RESEARCH REPORT
548

Safety Improvement Program for Toll Roads KYP-77-84, HPR-PL-1(15), Part III-B

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16. Abstract

This report presents proposed safety improvements for Kentucky's toll roads. The primary methods of identifying needed improvements were an accident analysis and a field inventory. The accident analysis identified specific high-accident spots and sections. Also, accident rates were calculated for each toll road, and the types of accidents which had occurred in the 3-year period were summarized. A separate 10-year analysis of fatal accidents was made. The field inventory was used to identify roadway features which are now substandard and in need of upgrading. Also, high-accident spots and sections were investigated in the field. The benefits and costs for each improvement were estimated and used as input into a dynamic programming model used as a means of priority ranking the improvements. A total of 42 improvement alternatives were included in the analysis at an estimated cost of $58.5 million. Those alternatives with benefit-cost ratios greater than 1.0 totaled only $8.7 million.

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SUBJECT: Research Report 548; "Safety Improvement Program for Toll Roads," KYP-77-84; HPR-PL-1(15), Part III-B

Reports 495 and 517 were prepared to document the safety improvement needs of the interstate system. This report, which closely follows a users' guide included in Report 517, is a compilation of recommended improvements for the toll roads. Our studies are progressing from interstates to toll roads and then to the primary system. Certainly the most difficult is the development of a safety improvement program for the primary system. This task will be undertaken sometime after January 1, 1981, which is the date when one year of accident data will be available using new codes for accident tapes.

Experience gained in preparation of the interstate reports aided in the preparation of a safety improvement program for toll roads. In addition, we were able to analyze longer periods of accident data for the toll road system.

A total of 42 alternatives were included in the list of potential improvements for the toll road system. The estimated cost for all improvements was $58.5 million; however, those alternatives having benefit-cost ratios greater than 1.0 totaled only $8.7 million.

Respectfully submitted,

Jas. H. Havens

Jas. H. Havens
Director of Research

JGP:gh
cc: Research Committee

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Introduction

To provide the highest degree of safety on the highway system, there is a need to continually monitor the accident experience and to make improvements where justifiable. Since 1968, the Kentucky Department of Transportation has had a program to facilitate safety improvements at high-accident locations. An evaluation of this program showed that improvements have reduced accidents, and the improvements were cost-effective.[1]

In a previous report, an accident analysis and field inventory was used to prepare a priority ranking of improvements for the interstate system.[2] The objective of the study reported here was to prepare a list of recommended improvements for Kentucky's toll roads. The toll road system consists primarily of four-lane highways with full-access control. However, most of one toll road and part of another are two-lane, and there are some at-grade intersections. The previous report contained a users' guide for preparation of a safety improvement program. The methodology contained in that guide was used in this study of toll roads.

Procedure

Accident Analyses

Much of the information required for each accident is available from a computer file. However, since additional details concerning the type of accident were needed, copies of the reports of all accidents occurring on toll roads during a three-year period (1976-1978) were obtained. Information given on the accident report enabled each accident to be classified into one of three categories:

- Interchange- and intersection-related (Table 1);
- Bridge-related (Table 2); or
- Mainline-related (Table 3).

These categories are divisions of a revised directional analysis and were subsequently approved by the Kentucky State Police and included in the computer accident file.[3] Other information coded from the accident report included such vari-

Table 2. Bridge-Related Accident Categories.

51 — Not stated
52 — Hit bridge rail or curb
53 — Hit bridge abutment
54 — Rear end accident
55 — Ran off road after losing control on bridge
56 — Head-on
57 — Opposite-direction sideswipe
58 — Same direction sideswipe
59 — Through or over bridge rail
60 — Gap between bridges
61 — Hit approach guardrail
62 — Other bridge related accident

Table 1. Interchange- and Intersection-Related Accident Categories.

Interchange	Intersection
Entrance Ramp	00 — Not stated
71 — Not stated	01 — Angle accident — both straight
72 — Rear-end accident on ramp	02 — Angle accident — one turning left
73 — Angle accident between ramp vehicle and mainline vehicle	03 — Angle accident — one turning right
74 — Sideswipe accident on ramp	04 — Angle accident — other
75 — Rear-end accident on mainline at ramp	05 — Rear end — both straight
76 — Ramp vehicle hit fixed object	06 — Rear end — one turning left
77 — Ramp vehicle ran off road	07 — Rear end — one turning right
78 — Sideswipe accident between mainline vehicles	08 — Rear end — accident on exit ramp
79 — Other accident related to entrance ramp	09 — Rear end — other
	10 — Opposite direction — one left turn, one straight
Exit Ramp	11 — Opposite direction — both going straight
81 — Not stated	12 — Opposite direction — other
82 — Sideswipe accident related to ramp	13 — Fixed object
83 — Vehicle hit fixed object in gore	14 — Single vehicle
84 — Ramp vehicle hit fixed object not in gore	15 — Pedestrian
85 — Rear-end accident before ramp	16 — Vehicle backing
86 — Ramp vehicle ran off road	17 — Merging from ramp
87 — Other accident related to exit ramp	18 — Merging onto ramp
	19 — Other

Table 3. Mainline Accident Categories.

Roadway Sections and Mid-Block
26 — Not stated
27 — Rear end accident in traffic lane
28 — Hit fixed object
29 — Ran off roadway
30 — Head-on collision
31 — Sideswipe accident (same direction)
32 — Sideswipe accident (opposite direction)
33 — Pedestrian
34 — One car entering driveway or alley
35 — One car leaving driveway or alley
36 — Entering or leaving parked position
37 — Median cut accident
38 — Wrong-way vehicle accident
39 — Vehicle backing
40 — Rear end accident on shoulder
41 — Other shoulder-related accident
42 — Animal-related accident
43 — Other
Miscellaneous
91 — Not stated
92 — Parking lot
93 — Train
94 — Toll booth
95 — Other train-crossing-related
96 — Other

ables as lighting and roadway surface conditions. Accident location information (route and milepost) was also coded. The coded information was punched onto computer cards (one card per accident), for a detailed analysis. A list of the accident characteristics summarized from the coded data is given in Table 4.

Lists of high-accident, mainline sections were obtained using various section lengths: 0.3 mile (0.48 km), 1 mile (1.6 km), 2 miles (3.2 km), 5 miles (8.0 km), and 10 miles (16 km). Also, lists of high-accident interchanges and bridges were obtained. Each accident classified as bridge- or interchange-related was assigned to a specific bridge or interchange. The number of accidents occurring at each interchange and bridge was found and compared to a critical number. The critical number of accidents for an interchange, bridge, or specific length of road was calculated using the following formula:[4]

$$Nc = Na + K(SQRT(Na)) + 0.5, \quad (1)$$

in which Nc is the critical number of accidents; Na is the average number of accidents; K is the constant related to levels of statistical significance (P) selected (for P =0.95, K = 1.645; for P = 0.995, K = 2.576); and SQRT is the square root.

Average and critical accident rates were calculated using traffic volumes. A level of significance of 0.995 was used. Volumes within a given milepost range for mainline section were obtained from a computer file. The number of vehicle-miles (vehicle-kilometers) traveled on a particular section of road was calculated directly from the volume and section length. The lengths of bridges along with the volumes also gave vehicle-miles (vehicle-kilometers). The total interchange volume was estimated using the mainline volume and the number of ramps. The critical rate for a highway section is given by[5]

$$Ac = Aa + K(SQRT(Aa/m)) + 1/(2m), \quad (2)$$

in which Ac is the critical accident rate, in accidents per million vehicle-miles (1.6 million vehicle-kilometers); Aa is the average accident rate, in accidents per million vehicle-miles (1.6 million vehicle-kilometers); and m is the annual million vehicle-miles (vehicle-kilometers).

For spots and within interchanges, the annual volume was used rather than the number of vehicle-miles. Thus, the values of Ac and Aa were expressed in terms of accidents per million vehicles.

Comparing these calculated critical rates with actual rates resulted in lists of high-accident locations. Dividing the accident rate for a particular interchange, bridge, or roadway section by the critical accident rate for the location resulted in a critical rate factor. A critical rate factor of 1.0 or above meant that the location had a critically high accident rate. A computer listing by critical rate factor (in descending order) was then obtained for each accident category. These lists identified the high-accident locations.

Table 4. Accident Characteristics Summarized from Coded Data.

