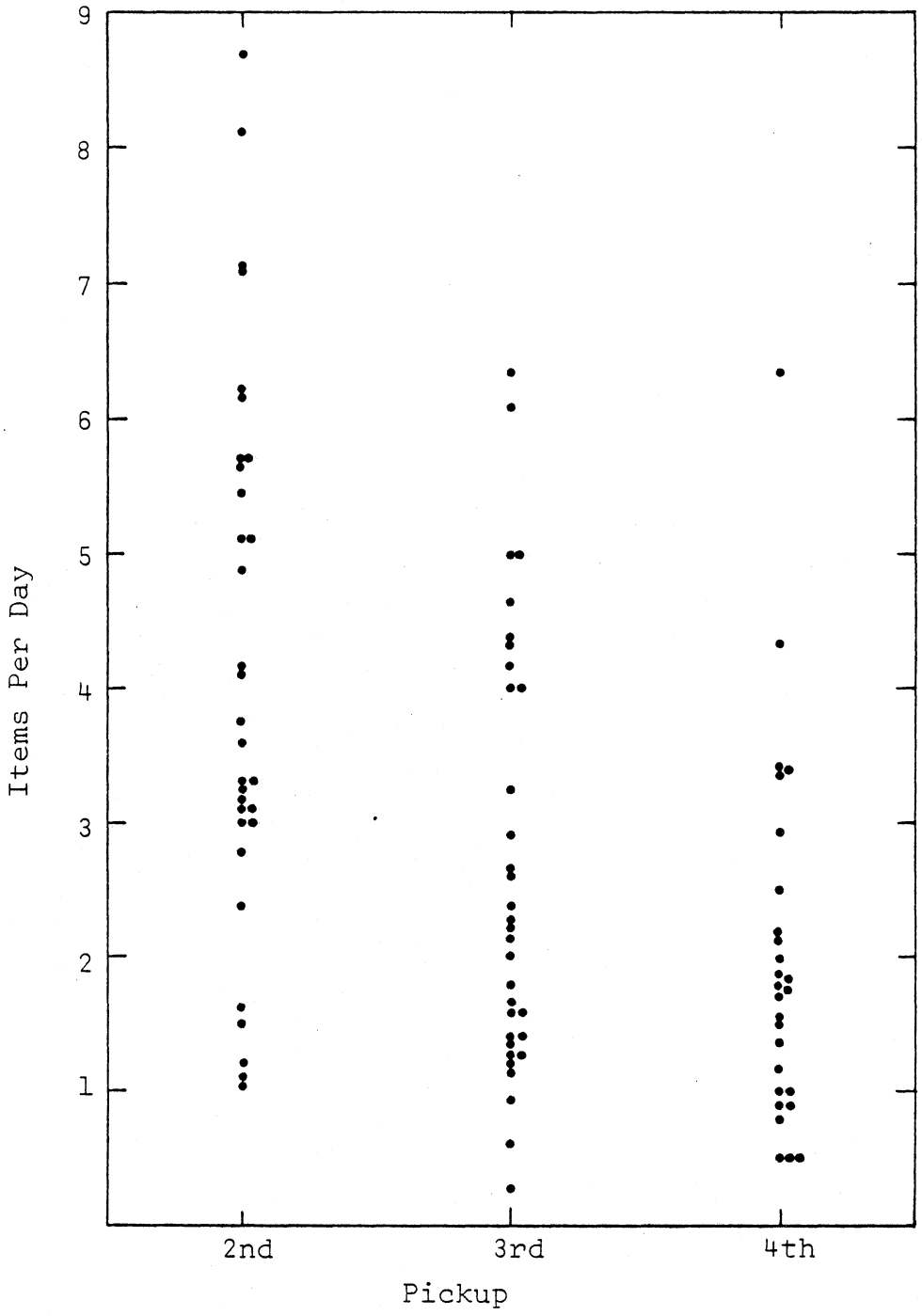


Figure E-1. Items per day for each site by pickup.

