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AN EVALUATION OF CHARACTERISTICS THAT IMPACT VIOLATION RATES AT RIGHT-IN / RIGHT-OUT DRIVEWAYS

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Abstract

One popular method of reducing congestion and improving safety on our roadways is the implementation of Access Management techniques on arterial streets. One such technique is the right-in/right-out (RIRO) driveway, which is constructed to dissuade left turns. Reducing left turns reduces vehicular conflict points, which decreases the potential for vehicular crashes and delays.

This research focuses exclusively on RIRO driveways where there is not a center median on the arterial to physically prevent left turns, where compliance is necessary to realize the benefits. Numerous specific driveway and site characteristics that may impact violation rates were identified through surveys, a literature review, and a qualitative review of seven existing RIRO driveway sites. A method is developed to quantitatively evaluate RIRO characteristics based on their impact on violation rates. This method includes linear regression models that incorporate these characteristics. Though due to the limited number of RIRO driveways studied in this research, statistically significant relationships between characteristics and violation rates could not be developed, some interesting initial results were obtained that deserve further investigation.

The findings indicate some characteristics that may impact violation rates are the shape and size of the raised island, the existence of vehicle storage on the arterial, the existence of delineators on the island, and the volume of traffic on the arterial.

INTRODUCTION

Background and Purpose

Much effort has been spent developing techniques to improve traffic flow and safety on our public roadways. This is especially true along commercially developed, highly traveled corridors. Access Management is the application of methods such as, adequate driveway and intersection spacing, optimal traffic signal spacing, and the addition of exclusive turn lanes to reduce delay and crashes.

One specific Access Management technique is the use of right-in/right-out (RIRO) driveways. RIRO driveways are designed to dissuade a driver from making left turns to or from the adjacent street. RIRO driveways generally consist of a raised curbed or solid concrete island and regulatory signage ("No Left Turn" signs). Placing "No Left Turn" regulatory signs makes the movement illegal and enforceable *(1)*. The island that is constructed to guide and dissuade vehicles is often referred to as a "pork chop" island. Some designs consist of a painted island in lieu of a raised island. Figure 1 portrays an example of a RIRO driveway design. The use of RIRO driveways is discretionary based on local codes and policies, alternate available access, and the specific site layout.

The purpose for dissuading left turns is to reduce vehicular conflict points, which are directly related to traffic crashes and delay. Figure 2 shows the number of vehicular conflict points at a typical driveway.

Assuming compliance, a right-in/right-out (RIRO) driveway reduces the conflicts from 9 to 2 by eliminating left-in (LI) and left-out (LO) movements, as shown in Figure 3. The three crossing conflict points that are eliminated are likely the most critical with respect to accident severity.

Figure 4 depicts the estimated percentage of annual crashes that occur for each turning movement at a typical driveway. As can be seen, the majority of crashes at driveways involve left turning vehicles. Thus, eliminating left-turn movements should significantly reduce the potential for crashes. The primary issue with RIRO driveways is that compliance is necessary to realize the reduction in conflict points.

For this research, specific general site characteristics and time frames were explored and are described as follows. First, this research includes only RIRO locations that do not have a center median on the adjacent arterial that would serve as a physical barrier to left turning vehicles. Without a center median, RIRO driveways can only serve to dissuade left turns, utilizing a raised island, pavement markings, signs, and delineators. Second, only RIRO driveways located on arterial streets were chosen for this study. Since, by definition, arterials are the roadways that carry the greatest volume of through traffic at the greatest speeds, the accident and delay reduction benefits of dissuading left turns may be the greatest on arterial streets. Third, the PM peak hour was chosen because it is often the highest hour of traffic for the combination of the driveway and the adjacent street.

Lastly, the fact that the locations studied are in Central Ohio (Franklin County) is a significant factor to note. The temperament and regional behavior of drivers may have an impact on violation rates. For example, drivers in New York City, generally characterized as aggressive, may be less likely to comply with RIRO driveways than those in the Midwest, which are generally characterized as less aggressive. It may not be appropriate to combine the data in this study with data from other regions, though comparisons could be made between similar studies to evaluate this possible characteristic.

In order to gain some insight into current design practice and to discover design standards, publications, and literature on this topic, an informal email and telephone survey of several state Departments of Transportation (DOTs) and the Institute of Transportation Engineers' Traffic engineering email discussion group was conducted. Twenty state DOTs, and eight Transportation engineering professionals from the ITE email group responded. Several RIRO design characteristics that may impact violations rates were identified by the respondents: lane widths and turn radii of the driveway; island size and shape; type and placement of signs; pavement markings; acceleration and deceleration lanes; and traffic volume on the adjacent street. The seven sites evaluated in this research include all of the above design features and data was collected for each of these characteristics.

The purpose of this research is to develop a violation rate that is a direct measure of the number of violations versus the number of vehicles completing the maneuver at the preferred location, develop a method for evaluating the impact of various RIRO design and site characteristics on violation rates, and evaluate, at least preliminarily, some of these relationships.