1. Summary by parkway
2. Summary by year
3. Summary by month
4. Summary by hour of day
5. Summary by roadway surface condition
6. Summary by light conditions
7. Summary by roadway character
8. Summary by type of accident
9. Summary by contributing factors — environmental
10. Summary by contributing factors — vehicular
11. Summary by contributing factors — human
12. Summary by accident severity
13. Summary by directional analysis
14. Summary by weather conditions
15. Summary by traffic control
16. Summary by county by route
17. Summary by directional analysis by severity
18. Summary by severity by route
19. Summary by directional analysis by route
20. Summary by severity by light conditions
21. Summary by severity by roadway surface conditions
22. Summary by severity by type of accident
23. Summary by type of accident by parkway

The severity of each accident was determined and used to compare several of the accident characteristics shown in Table 4. The severity index used to make these comparisons is given by[1]

$$\text{Severity Index (SI)} = \text{EPDO}/N, \quad (3)$$

in which N is the total number of accidents; EPDO is 9.5 (K + A) + 3.5 (B + C) + PDO; K is the number of fatal accidents; A is the number of A-type injury accidents (accidents in which an A-type (incapacitating) injury was the most severe injury sustained); B is the number of B-type (nonincapacitating) injury accidents; C is the number of C-type (possible) injury accidents; and PDO is the number of property-damage-only accidents.

A separate analysis was used to determine locations which had a critical number of a particular type of accident. The average number of accidents of a specific type was determined for a given length of roadway. Using Equation 1, the critical number of accidents was calculated. The specific accident types investigated included wet-pavement accidents, snow and ice accidents, fatal or injury accidents, accidents due to unsafe speed, accidents during darkness, animal-related accidents, and accidents involving guardrail.

A special investigation of fatal accidents was performed. Copies of the reports of all accidents involving a fatality were obtained for a 10-year period (1970-1979). Information from these reports was coded and summarized. Each accident was placed into one of several descriptive categories. Sections of toll road where several fatal accidents had occurred were identified.

A comparison of accident data on bridges with and without full-width shoulders was made. A comparison of accident rates on bridges with various sufficiency ratings was performed. Also, interchanges were divided into several types, and accident rates were calculated for each type.

An information source utilized to identify substandard and hazardous bridges was the adequacy rating of each bridge. This rating involves the subjective and objective ratings of condition, safety, and service elements. Adequacy ratings were useful in selecting various types of recommended bridge improvements. Bridges with deficient safety features were included in the list of recommended improvements. The improvements included

- Upgrading approach guardrail,
- Upgrading bridge rail,
- Attaching approach guardrail to bridge structure, and
- Installation of acceptable end-treatment on approach guardrail.

Table 5. Roadway Features Included in the Field Inventory

1.	Type of guardrail end
2.	Bridge pier protection
3.	Bridge shoulder width
4.	Bridge safety features
5.	Curb on bridge
6.	Protection of gap between bridges
7.	Bridge deck condition
8.	Sidewalk on bridge
9.	Interchange lighting
10.	Gore area features
11.	Toll booth protection
12.	Unnecessary guardrail
13.	Additional guardrail
14.	Signs
15.	Hazardous culvert headwall
16.	Nonbreakaway lighting standards
17.	Unprotected overhead sign support
18.	Hazardous rock outcropping or rock cut
20.	Median crossovers
21.	Roadway delineation

Field Inventory

It was necessary to survey all toll roads (approximately 650 miles (1046 km)) for the purpose of inspecting high-accident locations and conducting an inventory of selected roadway features. Some toll roads had features which are now in need of upgrading. To obtain an estimate of the total cost for such improvements, it was necessary to count the number of each offending feature. For example, the present standard for guardrail ends is the breakaway cable terminal; however, almost all guardrail ends on toll roads are either buried or blunt. It was necessary to conduct an inventory of the number of each type of guardrail end to estimate the costs of updating all guardrail ends to current standards.

A listing of the general roadway features included in the field inventory is given in Table 5. The numbers of buried, breakaway, blunt, and flared guardrail ends were determined for guardrail used on fills, at bridge piers, at bridge rails, and in gaps between bridges. The type of protector used for bridge piers in medians was noted — guardrail, earth mounds, and shrubs have been used; several had no protector. For bridges, the shoulder width, the existence of a curb or sidewalk, the type of protector at the median gap, and the traffic safety features were inventoried. Safety features consisted of the bridge-rail/guardrail transition, and guardrail end-treatment. Safety features had previously been rated as good or poor, and these ratings were verified. Bridge deck conditions had also been rated previously.

The number of signs (classified as breakaway, rigid, or protected) and nonbreakaway lighting standards were determined. The number of lighted interchanges was counted. Gore areas were classified as clear or the features in the gore were

noted. The features included exit signs (if not breakaway), lightposts, guardrail, or a combination of several features. Toll-booth protection was summarized. The lengths of all rock cuts and rock outcroppings closer than 30 feet (9.1 m) to the roadway were tabulated. Hazardous culvert headwalls were summarized. Median crossovers were counted. Crossovers were divided into those which were designed and those which had been created by frequent use. All features inventoried, with the exception of bridges, were summarized by mile. Photographs of various roadway features were taken and are presented in APPENDIX A.

Other Improvement Recommendations

Memos were sent to district engineers and division directors asking their recommendations for needed improvements on the toll roads. Recommendations for improvements at specific locations, as well as general improvements to certain roadway features, were received. All of these recommendations were considered for inclusion into the safety improvements for toll roads.

Determination of Benefits and Costs

To obtain a priority ranking of the recommended safety improvements, benefits and costs had to be assigned. The annual benefits were calculated based on the number of fatal, injury, and property-damage-only accidents which would be affected by the improvement, and the estimated percentage reduction for each of the types of accidents. Monetary benefits from the reduction in accidents were based on the following National Safety Council costs (1978) for various degrees of accident severity:

Fatality	$150,000
Injury	$ 5,800
Property-Damage-Only	$ 850

The percentage reductions were based on previous research findings for the type of improvements considered, as well as subjective opinions based on results of past safety improvement programs. The costs were the actual installation or construction costs of the improvement, plus the annual maintenance costs. The improvement cost was based on past unit price bids for the type of improvement, other research reports, and information from manufacturers of various safety devices.

The present worth of the benefits was calculated from a given interest rate, an exponential growth rate factor for traffic volume, and a service life for each improvement. Benefit-cost ratios were then determined for each improvement type.

Dynamic Programming

Multistage dynamic programming was used as the means of priority ranking the improvements. Using the present worth of the benefits and costs of the improvements, along with a specific program budget, the combination of improvements which would yield the greatest benefits was determined. Several theoretical budgets were input into the program, and the improvement types which would yield optimum results were output for each budget. Dynamic programming procedures used for priority ranking in this study were similar to those applied to Kentucky's High-Accident, Spot Improvement Program.[6]

Results

Accident Analyses

A search of the 1976-1978 accident reports disclosed a total of 2,044 accidents on the toll roads. The accidents were summarized by type for each toll road, as shown in Table 6. A large majority of the accidents (86 percent) was classified as mainline occurrences. The percentage of interchange-related accidents was much smaller (10 percent), while bridge-related accidents made up the smallest percentage (5 percent). The Pennyrile and Western Kentucky Parkways had the largest number of accidents, while

Table 6. Accident Summary by Type of Accident for Each Toll Road (1976-1978).

	Number of Accidents by Type			
Parkway	Mainline	Interchange Related	Bridge Related	Total
Mountain (Mtn)	316	16	18	350
Western Kentucky (WKy)	387	31	19	437
Bluegrass (BG)	210	11	19	240
Purchase (Pur)	70	14	3	87
Pennyrile (Pen)	385	38	23	446
Audubon (Aud)	39	10	4	53
Daniel Boone (DB)	128	41	1	170
Green River (GR)	159	19	9	187
Cumberland (Cum)	54	17	3	74
All	1748	197	99	2044

the Audubon, Cumberland, and Purchase Parkways had the fewest accidents.