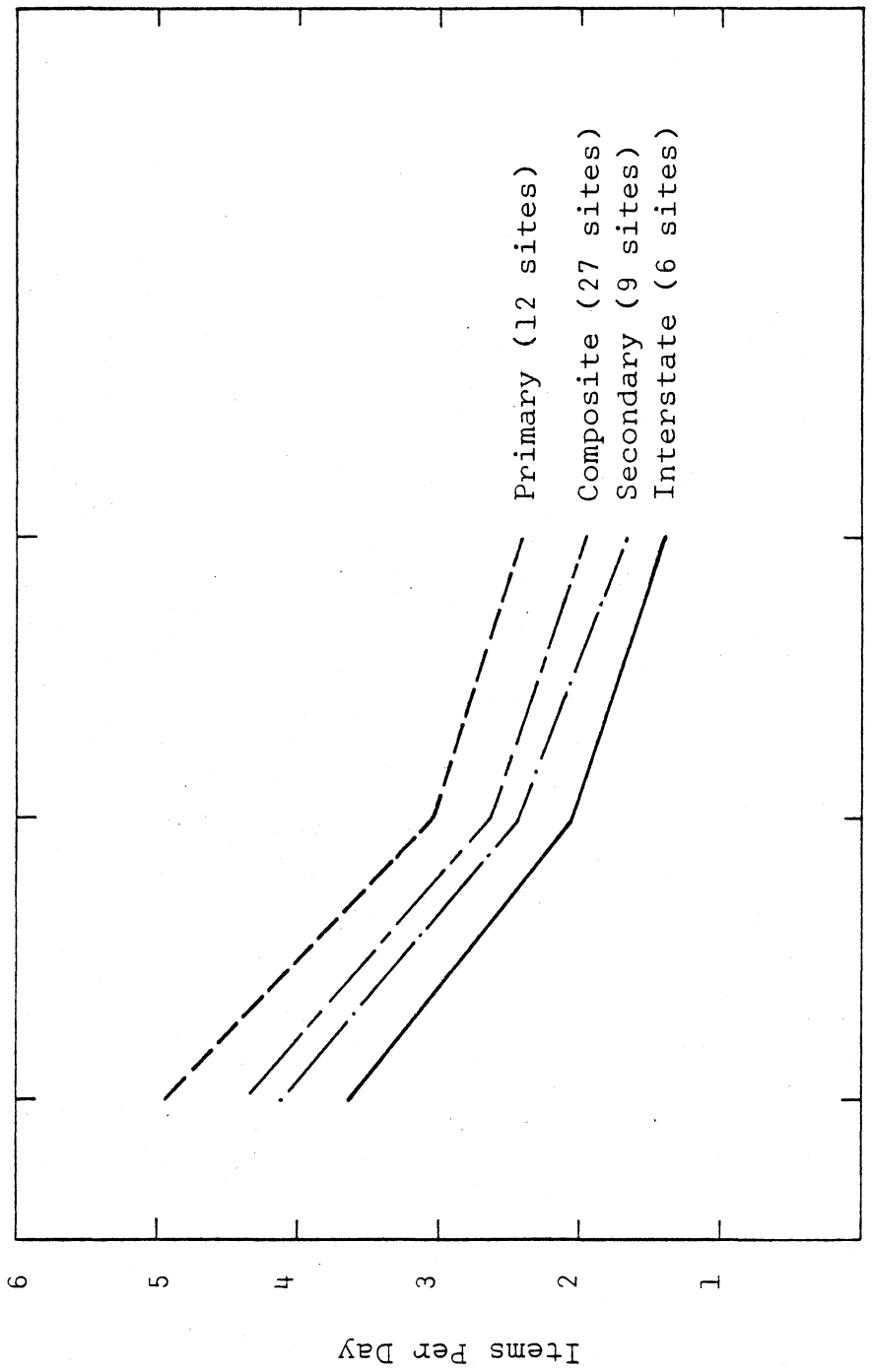


Figure E-2. Average items per day by pickup.

Appendix F

Within Site Standard Deviation Values Computed Based on Average Item Per Day Corrections

Highway System	Number of Sites	Within Site Standard Deviation From Table 4	Adjusted
Interstate	6	1.24	0.76
Primary	12	1.57	1.20
Secondary	9	1.43	1.25
All Systems	27	1.45	1.12

Appendix G

Approximate Sample Sizes (Number of Pickups Per Site)
Required to Detect Changes in Items Per Day
Of Prescribed Magnitude with 95% Confidence Level

Estimate of σ	Sample Size Required to Detect 50% Change		Sample Size Required to Detect 25% Change	
	β=.50	β=.20	β=.50	β=.20
Within Site - Table 4	6	10	16	30
Adjusted - Table 5	4	6	10	17

Appendix H

Proportions of Litter by Type

Description		Cans	Bottles	Paper/Plastic	Auto/Other
Initial Pickup:	Interstate	19%	9%	66%	6%
	Primary	21	9	66	4
	Secondary	29	16	54	1
Other Pickups:	Interstate	14	6	76	4
	Primary	13	11	73	3
	Secondary	23	13	62	2
All Pickups:	Interstate	17	8	69	6
	Primary	17	10	70	3
	Secondary	27	15	56	2
1976 Survey Results:	Interstate	24	5	57	14
	Primary	30	9	56	5
	Secondary	39	11	49	1