Methodology

The approach for this research was as follows. First, literature was reviewed to identify important RIRO design characteristics in addition to those identified by the state DOT and ITE survey. Second, twenty-two RIRO driveway and site characteristics were identified for consideration in this study. Third, seven RIRO driveways were field reviewed and data was collected for the twenty-two characteristics, and peak hour violations, driveway volumes, and legal alternate left turn volumes. Last, regression analysis was performed to show a method to quantitatively evaluate relationships between RIRO and site characteristics and violation rates. The development of statistically significant relationships was not expected due to the small number of sites reviewed and the large number of characteristics that potentially impact violation rates, but some preliminary relationships were explored. Furthermore, a technique was established that could be used in a wider, more conclusive study.

LITERATURE REVIEW

Published national standards do not exist with respect to the design of RIRO driveways without a mainline center median, but the application and design of RIRO driveways has been addressed in a federal publication and an Oregon State University research project. The following is a discussion of some published information on the topic.

Ahmet Aksan and Robert Layton *(2)* prepared a paper specifically on the topic of RIRO driveways. The paper summarized literature on RIRO driveway design. A thorough discussion of current American Association of Highway and Transportation Officials' *(3)* design criteria for channelization and island design was presented. The research included data collection and analysis of violations and accidents at twenty locations in the states of Oregon and Washington. Fifteen locations were of the type without a median on the mainline street. Characteristics evaluated include driveway location, island size and shape, the use of signage and delineators, and existence of acceleration and deceleration lanes.

Aksan's paper emphasizes the impact of what it defines as the "setting" of the driveway. The setting refers to the location (up stream or down stream) of the RIRO driveway with respect to the adjacent alternate legal left turn access (see Figure 5). Aksan concluded that the setting is the most critical feature of a RIRO driveway with respect to violation rates. Aksan concluded that for "Setting A" LO violation rates are expected to be higher than LI violation rates, and for "Setting B" LI violation rates are expected to be higher. Aksan concluded that the reason for this relationship is that the respective violations reduce the travel distance and time for the driver. For example, with "Setting A" there would likely be no advantage to driving past the alternate legal access to complete a direct left turn into the site at the RIRO driveway, but time and distance could be saved by making the illegal left turn exiting the site. "Setting C" is a condition where the RIRO driveway is located between two alternate legal accesses. Aksan presents no conclusions regarding the expected violation rates for "Setting C." The findings of the research included herein supports Aksan's conclusion that LO violation rates are expected to be higher than LI violation rates for sites with "Setting A."

Another of Akson's conclusions was that "…bigger island sizes have been found helpful but are not sufficient to prevent violations." An additional conclusion was that "…at arterials with a middle lane (two-way left turn lane or left turn lane for an adjacent intersection) between through traffic lanes, the violation rate is high." These characteristics have been included in the data collected for each site studied in this research.

Two other sources that explore the topic of RIRO driveways are a National Highway Institutive (NHI) short course *(4)* and a Federal Highway Administration (FHWA) report *(5)*. Though specific references were not provided in the NHI course, it is apparent that the material in the course was derived from the FHWA report. In the FHWA report, general design guidelines were given related to island design that significantly match the requirements of AASHTO *(3)* for raised islands, and turn prohibition regulatory signs, per the Manual of Uniform Traffic Control Devices *(1)*, are recommended.

The FHWA report recommended the following design characteristics, which have been included in the characteristics evaluated in this study:

> *"A triangular shaped island is located in the driveway throat to prevent both maneuvers. Widening of the driveway on both sides is required to accommodate the turning radii for right-turn egress and ingress vehicles. A minimum of a 50-ft curb return radius is recommended for the efficient operation of this design…"*

In summary, the literature review has identified several potentially important RIRO design characteristics. The research herein will attempt to quantitatively evaluate the relationship between violation rates and these and other design characteristics.

DATA COLLECTED

RIRO Driveway Design and Site Characteristics

Site data were collected for seven RIRO driveway sites located on arterial roadways in Franklin County, Ohio. The data collected represent information that would likely be readily available to a design engineer at the time of site design. The following describes the data collected and the methods used to collect it.

The geometric design characteristics of island length, island width, lane width, and curb radius were measured in the field (in feet) using a tape measure. Figure 6 shows these geometric design characteristics.

Other characteristics that were collected by field observation or as stated herein are:

Existence of adequate "no left-in, left-out" regulatory signage – Adequate signage is defined as at least one regulatory sign meeting the requirements of the Federal *Manual of Uniform Traffic Control Devices (1)* for each undesired left turn movement.

Availability of vehicle storage on mainline – Vehicle storage generally consists of a center two-way left turn lane on the mainline, or a left turn lane for an adjacent intersection that extends into the functional area of the driveway.

Setting – All of the sites were categorized as either setting A, B or C, as defined in Aksan's *(2)* research.

Distance to closest legal alternate LI or LO access – The distance is measured in feet using a distance wheel along the roadway(s) adjacent to the site that the legal alternate access is located.