A detailed analysis of accident rates is given in Table 7. The overall accident rate for all toll roads was 80 accidents per 100 million vehicle-miles (MVM) (160 million vehicle-kilometers (MVK)). This low rate is similar to the rate for rural interstates. Almost all of the toll roads are in rural areas, and only parts of some pass near the edges of cities. Therefore, the system was not divided into rural and urban sections. The highest accident rates in terms of accidents per 100 MVM (160 MVK) were for the Daniel Boone and Mountain Parkways. These are the only toll roads with two-lane sections, and the higher rates are probably related to the geometries of the road. The Daniel Boone Parkway is two-lane with truck-climbing or passing lanes. The lowest rate was on the Cumberland Parkway, which also had the lowest volume of traffic. The overall average volume for the toll roads was only 3,600 vehicles per day. The Pennyrile Parkway had the highest volume and also the highest number of accidents per mile. The Cumberland Parkway had the lowest number of accidents per mile.

Each accident was categorized into one of the three major divisions (mainline-related, interchange-related, and bridge-related). Summaries of the accidents in each category are given in Tables 8, 9, and 10.

Mainline accidents primarily involved vehicles running off the roadway or hitting a fixed object (Table 8). These are single-vehicle

Table 7. Accident Rate by Toll Road.

Parkway	Length Miles	Length km	Accidents per Year (1976-1978)	Vehicle Miles (100 million)	Average AADT (1977)	Accidents per 100 Million Vehicle Miles (160 million Vehicle kms)	Accidents per Mile (1.6 km)
Mtn	75.6	121.6	117	1.284	4650	91	1.5
WKy	133.1	214.2	146	1.866	3840	78	1.1
BG	71.1	114.4	80	1.015	3910	79	1.1
Pur	52.3	84.2	29	0.339	1770	86	0.6
Pen	71.4	114.9	149	1.740	6680	86	2.1
Aud	23.5	37.8	18	0.268	3130	67	0.8
DB	59.1	95.1	57	0.598	2770	95	1.0
GR	70.2	113.0	62	0.779	3040	80	0.9
Cum	88.5	142.4	25	0.549	1700	46	0.3
All	644.8	1037.5	681	8.438	3600	80	1.1

Table 8. Summary of Mainline Accidents

Directional Analysis	Number of Accidents	Percent of Total	Severity Index
Not Stated	4	0.2	3.83
Rear-End accident in traffic lane	152	8.7	2.84
Hit fixed object	390	22.3	3.06
Ran off roadway	453	25.9	2.89
Head-on collision	17	1.0	5.59
Sideswipe accident (same direction)	95	5.4	1.75
Sideswipe accident (opposite direction)	25	1.4	2.82
Pedestrian	1	0.1	3.50
One car entering driveway or alley	2	0.1	2.25
Entering or leaving parked position	3	0.2	4.67
Median cut accident	22	1.3	3.34
Wrong-way vehicle accident	8	0.5	4.06
Vehicle backing	7	0.4	2.21
Rear-end accident on shoulder	24	1.3	4.21
Other shoulder related accident	19	1.1	2.55
Animal related accident	182	10.4	1.36
Other	218	12.4	1.73
Parking lot	8	0.5	1.00
Toll Booth	118	6.8	1.67

accidents and were the predominant accident type on toll roads. Head-on collisions were the most severe, occurring primarily on the two-lane sections of road. Also, wrong-way-vehicle accidents involving a head-on collision on four-lane roads were very severe. Accidents involving a vehicle parked on the shoulder were also severe. There was a relatively large percentage (10 percent) of animal-related accidents, primarily involving deer. There was also a large number of accidents related to toll booths (7 percent).

Interchange-related accidents were divided into those occurring on the exit ramp, entrance ramp, or intersection of the ramp and cross-road (Table 9). More accidents occurred on the exit ramp than the entrance ramp, but the largest number occurred at the intersection of the ramp and the crossroad. Accidents there had to be directly related to the ramp to be included in this category. On entrance ramps, rear-end accidents occurred most often, followed by angle accidents between a vehicle leaving the ramp and a vehicle on the mainline. This indicates that merging created the largest number of accidents on entrance ramps. On exit ramps, most accidents were single-vehicle accidents on the ramp — the vehicle hit a fixed object in most cases. There were also several rear-end accidents on the exit ramp. In most cases, these were caused by drivers failing to properly decelerate when exiting. Most intersection accidents were angle accidents involving a vehicle turning onto or from a ramp.

Table 9. Summary of Interchange-Related Accidents.

Directional Analysis	Number of Accidents	Percent of Total	Severity Index
Entrance Ramp			
Not Stated	1	0.5	3.50
Rear-end accident on ramp	10	5.1	1.50
Angle accident between ramp vehicle and mainline vehicle	8	4.1	1.00
Sideswipe accident on ramp	3	1.5	1.00
Rear-end accident on mainline at ramp	2	1.0	1.00
Ramp vehicle hit fixed object	6	3.0	1.00
Ramp vehicle ran off road	6	3.0	2.67
Sideswipe accident between mainline vehicles	1	0.5	1.00
Other accidents related to entrance ramp	9	4.6	3.17
Exit Ramp			
Sideswipe accident related to ramp	3	1.5	1.00
Vehicle hit fixed object in gore	7	3.6	1.71
Ramp vehicle hit fixed object not in gore	21	10.7	1.12
Rear-end accident before ramp	3	1.5	1.83
Ramp vehicle ran off road	13	6.6	3.92
Other accidents related to exit ramp	17	8.6	1.44
Intersection			
Angle accident — both straight	23	11.7	2.35
Angle accident — one turning left	14	7.1	2.93
Angle accident — one turning right	9	4.6	1.28
Angle accident — other	2	1.0	2.25
Rear-end accident — both straight	4	2.0	1.62
Rear-end accident — one turning right	1	0.5	3.50
Rear-end accident — on ramp	12	6.1	1.21
Other rear end	1	0.5	1.00
Opposite direction — one turning left, one straight	2	1.0	1.00
Opposite direction — both going straight	4	2.0	3.12
Fixed Object	3	1.5	2.67
Single vehicle	2	1.0	1.00
Vehicle backing	1	0.5	1.00
Merging from ramp	5	2.5	2.00
Merging onto ramp	2	1.0	2.25
Other	2	1.0	2.25

The most common type of bridge-related accident involved a vehicle out of control and hitting the bridge rail or curb or running off the road past the bridge (Table 10). In many instances, these were related to adverse road surface conditions (ice). The next most common type involved hitting a bridge wingwall. These accidents were the result of the large number of older bridges that were constructed without full-width shoulders.

A separate analysis of rates was done for mainline-related, interchange-related, and bridge-related accidents. A summary of the mainline accident rate analysis is given in Table 11. Accident rates were calculated in terms of accidents per 1-mile (1.6-km) sections and 0.3-mile (0.5-km) spots. Also, spot and section rates were calculated using traffic volumes. The average mainline rate was lower than the overall rate for toll roads. Next, using Equation 1, the critical num-

Table 10. Summary of Bridge-Related Accidents.

Directional Analysis	Number of Accidents	Percent of Total	Severity Index
Hit bridge rail or curb	30	30.3	2.15
Hit bridge abutment	13	13.1	2.61
Rear-end accident	7	7.1	1.71
Ran off road after losing control on bridge	19	19.2	2.05
Head-on	2	2.0	6.50
Sideswipes –			
Opposite-direction	1	1.0	1.00
Same direction	5	5.1	3.20
Through or over bridge rail	3	3.0	6.67
Hit approach guardrail	9	9.1	2.89
Other bridge related accidents	10	10.1	1.50

Table 11. Mainline Accident Rate.*

Mainline Accidents per Year (1976-1978)	583
Total Miles	635.9
Accidents per Mile	0.9
Average AADT	3595
Accidents per 0.3 Mile (0.5 km) Spot	.27
Million Vehicles Per Year per Spot	1.312
Average Spot Accident Rate (Accidents per Million Vehicles)	0.21
Vehicle Miles Driven (100 Million)	8.343
Section Accident Rate (Accidents per 100 mvm)**	70

*Mainline excludes bridge-related and interchange-related accidents. Also, miles of bridges and vehicle-miles driven on bridges were excluded.

**A section is greater than 0.3 mile (0.5 km) in length.

ber of mainline-related accidents for the 3-year study period was calculated for 0.3-mile (0.5-km) spots and section lengths of 1 mile (1.6 km), 2 miles (3.2 km), 5 miles (8.0 km), and 10 miles (16 km) (Table 12). A computer program identified spots and sections having a critical number of accidents; these were analyzed further using Equation 2. Computer listings of these locations were made in order by critical rate factor. These listings, shown in Tables 13-17, give the high-accident spots and sections on the mainline. The most dangerous locations have the highest critical rate factors. More detailed accident analyses were done at those locations to determine the types of safety improvements that would alleviate the accident problems.