Visibility of the closest legal LI or LO – This is a qualitative evaluation of how visible the alternate legal access is to the driver from the location of the RIRO driveway. Good is defined as clearly visible to the driver with very little effort. Fair would be a condition where some minor effort would be required for the driver to locate the alternate legal access, but it is clearly visible. Poor would be a situation where the driver cannot see the alternate legal access, or where it is very difficult to see.

Average Daily Traffic (ADT) - The ADT on the adjacent arterial was obtained from the Mid-Ohio Regional Planning Commission website. This is the average number of vehicles per day that traverse the section of roadway.

Number of through lanes on the adjacent arterial - The number of lanes on the adjacent arterial that carry through traffic was field observed.

Number of arterial lanes that must be crossed to perform a LI or LO – The number of lanes that a vehicle would have to cross on the adjacent arterial to complete a LI or LO, respectively, was field observed.

Average Daily Traffic (ADT) divided by the number of through lanes on the adjacent arterial in vehicles per day - This value is calculated from the ADT and number of through lanes on the arterial, and is a relative measure of how "busy" the adjacent arterial is. It gives a rough measure of the relative number of gaps in traffic that may available to driveway traffic.

The existence of delineators – Delineators are colored plastic posts that delineate the edge of the raised island, or are extended along the adjacent arterial to direct traffic and dissuade left turns.

Existence of RI deceleration lane or RO acceleration lanes – This feature was field observed.

Detailed descriptions and drawings of each site are available from the author. Table 1 summarizes the site characteristics collected for the seven case studies.

Peak Hour Traffic Volumes and Violations

In order to develop violation rates, field data were manually collected for each site. All counts were performed on weekdays between January 2002 and May 2002. The following are the types of data collected.

RIRO Driveway Peak-Hour Traffic Volume - The weekday PM Peak hour was determined based on a two-hour manual count of total volume of the driveway (RI plus RO), conducted in fifteen-minute intervals, for each driveway, from 4:00PM to 6:00PM. From the two-hour count, the four consecutive fifteen-minute intervals with the highest cumulative traffic volume represent the peak-hour for the RIRO driveway. This hour was used as the time frame for other traffic volume data collected for each driveway.

LI and LO Peak-Hour Violations – The number of LI and LO violations during the peak hour for each driveway was manually counted. This count was performed simultaneously with the RI and RO driveway peak hour traffic volumes above.

Legal Alternate Left-turn Volume – At each site, the volume of traffic to and from the site that made left turns at the legal alternate access(s) was manually counted. It was not physically possible for a single observer to count this volume simultaneously with the RI and RO volumes and LI and LO violations, so it was collected on a different day. To collect this data it was necessary to choose a location at each site that allowed the observer to see the origin and destination of a vehicle which turns LI or LO at the alternate legal access.

CALCULATION OF VIOLATION RATES

The following describes the calculation of the violation rates that were considered in this study. These rates are calculated from the peak hour violations and the volume of traffic using the legal alternate left turn access(s). The rates represent the number of violations per one thousand (1000) legal alternate vehicular movements to or from the site. The rates are calculated as follows:

LI Legal Alternate (LILA) Rate =
[LI Peak Hour Violations / LI Legal Alternate Peak Hour Volume] x 1000

LO Legal Alternate (LOLA) Rate =
[LO Peak Hour Violations / LO Legal Alternate Peak Hour Volume] x 1000

The rates compare the number of violations to the number of vehicles that complete the same movement via the legal alternate access (the preferred access). This rate gives a direct measure of what portion of the LI or LO volume to or from a site makes the movement at the desired location versus making a violation at the RIRO driveway.

For comparison purposes, an average violation rate was also calculated for all seven sites. The average rate is calculated based on the cumulative sum of violations for all sites versus the appropriate cumulative total legal alternate left turn volume of all sites. This rate indirectly “weights” each location based on the total volume since it is a cumulative total for all sites. The average rates are calculated as:

LILA Average Rate =
[Total LI Peak Hour Violations for All 7 Sites / Total LI Legal Alternate Peak Hour Volume into All 7 Sites] x 1000

LOLA Average Rate =

[Total LO Peak Hour Violations for All 7 Sites / Total LO Legal Alternate Peak Hour Volume from All 7 Sites] x 1000

Table 2 represents the violation rates calculated for each site, and the average violation rates.

In order to evaluate Aksan's *(2)* conclusion that LO rates are expected to be higher for Setting A and LI rates are expected to be higher for Setting B, the Average Rate was calculated separately for each setting. Since there is only one site, respectively, for each setting B and C, the results do not provide much insight into these setting types. There are only five sites with setting A, but one observation can still be made. The average rates calculated for Setting A support the conclusions of Aksan *(2)* that the LO violation rates are higher than LI violation rates for Setting A. The LILA violation rate was 17.79 while the LOLA rate was 39.53 for the five sites that were Setting A.

ANALYSIS

Regression Analysis

Numerous RIRO driveway and site characteristics have been identified thus far that may impact violation rates. This section attempts to quantitatively relate the various site characteristics to violation rates through linear regression models. The intent of this analysis is to demonstrate a method of understanding violation rates as they are influenced by RIRO driveway and site characteristics. It is understood that due to the large number of characteristics, many additional case studies would be required to develop statistically significant relationships that include all characteristics and rates.

The selection of characteristics to be evaluated is based on which violation rate is being evaluated. Only characteristics that would likely influence the specific violation rate (LILA or LOLA) that is being analyzed are included in the analysis. For example, the RI turn radius as shown in Figure 6 does not influence illegal left out maneuvers, so it is excluded from the selected variables for the LO Legal Alternate rate.

The first part of the analysis is to individually evaluate the relationship of each characteristic with the appropriate violation rate. *SPSS (6)* is used to calculate the simple linear regression relationship for each characteristic. The form of the linear equation is as follows:

Violation Rate = Constant + (Coefficient x Characteristic Value)

First, the LILA rate was explored. None of the characteristics alone explain the LILA rate well. Next, the same analysis was performed for the LOLA rate. Similar to the LILA rate, most characteristics do not display a significant relationship, though in this case the ADT per through lane on the arterial displays a significantly higher R Square value (0.54) than any other variable. The t statistic indicates that the coefficient is significantly different from zero with a level of confidence greater than 96 percent. The coefficient had a positive sign, which is logical since it would be expected that as traffic increases on the arterial, completing the LO maneuver would become more difficult and less attractive to the driver.

Multiple linear regression analysis was then performed since it is expected that the there are interrelationships between characteristics. The value, or existence, of one characteristic may have an effect on the impact of another characteristic. For example, the RI radius may have less or more of an impact on violation rates if the site has vehicle storage available on the arterial. SPSS was used to perform multiple linear regression analyses to evaluate these potential interrelationships. Numerous models were developed and reviewed that included nearly all combinations of the pertinent characteristics for each violation rate. A large number of models were developed relatively quickly using SPSS. Based on the results of the prior model, the next model was developed by removing or adding variables. Due to the limited number of cases, four was the maximum number of characteristics that could be included in the model, while still maintaining at least two degrees of freedom in the regression model.

The models presented are those that resulted in the highest values for Adjusted R Square, and highest levels of confidence for the coefficients. Though there are not enough cases to develop a model that would predict violation rates for any given site to a great degree of confidence, some interesting observations can still be made from the models that were developed. All models represent the violation rate as the dependent variable and include all seven cases.

First, LILA Model 1 is as follows:

Adjusted R Square = 0.645

Variables	Coefficients	t	p
Constant	260.0	2.840	0.066
Total Island Area	-0.06833	-3.186	0.050
RI Lane Width	3.23	2.729	0.072
RI Corner Radius	-6.337	-2.588	0.081

LILA Model 1 shows a relationship between the LILA rate and the size and shape of the island. The t-statistics indicate that there is at least a 92% confidence level that the coefficients for each characteristic are statistically different than zero and have an impact on the estimate. The signs of the coefficients appear to be logical. It would be expected that a larger island area would create the appearance of a greater barrier and would likely reduce violations. Second, a larger RI lane width would provide a wider opening for the LI movement, thus making the undesired maneuver more attractive. Third, as the corner radius increases, the violation rate would be expected to decrease, since the angle of entry to the adjacent arterial would become steeper, thus making it more difficult to make the undesired maneuver.

Additional characteristics were added to this model to try to improve the relationship. The only improvement to the Adjusted R Square is observed when the characteristic of whether or not vehicle storage is available on the arterial is added, resulting in LILA Model 2 as follows.

Adjusted R Square = 0.828

Variables	Coefficients	t	p
Constant	185.501	2.532	0.127
RI Lane Width	5.733	3.496	0.073
RI Corner Radius	-5.015	-2.749	0.111
Total Island Area	-0.05897	-3.772	0.064
Vehicle Storage on Arterial			

(Yes = 1, No = 0)	26.618	2.044	0.178

The addition of the vehicle storage on arterial variable improved the R Square value, but decreased the level of confidence for each coefficient. The sign of the coefficient for this additional variable makes sense. The existence of a place for a vehicle to rest out of the flow of traffic while waiting to make the LI would increase the attractiveness of making the undesired LI maneuver.

Several other models displayed significant positive values for R Squared, but none displayed significant t-statistic values.

Next, the following two models were developed for the LOLA violation rate. LOLA Model 1 is as follows:

Adjusted R Square = 0.996

Variables	Coefficients	t	p
Constant	264.636	31.632	0.000
RO Corner Radius	-4.319	-25.057	0.000
Total Island Area	-0.04331	-24.936	0.000
Delineators Used?			
(Yes = 1, No = 0)	-32.607	-21.279	0.000

Similar to the LILA models, the most significant relationships developed include characteristics of the raised island only. LOLA Model 1 has a very high R Square value and the t-statistics are such that the levels of confidence are approaching 100 percent that all coefficients are statistically significantly different from zero. The signs of the coefficients are logical. As discussed for LILA Model 1, as the RO corner radius and the island area increase one would expect the violation rate to decrease. Also, the usage of delineators create a greater visual barrier that would likely decrease violations, so the negative sign makes sense.