Table 12. Critical Number of Mainline Accidents (1976-1978).

Length		Number of Spots or Sections	Accidents per Spot or Section	Critical Number of Mainline Accidents in a 3-Year Period (1976-1978)
Miles	km			
0.3	0.5	2120	0.8	4
1	1.6	636	2.7	8
2	3.2	318	5.5	12
5	8.0	127	13.7	24
10	16	63.7	27.4	42

A summary of interchange accident rates is given in Table 18. The rate, critical rate, and critical rate factor were calculated for each interchange, and Table 19 provides a listing by critical rate factor. This table gives the location, interchange volume, total number of ramps, number of entrance ramps, number of exit ramps, number of accidents per ramp, and other rate information.

A summary of accident rates for bridges is given in Table 20. These rates, in terms of vehicle-miles, were very high. Table 21 lists the bridges by critical rate factor and gives the bridge location, its length, traffic volume, sufficiency rating, number of accidents, rate, critical rate, and critical rate factor. Only a few bridges had accumulated several accidents during the three-year study period. Three or more accidents had occurred on only eight bridges. No bridge had a critical rate factor of one or higher.

In addition to searching for specific high-accident locations, the analysis also included an investigation of roadway elements which contributed to either the occurrence of accidents or accident severity. To identify hazardous roadway elements, general summaries of accident information, as shown in Table 4, were prepared. One useful summary was a printout by type of collision, as shown in Table 22. The data there show that the most common types of fixed-object accidents involved either a guardrail, a rock cut, or an earth embankment. The data would enable calculation of the average number of a specific accident type in a given section length. The critical number of accidents for that section could then be calculated and a list of locations exceeding the critical number could be obtained. Similar types of analyses could be made using other summaries of data given in Table 4.

Table 13. Listing of 0.3-Mile (0.5-km) Spots in Order by Critical Rate Factor (CRF).

County	Route	Beginning Milepost	Ending Milepost	Number of Accidents	Number of Lanes	Class	Average Daily Traffic	Accident Rate	Critical Rate	CRF	EPDO
43	9001	106.900	107.100	14	4	6	3640	3.51	1.61	2.18	27.5
99	9000	32.800	33.000	12	4	6	5540	1.98	1.29	1.54	14.5
119	9000	38.000	38.200	12	4	6	6030	1.82	1.23	1.47	33.0
3	9002	58.700	58.900	10	4	6	5480	1.67	1.29	1.29	12.5
114	9007	7.400	7.600	7	4	6	2960	2.16	1.81	1.19	12.0
77	9000	72.200	72.400	6	4	6	2400	2.28	2.04	1.12	19.5
89	9001	57.900	58.100	7	4	6	3590	1.78	1.62	1.10	9.5
79	9003	42.600	42.800	5	4	6	1610	2.84	2.60	1.09	13.5
63	9006	7.000	7.200	7	4	6	3750	1.70	1.58	1.08	9.5
117	9004	62.500	62.700	7	4	6	4770	1.34	1.39	0.96	18.0
89	9001	63.900	64.100	6	4	6	3590	1.53	1.62	0.94	8.5
51	9005	10.100	10.300	5	4	6	3140	1.45	1.75	0.83	18.5
54	9004	37.000	37.200	9	4	6	10710	0.77	0.93	0.82	16.5
99	9000	21.000	21.200	7	4	6	6710	0.95	1.17	0.82	12.0
54	9001	24.300	24.500	5	4	6	3480	1.31	1.65	0.79	7.5
54	9001	32.900	33.100	5	4	6	3550	1.29	1.63	0.79	10.0
43	9001	91.800	92.000	5	4	6	3640	1.25	1.61	0.78	10.0
92	9001	75.000	75.200	5	4	6	3650	1.25	1.61	0.78	7.5
120	9002	63.000	63.200	6	4	6	5360	1.02	1.31	0.78	14.5
26	9006	33.800	34.000	4	4	6	2400	1.52	2.04	0.75	4.0
66	9006	42.000	42.200	4	4	6	2340	1.56	2.07	0.75	17.5
66	9006	43.900	44.100	4	4	6	2340	1.56	2.07	0.75	9.0
119	9000	53.900	54.100	4	4	6	2440	1.50	2.02	0.74	15.0
16	9007	28.700	28.900	4	4	6	2780	1.31	1.87	0.70	4.0
99	9000	14.600	14.800	6	4	6	6710	0.82	1.17	0.70	14.5
99	9000	15.000	15.200	6	4	6	6710	0.82	1.17	0.70	8.5
26	9006	14.800	15.000	4	4	6	3140	1.16	1.75	0.67	23.5
54	9004	28.900	29.100	5	4	6	5400	0.85	1.30	0.65	10.0
90	9002	9.500	9.700	4	4	6	3360	1.09	1.68	0.65	6.5
90	9002	11.500	11.700	4	4	6	3360	1.09	1.68	0.65	9.0
43	9001	18.800	19.000	4	4	6	3480	1.05	1.65	0.64	12.5
47	9002	3.000	3.200	4	4	6	3390	1.08	1.68	0.64	6.5
54	9004	38.900	39.100	7	4	6	10710	0.60	0.93	0.64	12.0
54	9004	39.700	39.900	7	4	6	10710	0.60	0.93	0.64	29.0
90	9002	36.900	37.100	4	4	6	3390	1.08	1.68	0.64	23.5
115	9002	41.700	41.900	4	4	6	3430	1.07	1.66	0.64	15.0
54	9004	54.900	55.100	5	4	6	5730	0.80	1.27	0.63	16.0
89	9001	45.900	46.100	4	4	6	3590	1.02	1.62	0.63	4.0
43	9001	99.000	99.200	4	4	6	3640	1.00	1.61	0.62	4.0
43	9001	112.800	113.000	4	4	6	3640	1.00	1.61	0.62	9.0
43	9001	115.000	115.200	4	4	6	3640	1.00	1.61	0.62	6.5
43	9001	118.300	118.500	4	4	6	3640	1.00	1.61	0.62	11.5
92	9001	75.500	75.700	4	4	6	3650	1.00	1.61	0.62	12.5
24	9004	7.000	7.200	5	4	6	6040	0.76	1.23	0.61	10.0
63	9006	2.300	2.500	4	4	6	3750	0.97	1.58	0.61	9.0
119	9000	36.800	37.000	5	4	6	6030	0.76	1.23	0.61	13.5
119	9000	38.300	38.500	5	4	6	6030	0.76	1.23	0.61	27.0

Table 13. Listing of 0.3-Mile (0.5-km) Spots in Order by Critical Rate Factor (CRF). *(Continued).*