LOLA Model 2 adds the variable “RO Lane Width” as follows:

Adjusted R Square = 0.999

Variables	Coefficients	t	p
Constant	269.381	62.019	0.000
RO Corner Radius	-4.575	-39.903	0.001
Total Island Area	-0.0449	-46.078	0.000
Delineators Used?			
(Yes = 1, No = 0)	-32.862	-43.68	0.001
RO Lane Width	0.455	3.27	0.082

The addition of this variable improves the R Square value, but the resultant t-statistic for the added variable is significantly lower than the other variables. The sign of the coefficient makes sense. As the RO lane width increases, maneuvering to make the illegal left would become easier.

Summary of Analysis

Numerous RIRO characteristics have been identified that may have an influence on violation rates. Regression analysis was performed to investigate some of these potential relationships. Since there were data for very few cases, and there was a significant lack of variability in values for many characteristics, it was not possible to develop models that display significant relationships between the numerous potentially important RIRO driveway characteristics that have been identified in this research, and violation rates. Some interesting relationships were observed that deserve further exploration in future research.

Overall, the models developed for the LILA rate indicate that there may be a relationship between violation rates and the shape and size of the raised island, and also the existence of vehicle storage on the arterial. The models developed for the LOLA rate indicate that there may be a significant relationship between the shape and size of the raised island and the existence of delineators on the island.

It should be noted that no model that included the characteristic "Setting" as a variable resulted in a significant model relationship. Aksan's *(2)* conclusion that "setting" is the most critical feature impacting the effectiveness of RIRO driveways could not be supported, although since five of the seven cases are of Setting "A" and only one site has Setting "B" and "C" respectively, a good comparison was not possible.

It should also be noted that although individually the characteristic of ADT per through lane on the arterial showed the most significant relationship with the LI and LO Legal Alternate rate, combining it with other RIRO characteristics did not strengthen this relationship.

SUMMARY AND CONCLUSIONS

Right-in, right-out (RIRO) driveways are sometimes constructed to dissuade left turns at a driveway. Dissuading left-turns at driveways reduces vehicular conflict points, which has the potential to decrease vehicular crashes and delay. RIRO driveways most often consist of a raised island that is designed to guide vehicles away from the undesired left turns. "No Left Turn" signage is generally provided at these locations to prohibit the left turn movements. RIRO driveways that do not have a center median on the arterial to prevent left turns are the exclusive focus of this research.

Numerous specific RIRO driveway, and site characteristics were identified in this research that may impact violation rates. These characteristics were identified through surveys, literature review, and a review of seven existing RIRO driveway sites in Franklin County, Ohio.

A method was developed to quantitatively evaluate RIRO characteristics based on their impact on violation rates at these driveways. This method includes the development of linear regression models. Although due to the small number of sites for which data was collected as part of this research, and the large number of driveway geometric and traffic control characteristics that may impact violation rates, statistically significant relationships between characteristics and violation rates could not be developed, some interesting results were obtained that deserve further investigation.

The preliminary findings, based on quantitative analysis of data from seven RIRO driveways, indicate that factors that may have a significant impact on the LI violations include the shape and size of the raised island, the existence of vehicle storage on the arterial, and the volume of traffic on the arterial. Also, characteristics that may have a significant impact on the LO violations include the shape and size of the raised island, the volume of traffic on the arterial, and the existence of delineators on the island.

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LIST OF TABELS AND FIGURES

TABLE 1 Site Characteristics

Site No.	Site/ Characteristic	Setting	RI Width (ft.)	RO Width (ft.)	RI Radius (ft.)	RO Radius (ft.)	Island Area (ft^2.)	Island Width (ft.)	Island Length (ft.)
1	Wilson Bridge Rd @ Worthington Mall	A	14	14	40	40	180	18	12.33
2	Sawmill Rd @ CVS/Giant Eagle	A	16	16	50	50	440	33.5	30.5
3	Frantz Rd @ Shopping Center	A	14	14	40	40	1360	65	92.3
4	SR 161 @ Shopping Center	B	15	15	40	40	1360	71	55.4
5	Morse Rd @ Walgreen’s	A	16.5	16.5	50	50	340	27	30
6	Sawmill Rd @ Max & Erma’s/CVS	C	22	22	45	45	890	44	50
7	Cleveland Ave @ Meijer	A	15.5	24	30	50	1160	40	130

TABLE 1 Site Characteristics (continued)

Site No.	Site/Characteristic	No LI Signage	No LO Signage	Delin-eators	Vehicle Storage Adj. Arterial	# Thru Lanes Adj. Arterial	# Lanes Crossed for LI	# Lanes Crossed for LO
1	Wilson Bridge Rd @ Worthington Mall	Yes	Yes	No	Yes	4	2	2
2	Sawmill Rd @ CVS/Giant Eagle	No	No	No	Yes	4	2	2
3	Frantz Rd @ Shopping Center	Yes	Yes	No	Yes	4	2	2
4	SR 161 @ Shopping Center	Yes	Yes	Yes	No	2	1	2
5	Morse Rd @ Walgreen’s	Yes	Yes	Yes	No	5	4	4
6	Sawmill Rd @ Max & Erma’s/CVS	Yes	Yes	Yes	Yes	4	2	2
7	Cleveland Ave @ Meijer	No	Yes	No	Yes	4	2	2

TABLE 1 Site Characteristics (continued)

Site No.	Site/Characteristic	ADT Adj. Road	Dist. LI Alt. (ft.)	Dist. LO Alt. (ft.)	LI & LO Legal Alt. Visibility	Accele-ration Lane Exist?	Decele-ration Lane Exist?
1	Wilson Bridge Rd @ Worthington Mall	13704	515	515	Poor	No	No
2	Sawmill Rd @ CVS/Giant Eagle	13609	245	245	Good	No	No
3	Frantz Rd @ Shopping Center	15504	513	513	Good	No	No
4	SR 161 @ Shopping Center	15709	560	560	Fair	Yes	Yes
5	Morse Rd @ Walgreen’s	42506	550	550	Fair	No	No
6	Sawmill Rd @ Max & Erma’s/CVS	24909	280	594	Fair	No	No
7	Cleveland Ave @ Meijer	33105	420	420	Good	No	No

TABLE 2 Violation Rates

Site No.	RIRO Driveway Site	Violation Rates (Violations per 1000 legal alternate left turns)	
		LILA	LOLA
1	Wilson Bridge Rd @ Worthington Mall	81.1	85.4
2	Sawmill Rd @ CVS/Giant Eagle	37.0	28.0
3	Frantz Rd @ Shopping Center	0.0	31.3
4	SR 161 @ Shopping Center	0.0	0.0
5	Morse Rd @ Walgreen’s	0.0	0.0
6	Sawmill Rd @ Max & Erma’s/CVS	60.6	0.0
7	Cleveland Ave @ Meijer	0.0	0.0
	Average Violation Rate of All 7 Sites	14.6	34.0