County	Route	Beginning Milepost	Ending Milepost	Number of Accidents	Number of Lanes	Class	Average Daily Traffic	Accident Rate	Critical Rate	CRF	EPDO
25	9000	4.900	5.100	5	4	6	6470	0.71	1.19	0.59	21.0
25	9000	7.300	7.500	5	4	6	6470	0.71	1.19	0.59	18.5
25	9000	10.200	10.400	5	4	6	6470	0.71	1.19	0.59	16.0
24	9004	14.000	14.200	4	4	6	4240	0.86	1.48	0.58	12.5
99	9000	19.900	20.100	5	4	6	6710	0.68	1.17	0.58	5.0
99	9000	26.900	27.100	5	4	6	6710	0.68	1.17	0.58	16.0
51	9004	77.200	77.400	5	4	6	6900	0.66	1.15	0.57	5.0
63	9006	0.700	0.900	4	4	6	4665	0.78	1.41	0.56	6.5
24	9004	20.200	20.400	4	4	6	4690	0.78	1.40	0.55	9.0
24	9004	26.900	27.100	4	4	6	4690	0.78	1.40	0.55	9.0
54	9004	32.700	32.900	6	4	6	10710	0.51	0.93	0.55	19.5
54	9004	40.200	40.400	6	4	6	10710	0.51	0.93	0.55	14.5
54	9004	41.800	42.000	6	4	6	10710	0.51	0.93	0.55	17.0
117	9004	59.600	59.800	4	4	6	4770	0.77	1.39	0.55	21.0
117	9004	64.200	64.400	4	4	6	4770	0.77	1.39	0.55	11.5
51	9004	73.900	74.100	4	4	6	5450	0.67	1.30	0.52	23.5
54	9004	29.500	29.700	4	4	6	5400	0.68	1.30	0.52	6.5
3	9002	59.000	59.200	4	4	6	5480	0.67	1.29	0.51	4.0
99	9000	35.200	39.400	4	4	6	5540	0.66	1.29	0.51	4.0
99	9000	35.800	36.000	4	4	6	5540	0.66	1.29	0.51	17.5
47	9001	120.300	120.500	4	4	6	5900	0.62	1.25	0.50	6.5
47	9001	134.300	134.500	4	4	6	5900	0.62	1.25	0.50	6.5
25	9000	1.000	1.200	4	4	6	6470	0.56	1.19	0.47	17.5
25	9000	11.800	12.000	4	4	6	6590	0.55	1.18	0.47	9.0
54	9004	50.600	50.800	4	4	6	6630	0.55	1.18	0.47	6.5
54	9004	35.700	35.900	5	4	6	10710	0.43	0.93	0.46	7.5
54	9004	36.400	36.600	5	4	6	10710	0.43	0.93	0.46	7.5
54	9004	36.700	36.900	5	4	6	10710	0.43	0.93	0.46	16.0
54	9004	38.200	38.400	5	4	6	10710	0.43	0.93	0.46	10.0
54	9004	40.900	41.100	5	4	6	10710	0.43	0.93	0.46	16.0
54	9004	42.100	42.300	5	4	6	10710	0.43	0.93	0.46	7.5
54	9004	42.400	42.600	5	4	6	15150	0.30	0.80	0.38	7.5
54	9004	30.900	31.100	4	4	6	10710	0.34	0.93	0.36	20.0
54	9004	37.300	37.500	4	4	6	10710	0.34	0.93	0.36	6.5
54	9004	37.600	37.800	4	4	6	10710	0.34	0.93	0.36	15.0
54	9004	42.900	43.100	4	4	6	15150	0.24	0.80	0.30	12.5
54	9004	43.400	43.600	4	4	6	15150	0.24	0.80	0.30	12.5

Table 14. Listing of 1-Mile (1.6-km) Sections in Order by Critical Rate Factor (CRF).

County	Route	Beginning Milepost	Ending Milepost	Number of Accidents	Number of Lanes	Class	Average Daily Traffic	Accident Rate	Critical Rate	CRF	EPDO
43	9001	106900	107.800	16	4	6	3640	401.	295.	1.36	32.0
119	9000	37.400	38.300	19	4	6	6030	288.	238.	1.21	62.0
3	9002	58.700	59.600	16	4	6	5480	267.	247.	1.08	18.5
66	9006	43.400	44.300	9	4	6	2340	351.	362.	0.97	19.0
99	9000	32.100	33.000	14	4	6	5540	231.	246.	0.94	19.0
89	9001	57.200	58.100	9	4	6	3590	229.	296.	0.77	11.5
54	9004	37.100	38.000	17	4	6	10710	145.	192.	0.76	44.0
54	9004	28.900	29.800	11	4	6	5400	186.	249.	0.75	21.0
63	9006	7.000	7.900	9	4	6	3750	219.	291.	0.75	11.5
114	9007	6.800	7.700	9	4	6	4040	203.	281.	0.72	16.5
54	9004	41.500	42.400	16	4	6	10710	136.	192.	0.71	29.5
92	9001	75.100	76.000	8	4	6	3650	200.	294.	0.68	16.5
54	9004	36.100	37.000	15	4	6	10710	128.	192.	0.67	39.5
117	9004	61.800	62.700	9	4	6	4770	172.	262.	0.66	25.0
54	9004	38.200	39.100	14	4	6	10710	119.	192.	0.62	26.5
24	9004	27.900	28.800	9	4	6	5400	152.	249.	0.61	22.5
25	9000	9.500	10.400	10	4	6	6470	141.	231.	0.61	37.0
120	9002	63.000	63.900	9	4	6	5360	153.	250.	0.61	20.0
54	9004	39.300	40.200	13	4	6	10710	111.	192.	0.58	43.5
117	9004	59.600	60.500	8	4	6	4770	153.	262.	0.58	30.0
119	9000	36.400	37.300	9	4	6	6030	136.	238.	0.57	20.0
25	9000	1.000	1.900	9	4	6	6470	127.	231.	0.55	30.0
54	9004	49.900	50.800	9	4	6	6630	124.	229.	0.54	14.0
99	9000	15.000	15.900	9	4	6	6710	122.	228.	0.54	22.5
99	9000	20.500	21.400	9	4	6	6710	122.	228.	0.54	22.5
99	9000	35.200	36.100	8	4	6	5540	132.	246.	0.54	21.5
24	9004	9.100	10.000	8	4	6	6040	121.	238.	0.51	13.0
119	9000	42.000	42.900	8	4	6	6030	121.	238.	0.51	13.0
25	9000	0.0	0.900	8	4	6	6470	113.	231.	0.49	35.0
25	9000	8.300	9.200	8	4	6	6470	113.	231.	0.49	23.0
54	9004	40.400	41.300	10	4	6	10710	85.	192.	0.44	26.0
54	9004	34.000	34.900	9	4	6	10710	77.	192.	0.40	14.0
54	9004	35.100	36.000	9	4	6	10710	77.	192.	0.40	14.0
54	9004	32.000	32.900	8	4	6	10710	68.	192.	0.36	21.5
54	9004	33.000	33.900	8	4	6	10710	68.	192.	0.36	21.5
54	9004	42.500	43.400	8	4	6	15150	48.	171.	0.28	27.5

Table 15. Listing of 2-Mile (3.2-km) Sections in Order by Critical Rate Factor (CRF).

County	Route	Beginning Milepost	Ending Milepost	Accidents	Number of Lanes	Class	Average Daily Traffic	Accident Rate	Critical Rate	CRF	EPDO
43	9001	106.900	108.800	21	4	6	3640	263.	221.	1.19	53.0
119	9000	36.400	38.300	28	4	6	6030	212.	184.	1.15	82.0
54	9004	35.800	37.700	29	4	6	10710	124.	153.	0.81	61.0
24	9004	27.600	29.500	18	4	6	5400	152.	191.	0.80	47.5
97	9006	56.000	57.900	12	4	6	2790	196.	246.	0.80	62.0
99	9000	32.100	34.000	18	4	6	5540	148.	190.	0.78	34.0
114	9007	7.400	9.300	12	4	6	2960	185.	240.	0.77	25.5
3	9002	58.700	60.600	17	4	6	5480	142.	190.	0.74	22.0
92	9001	75.000	76.900	13	4	6	3650	163.	221.	0.74	32.5
90	9002	10.800	12.700	12	4	6	3360	163.	228.	0.72	28.0
25	9000	9.000	10.900	18	4	6	6470	127.	180.	0.71	68.5
25	9000	0.0	1.900	17	4	6	6470	120.	180.	0.67	65.0
54	9004	37.800	39.700	24	4	6	10710	102.	153.	0.67	56.0
43	9001	19.000	20.900	13	4	6	4770	124.	200.	0.62	23.0
99	9000	14.000	15.900	16	4	6	6710	109.	178.	0.61	38.0
99	9000	34.200	36.100	14	4	6	5540	115.	190.	0.61	38.5
24	9004	25.500	27.500	12	4	6	4690	117.	201.	0.58	36.5
54	9004	41.800	43.700	24	4	6	12930	85.	145.	0.58	57.0
54	9004	49.900	51.800	15	4	6	6630	103.	178.	0.58	31.0
117	9004	59.300	61.200	12	4	6	4770	115.	200.	0.57	36.5
54	9004	39.800	41.700	19	4	6	10710	81.	153.	0.53	65.5
120	9002	63.000	64.900	12	4	6	5360	102.	192.	0.53	28.0
54	9004	33.800	35.700	17	4	6	10710	72.	153.	0.47	29.5
51	9004	76.800	78.700	12	4	6	6900	79.	176.	0.45	31.5
54	9004	31.800	33.700	16	4	6	10710	68.	153.	0.44	40.5
54	9004	43.900	45.800	14	4	6	11920	54.	149.	0.36	35.0
54	9004	29.600	31.500	12	4	6	10710	51.	153.	0.33	38.0

Table 16. Listing of 5-Mile (8.0-km) Sections in Order by Critical Rate Factor (CRF).