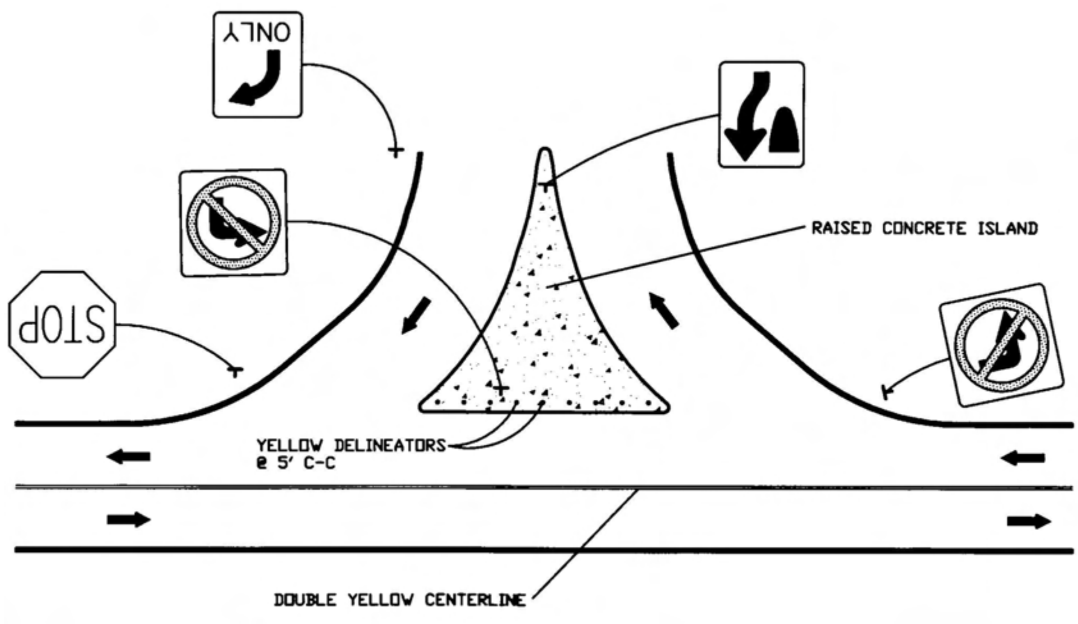


FIGURE 1 Example of a RIRO Driveway without a Center Median on the Mainline

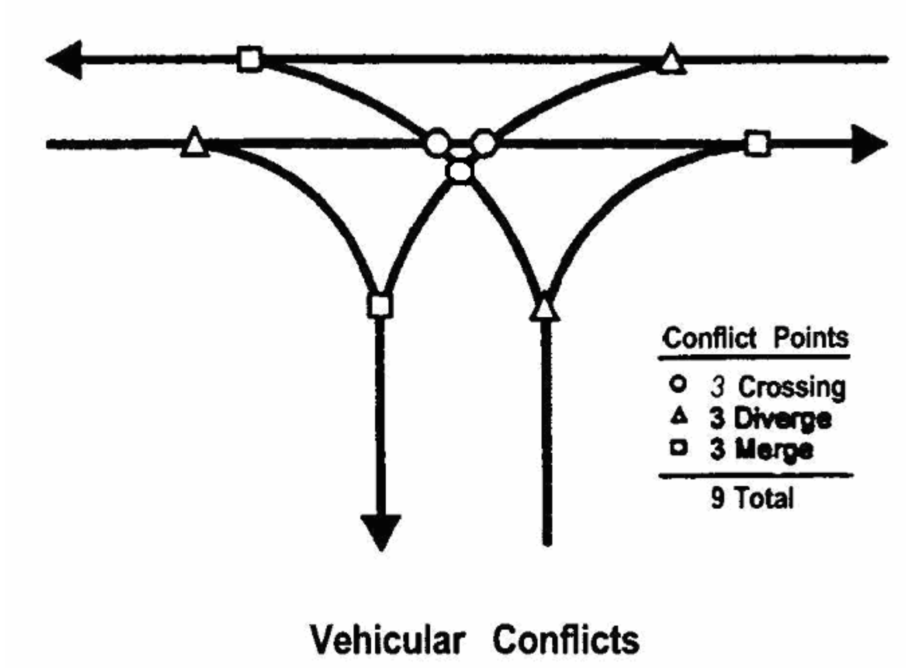


FIGURE 2 Vehicular Conflicts at a Typical Driveway (4)

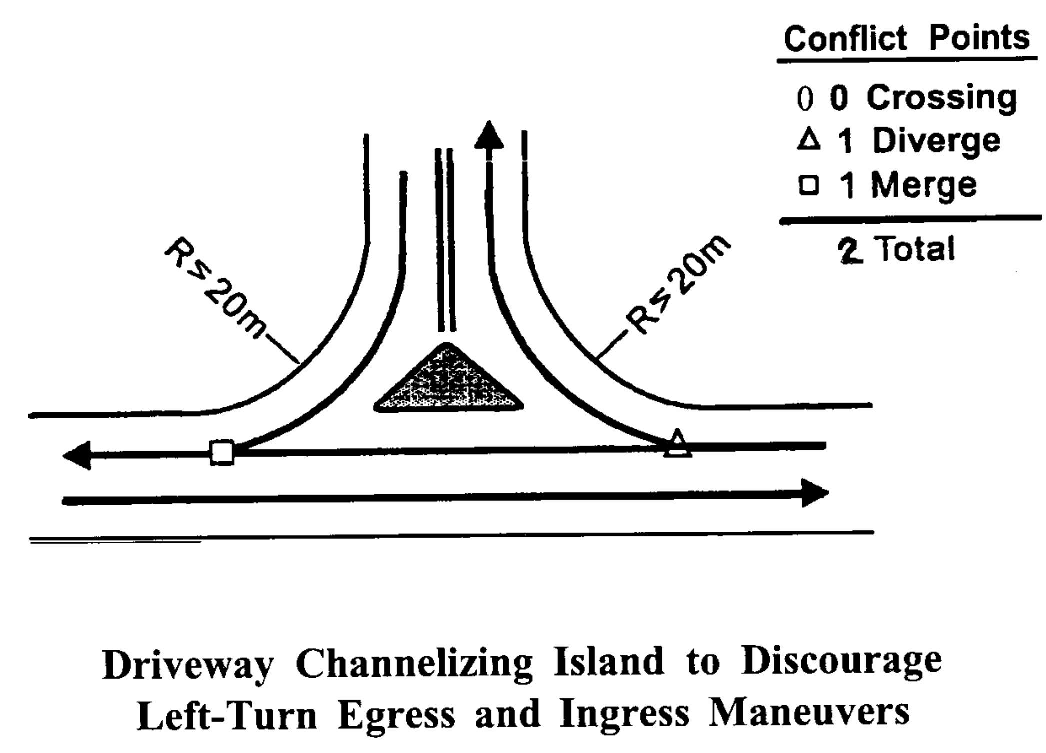


FIGURE 3 Theoretical Vehicular Conflicts at a RIRO Driveway (4)