County	Route	Beginning Milepost	Ending Milepost	Number of Accidents	Number of Lanes	Class	Average Daily Traffic	Accident Rate	Critical Rate	CRF	EPDO
99	9000	32.100	37.000	40	4	6	5540	132.	143.	0.92	89.0
54	9004	33.300	38.200	58	4	6	10710	99.	121.	0.82	135.5
54	9004	38.300	43.200	56	4	6	10710	96.	121.	0.79	137.0
43	9001	106.900	111.800	24	4	6	3640	120.	161.	0.75	56.0
119	9000	37.200	42.100	32	4	6	6030	97.	140.	0.69	102.0
24	9004	23.300	28.200	25	4	6	4690	97.	150.	0.65	77.5
117	9004	58.000	62.900	25	4	6	4770	96.	149.	0.64	65.5
25	9000	10.100	15.000	31	4	6	6590	86.	136.	0.63	85.0
3	9002	57.100	62.000	25	4	6	5480	83.	143.	0.58	37.5
25	9000	0.0	4.900	27	4	6	6470	76.	137.	0.56	102.0
54	9004	28.300	33.200	37	4	6	10710	63.	121.	0.52	86.5
25	9000	5.000	9.900	24	4	6	6470	68.	137.	0.49	71.0
54	9004	43.400	48.300	26	4	6	9275	51.	125.	0.41	69.0

Table 17. Listing of 10-Mile (16-km) Sections in Order by Critical Rate Factor (CRF).

County	Route	Beginning Milepost	Ending Milepost	Number of Accidents	Number of Lanes	Class	Average Daily Traffic	Accident Rate	Critical Rate	CRF	EPDO
99	9000	30.600	40.500	71	4	6	5785	112.	119.	0.94	185.0
43	9001	106.900	116.800	43	4	6	3640	108.	133.	0.81	96.0
24	9004	27.200	37.100	88	4	6	10710	75.	106.	0.71	212.5
117	9004	57.300	67.200	46	4	6	4770	88.	125.	0.71	115.0
54	9004	37.300	47.200	92	4	6	12930	65.	102.	0.63	238.0
25	9000	0.0	9.900	51	4	6	6470	72.	116.	0.62	173.0
25	9000	10.100	20.000	51	4	6	6710	69.	116.	0.60	123.5
51	9004	67.400	77.300	42	4	6	5450	70.	121.	0.58	124.0

Table 18. Interchange Accident Rate.*

Interchange-Related accidents per year (1976-1978)	65.7
Total number of interchanges	96
Accidents per interchange	0.68
Critical number of accidents per interchange (P=99.5)	4
Interchanges per mile	0.15
Average interchange volume	4850
Accidents per million vehicles	0.38

* Includes at-grade intersections on some parkways; does not include interchanges under construction or recently completed where accident data would not exist.

Table 19. Analysis of Interchange Data.

County	Route	Milepost	Number of Accidents	Inter-change ADT	Type	Number of Ramps	Accident Rate	Critical Rate	CRF	Accidents per Ramp	Entrance	Exit	Cross Road
63	9006	3.0	13	3750	5	0	3.17	2.13	1.49	0.00	0.00	0.00	KY 472
100	9008	87.9	10	3600	5	0	2.54	2.17	1.17	0.00	0.00	0.00	Ringo Road
63	9006	0.0	12	5580	5	0	1.96	1.76	1.11	0.00	0.00	0.00	US 25
79	9003	52.3	6	1610	5	0	3.40	3.34	1.02	0.00	0.00	0.00	US 62
30	9005	23.5	7	3517	1	4	1.82	2.20	0.83	1.75	1.50	2.00	US 60 Bypass
47	9001	136.8	11	9834	4	4	1.02	1.38	0.74	2.75	2.00	3.50	I-65
24	9004	7.0	8	6584	10	3	1.11	1.64	0.68	2.67	5.00	1.50	US 41A
25	9000	0.0	7	6858	9	2	0.93	1.61	0.58	3.50	1.00	6.00	I-64
97	9006	59.1	4	2790	5	0	1.31	2.48	0.53	0.00	0.00	0.00	KY 15
114	9007	3.6	5	4525	3	4	1.01	1.94	0.52	1.25	0.50	2.00	US 31W
30	9007	70.2	6	6451	1	4	0.85	1.65	0.51	1.50	0.50	2.50	US 60 Bypass
42	9003	24.7	3	2025	6	2	1.35	2.94	0.46	1.50	2.00	1.00	US 45
47	9001	136.8	6	8780	5	0	0.62	1.44	0.43	0.00	0.00	0.00	US 31W
54	9004	44.3	9	16968	3	4	0.48	1.12	0.43	2.25	1.00	3.50	KY 281
28	9006	20.5	3	2688	3	4	1.02	2.52	0.40	0.75	1.00	0.50	US 421

Table 19. Analysis of Interchange Data. *(Continued).*

County	Route	Milepost	Number of Accidents	Inter-change ADT	Type	Number of Ramps	Accident Rate	Critical Rate	CRF	Accidents per Ramp	Entrance	Exit	Cross Road
51	9005	0.0	3	3517	1	4	0.78	2.20	0.35	0.75	0.00	1.50	Pennyrile Pkwy
47	9002	0.0	3	3797	1	4	0.72	2.12	0.34	0.75	1.00	0.50	I-65
54	9004	42.4	7	16968	3	4	0.38	1.12	0.34	1.75	2.00	1.50	KY 70
63	9006	2.3	3	3750	5	0	0.73	2.13	0.34	0.00	0.00	0.00	KY 638
42	9003	22.2	2	1770	3	4	1.03	3.17	0.33	0.50	1.00	0.00	KY 80
92	9001	76.8	3	4526	11	8	0.61	1.94	0.31	0.38	0.25	0.50	Green River
114	9007	0.0	3	5188	1	4	0.53	1.82	0.29	0.75	1.00	0.50	I-65
88	9000	59.2	2	2491	6	2	0.73	2.63	0.28	1.00	1.00	1.00	KY 134
5	9008	0.0	2	2632	1	4	0.69	2.55	0.27	0.50	0.00	1.00	I-65
5	9008	11.4	2	2845	3	4	0.64	2.45	0.26	0.50	0.50	0.50	US31E
24	9004	7.9	3	6765	3	4	0.40	1.82	0.25	0.75	0.00	1.50	US 41
92	9007	41.3	2	3348	11	8	0.55	2.25	0.24	0.25	0.00	0.50	WK Pkwy
90	9002	24.5	2	3593	6	2	0.51	2.18	0.23	1.00	1.00	1.00	US 150
51	9004	77.2	3	7728	1	4	0.35	1.53	0.23	0.75	0.50	1.00	Audubon Pkwy
63	9006	0.8	2	3750	5	0	0.49	2.13	0.23	0.00	0.00	0.00	Moren Rd (KY 1769)
63	9006	1.2	2	3750	5	0	0.49	2.13	0.23	0.00	0.00	0.00	KY 754
100	9008	88.5	2	3600	5	0	0.51	2.17	0.23	0.00	0.00	0.00	KY 80 Bypass
89	9001	57.9	2	4021	4	4	0.45	2.06	0.22	0.50	0.50	0.50	US 431
43	9001	107.0	2	4077	4	4	0.45	2.04	0.22	0.50	0.50	0.50	KY 259
47	9001	135.8	3	9307	6	2	0.29	1.41	0.21	1.50	1.00	2.00	US 31 Bypass
3	9002	47.8	2	4278	3	4	0.43	2.00	0.21	0.50	0.00	1.00	KY 53
3	9002	58.8	2	6138	4	4	0.30	1.69	0.18	0.50	0.50	0.50	US 127
119	9000	43.1	2	6392	9	2	0.29	1.66	0.17	1.00	1.00	1.00	KY 15
104	9008	62.4	1	1624	4	4	0.56	3.32	0.17	0.25	0.50	0.00	US 127 Bypass
99	9000	22.3	2	7515	3	4	0.24	1.54	0.16	0.50	0.50	0.50	KY 213
42	9003	23.7	1	2139	3	4	0.43	2.85	0.15	0.25	0.00	0.50	KY 121
26	9006	34.3	1	2400	5	0	0.38	2.68	0.14	0.00	0.00	0.00	KY 66
97	9006	56.4	1	3125	3	4	0.29	2.33	0.13	0.25	0.00	0.00	KY 451
16	9007	26.4	1	3114	3	4	0.29	2.34	0.13	0.25	0.50	0.00	US 231
72	9001	3.7	1	3898	3	4	0.25	2.15	0.12	0.25	0.00	0.50	US 62
17	9001	11.7	1	3438	3	4	0.27	2.22	0.12	0.25	0.00	0.50	KY91
38	9003	0.5	1	3551	6	2	0.28	2.19	0.12	0.50	0.00	1.00	KY 166
54	9004	37.1	2	11995	8	4	0.15	1.27	0.12	0.50	0.00	1.00	KY 813
54	9004	45.2	2	12635	6	2	0.14	1.25	0.12	1.00	1.00	1.00	US 41
114	9007	7.4	1	3315	4	4	0.28	2.27	0.12	0.25	0.50	0.00	US 231
89	9001	38.3	1	4402	11	8	0.21	1.97	0.11	0.13	0.00	0.25	Pennyrile Pkwy
92	9001	74.6	1	4088	3	4	0.22	2.04	0.11	0.25	0.50	0.00	US 231
90	9002	9.5	1	3763	8	4	0.24	2.13	0.11	0.25	0.00	0.50	KY 52
90	9002	20.5	1	3763	3	4	0.24	2.13	0.11	0.25	0.00	0.50	US 31E
38	9003	1.4	1	3752	3	4	0.24	2.13	0.11	0.25	0.50	0.00	US 51
114	9007	5.0	1	4525	3	4	0.20	1.94	0.10	0.25	0.00	0.50	US 68
99	9000	32.8	1	6205	4	4	0.15	1.68	0.09	0.25	0.50	0.00	KY 11
51	9004	68.4	1	5777	6	2	0.16	1.73	0.09	0.50	0.00	1.00	KY 416 Toll Ramp
99	9000	16.4	1	7515	3	4	0.12	1.54	0.08	0.25	0.00	0.50	KY 15
99	9000	18.5	1	7113	6	2	0.13	1.58	0.08	0.50	1.00	0.00	KY 1057
24	9004	9.4	1	6765	3	4	0.13	1.62	0.08	0.25	0.00	0.50	US 68
51	9004	78.4	1	7314	3	2	0.12	1.56	0.08	0.50	0.00	1.00	US 41 End SB Lanes
54	9004	34.3	1	13280	11	8	0.07	1.22	0.06	0.13	0.00	0.25	WK Pkwy
119	9000	40.5	0	6754	3	4	0.00	1.62	0.00	0.00	0.00	0.00	KY 15
119	9000	46.2	0	2440	5	0	0.00	2.66	0.00	0.00	0.00	0.00	KY 191
119	9000	53.3	0	2733	3	4	0.00	2.50	0.00	0.00	0.00	0.00	KY 1010
119	9000	57.2	0	2733	3	4	0.00	2.50	0.00	0.00	0.00	0.00	KY 205
77	9000	71.7	0	2688	1	4	0.00	2.52	0.00	0.00	0.00	0.00	KY 30
77	9000	74.7	0	2688	8	4	0.00	2.52	0.00	0.00	0.00	0.00	KY 7
77	9000	75.6	0	2460	5	0	0.00	2.64	0.00	0.00	0.00	0.00	KY 114
54	9001	24.4	0	3898	4	4	0.00	2.09	0.00	0.00	0.00	0.00	KY 109
43	9001	94.2	0	4077	3	4	0.00	2.04	0.00	0.00	0.00	0.00	KY 79
90	9002	33.3	0	3797	4	4	0.00	2.12	0.00	0.00	0.00	0.00	KY 55
115	9002	41.4	0	3842	3	4	0.00	2.11	0.00	0.00	0.00	0.00	KY 555
120	9002	68.2	0	5682	6	2	0.00	1.75	0.00	0.00	0.00	0.00	KY 33

Table 19. Analysis of Interchange Data. *(Continued).*

County	Route	Milepost	Number of Accidents	Inter-change ADT	Type	Number of Ramps	Accident Rate	Critical Rate	CRF	Accidents per Ramp	Entrance	Exit	Cross Road
120	9002	71.1	0	6003	1	4	0.00	1.70	0.00	0.00	0.00	0.00	US 60
38	9003	2.5	0	2699	3	4	0.00	2.52	0.00	0.00	0.00	0.00	KY 307
42	9003	13.6	0	1770	4	4	0.00	3.17	0.00	0.00	0.00	0.00	KY 339
42	9003	21.3	0	1770	1	4	0.00	3.17	0.00	0.00	0.00	0.00	US 45 Bypass
79	9003	42.6	0	1803	4	4	0.00	3.13	0.00	0.00	0.00	0.00	KY 348
79	9003	47.0	0	1707	6	2	0.00	3.23	0.00	0.00	0.00	0.00	US 68
24	9004	11.7	0	4749	4	4	0.00	1.90	0.00	0.00	0.00	0.00	KY 1682
24	9004	22.7	0	5253	3	4	0.00	1.81	0.00	0.00	0.00	0.00	KY 800
54	9004	29.6	0	5724	6	2	0.00	1.74	0.00	0.00	0.00	0.00	US 41
54	9004	32.9	0	11995	3	4	0.00	1.27	0.00	0.00	0.00	0.00	US 62
54	9004	49.0	0	7028	6	2	0.00	1.59	0.00	0.00	0.00	0.00	KY 260
54	9004	54.1	0	7493	3	4	0.00	1.55	0.00	0.00	0.00	0.00	KY 138 Toll Ramps
117	9004	62.6	0	5342	4	4	0.00	1.80	0.00	0.00	0.00	0.00	KY 56
551	9005	10.2	0	3517	4	4	0.00	2.20	0.00	0.00	0.00	0.00	KY 416
66	9006	44.2	0	2200	5	0	0.00	2.81	0.00	0.00	0.00	0.00	KY 118
18	9007	33.8	0	3024	4	4	0.00	2.37	0.00	0.00	0.00	0.00	US 231
92	9007	47.8	0	3214	4	4	0.00	2.30	0.00	0.00	0.00	0.00	KY 69
6	9008	14.0	0	2845	3	4	0.00	2.45	0.00	0.00	0.00	0.00	KY 90
85	9008	27.4	0	1590	4	4	0.00	3.36	0.00	0.00	0.00	0.00	US 68
1	9008	48.9	0	1613	3	4	0.00	3.34	0.00	0.00	0.00	0.00	KY 55
100	9008	87.5	0	3600	5	0	0.00	2.17	0.00	0.00	0.00	0.00	To KY 80

Average ADT for 96 records was 4847.

Table 20. Accident Rate on Bridges

Bridge-related accidents per year (1976-1978)	32
Total number of bridges	197
Accidents per bridge	0.16
Critical number of accidents per bridge (P=99.5)	2
Average AADT	3810
Accidents per bridge per million vehicles	0.12
Average length per bridge (feet)	240
Total length of bridge (miles)	9.0
Vehicle miles driven on bridge (100 million)	0.125
Accidents per 100 million vehicle miles	256

Table 21. Analysis of Bridge Data.