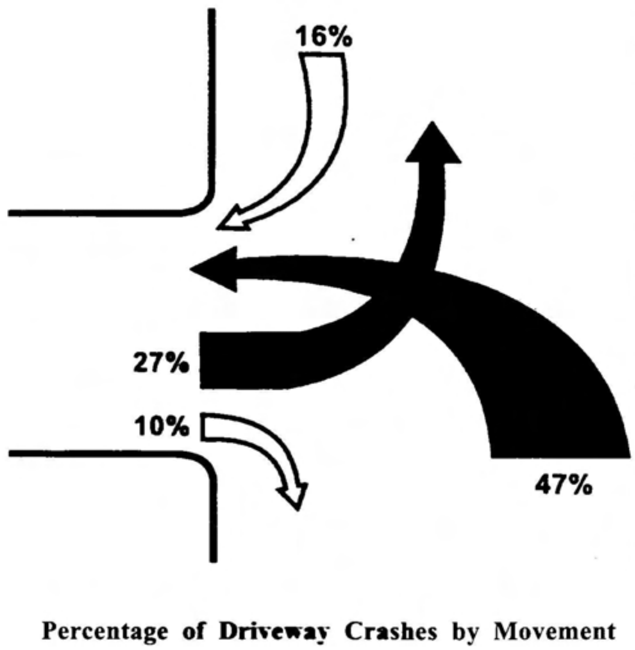
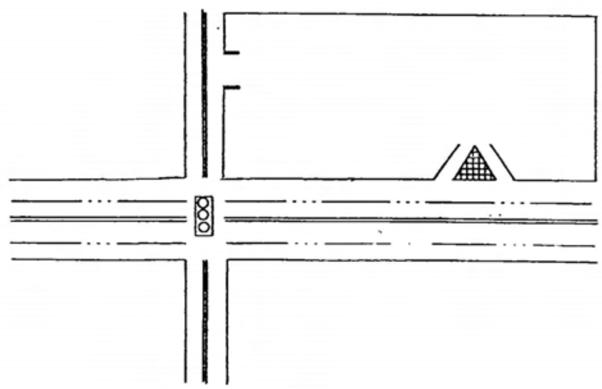
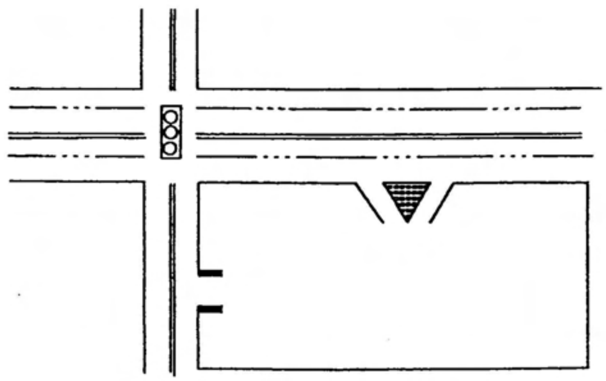


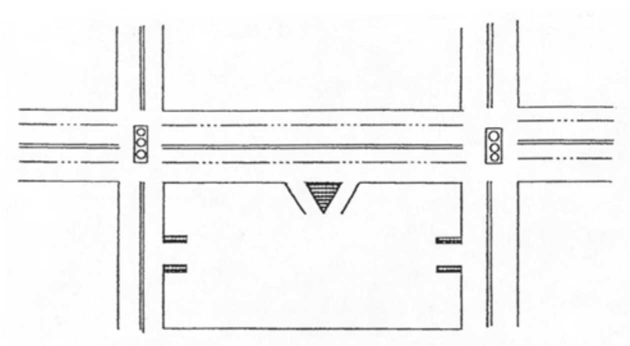
FIGURE 4 Crashes by Movement (4)



Setting A



Setting B



Setting C

FIGURE 5 Settings (2)

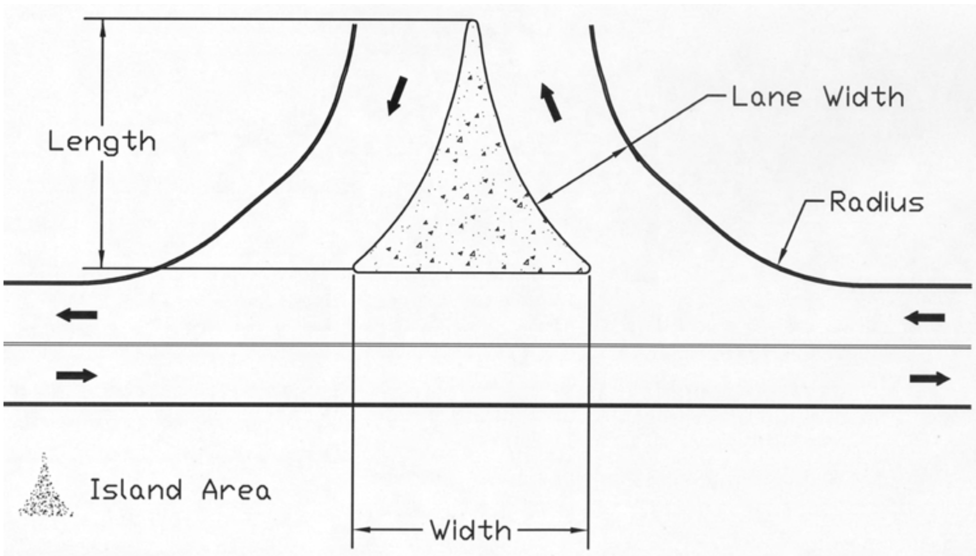


FIGURE 6 RIRO Driveway Geometric Characteristics