County	Route	Milepost	Volume	Bridge Length	Sufficiency Rating	Number of Accidents	Accident Rate	Critical Accident Rate	CRF	Underpass
Ohio	9001	76.8	3650	249	71.9	4	21.22	27.09	0.78	Green River Pkwy
Anderson	9002	61.8	5480	1088	62.6	9	7.28	10.26	0.71	Kentucky River
Hopkins	9004	32.3	10710	156	67.1	4	11.54	19.12	0.60	White Plains Road
Nelson	9002	39.2	3390	330	60.7	3	12.93	23.96	0.54	Chaplin River
Butler	9007	32.6	2700	780	69.2	4	9.16	16.89	0.54	Green River
Wolfe	9000	56.8	2440	159	77.5	2	24.86	46.55	0.53	Red River
Hopkins	9004	43.4	15150	159	67.3	4	8.01	15.75	0.51	L & N Railroad
Anderson	9002	51.8	3820	126	78.5	2	20.04	40.34	0.50	Cheeselick Pond
Hopkins	9001	43.4	3550	205	65.1	2	13.25	31.01	0.43	Pond River
Hopkins	9004	29.4	4754	157	91.7	2	12.92	30.53	0.43	Drakes Creek
Warren	9007	13.5	2960	260	67.2	2	12.53	29.96	0.42	Gasper River
Hopkins	9001	38.3	3550	226	66.7	2	12.02	29.21	0.41	Pennyrile Parkway
Clark	9000	9.8	6470	159	64.8	2	9.37	25.17	0.37	Upper Howards Creek
Hopkins	9004	32.6	10710	275	63.0	3	4.91	14.23	0.35	ICRR, Pleasant Run
Henderson	9005	15.8	3140	942	61.9	3	4.89	14.20	0.34	Green River
Metcalfe	9008	24.1	1420	128	77.1	1	26.53	79.37	0.33	KY 640
Graves	9003	34.3	1680	132	78.1	1	21.74	68.69	0.32	KY 564
Nelson	9002	21.5	3360	474	64.0	2	6.06	19.63	0.31	Beech Fork
Webster	9004	59.3	4770	368	59.7	2	5.49	18.61	0.30	Deer Creek
Graves	9003	17.8	1580	211	78.1	1	14.46	51.59	0.28	Opossum Creek
Clark	9000	0.1	6470	336	67.0	2	4.44	16.61	0.27	I 64
Magoffin	9000	66.5	2400	159	75.7	1	12.64	47.07	0.27	Johnson Fork
Magoffin	9000	74.8	2400	161	75.2	1	12.48	46.67	0.27	KY 7
Magoffin	9000	75.3	2460	159	78.7	1	12.33	46.29	0.27	Burning Fork
Morgan	9000	63.0	2350	180	74.7	1	11.40	43.93	0.26	Johnson Fork
Magoffin	9000	64.5	2400	172	77.0	1	11.68	44.65	0.26	Johnson Fork, KY 604
Muhlenberg	9001	59.2	3590	120	84.9	1	11.19	43.40	0.26	Mine Haul
Ohio	9001	85.7	3650	116	79.1	1	11.39	43.90	0.26	Arnold-Butler Road
Grayson	9001	99.1	3640	119	76.5	1	11.13	43.25	0.26	Millwood-Pleasant View Road
Butler	9007	27.4	2780	160	66.7	1	10.84	42.49	0.26	KY 70
Barren	9008	9.0	2350	174	64.3	1	11.79	44.94	0.26	KY 1297
Graves	9003	9.1	1580	310	87.2	1	9.84	39.89	0.25	Bayou de Chien
Magoffin	9000	66.1	2400	212	74.7	1	9.48	38.91	0.24	Johnson Fork, KY 134
Clay	9006	20.7	2400	224	67.9	1	8.97	37.55	0.24	Horse Creek
Butler	9007	26.1	2780	180	67.7	1	9.64	39.33	0.24	US 231
Muhlenberg	9001	56.0	3590	161	60.4	1	8.34	35.84	0.23	US 62
Hopkins	9004	39.8	10710	265	69.1	2	3.40	14.50	0.23	CRR, McCrew Lane
Henderson	9005	0.1	3140	191	77.0	1	8.04	35.01	0.23	Pennyrile Parkway
Magoffin	9000	70.2	2400	281	75.0	1	7.15	32.52	0.22	Middle Fork Creek
Muhlenberg	9001	65.4	3590	1813	77.7	3	2.22	9.88	0.22	Green River
Hopkins	9004	37.0	10710	318	77.1	2	2.83	13.26	0.21	KY 813
Webster	9004	56.5	4770	163	74.1	1	6.20	29.77	0.21	KY 147
Anderson	9002	58.0	5480	162	71.7	1	5.43	27.47	0.20	Southern Railroad
Hopkins	9001	28.3	3550	278	57.1	1	4.89	25.79	0.19	KY 112
Hardin	9001	132.6	5900	173	63.5	1	4.72	25.28	0.19	L & N Railroad
Powell	9000	32.1	5540	208	53.8	1	4.18	23.56	0.18	KY 11 & KY 15
Hopkins	9004	49.0	6630	161	75.7	1	4.52	24.63	0.18	KY 260
Daviess	9007	70.2	5760	189	61.1	1	4.43	24.35	0.18	Owensboro Beltline
Clark	9000	2.5	6470	195	63.8	1	3.82	22.36	0.17	Marris Road
Hardin	9001	132.5	5900	210	59.7	1	3.89	22.59	0.17	Valley Creek
Woodford	9002	71.1	5360	236	57.1	1	3.81	22.33	0.17	US 60
Webster	9004	63.9	4770	260	59.7	1	3.89	22.58	0.17	Graves Creek
Powell	9000	11.9	6710	204	49.3	1	3.52	21.35	0.16	Lulbegrud Creek
Nelson	9002	17.6	3360	465	57.3	1	3.09	19.83	0.16	Beech Fork River
Clark	9000	3.6	6470	253	59.8	1	2.95	19.33	0.15	C & O Railroad
Hopkins	9001	36.9	3550	448	60.4	1	3.03	19.64	0.15	US 41-A
Hopkins	9004	42.4	10710	192	78.0	1	2.34	17.10	0.14	KY 70, KY 85
Powell	9000	18.2	6710	341	49.4	1	2.11	16.17	0.13	Red River
Pulaski	9008	84.3	3130	1746	69.3	1	0.88	10.66	0.08	Fishing Creek
Clark	9000	5.3	6470	199	64.8	0	0.00	22.10	0.00	Stoner-Ephesus Road

Table 21. Analysis of Bridge Data. *(Continued).*

County	Route	Milepost	Volume	Bridge Length	Sufficiency Rating	Number of Accidents	Accident Rate	Critical Accident Rate	CRF	Underpass
Powell	9000	22.3	6710	159	61.4	0	0.00	24.63	0.00	KY 213
Powell	9000	24.8	6710	460	49.5	0	0.00	13.91	0.00	Red River
Powell	9000	26.1	6710	114	82.0	0	0.00	30.07	0.00	Cane Creek
Powell	9000	27.4	6710	114	81.5	0	0.00	30.07	0.00	KY 613
Powell	9000	27.9	6710	225	56.8	0	0.00	20.21	0.00	North Fork Red River
Powell	9000	31.2	5540	159	63.9	0	0.00	27.60	0.00	KY 77
Powell	9000	32.0	5030	207	49.5	0	0.00	24.99	0.00	Middle Fork Red River
Powell	9000	32.7	5540	159	64.9	0	0.00	27.60	0.00	Middle Fork Red River
Powell	9000	32.8	5540	159	58.2	0	0.00	27.60	0.00	KY 11 – Toll Plaza
Wolfe	9000	40.5	2440	159	69.2	0	0.00	46.55	0.00	KY 15
Wolfe	9000	43.8	2440	275	57.8	0	0.00	32.62	0.00	Swift Creek Camp Road
Wolfe	9000	46.2	2440	203	67.0	0	0.00	39.60	0.00	KY 191
Wolfe	9000	48.6	2440	172	75.1	0	0.00	44.16	0.00	Baptist Creek Road
Wolfe	9000	49.7	2440	188	65.7	0	0.00	41.64	0.00	KY 1812
Wolfe	9000	55.4	2440	159	73.3	0	0.00	46.55	0.00	Gilmore Road
Wolfe	9000	57.2	2440	120	80.4	0	0.00	56.43	0.00	KY 205
Morgan	9000	60.4	2350	159	82.6	0	0.00	47.74	0.00	KY 134
Morgan	9000	62.1	2350	186	68.6	0	0.00	42.99	0.00	KY 134
Magoffin	9000	65.2	2400	192	74.7	0	0.00	41.51	0.00	Johnson Fork, KY 3047
Magoffin	9000	65.9	2400	159	78.3	0	0.00	47.07	0.00	Johnson Fork Creek
Magoffin	9000	66.2	2400	192	75.7	0	0.00	41.51	0.00	Johnson Fork, KY 134
Magoffin	9000	67.5	2400	159	75.7	0	0.00	47.07	0.00	Johnson Creek
Magoffin	9000	67.6	2400	114	87.5	0	0.00	59.17	0.00	Cow Creek
Magoffin	9000	71.7	2400	159	75.9	0	0.00	47.07	0.00	KY 30
Magoffin	9000	74.5	2400	417	64.5	0	0.00	25.58	0.00	Licking River
Lyon	9001	3.7	3300	226	73.3	0	0.00	30.55	0.00	US 62
Caldwell	9001	11.4	3070	189	64.5	0	0.00	35.76	0.00	ICRR
Caldwell	9001	21.7	3480	207	47.8	0	0.00	31.21	0.00	Tradewater River
Hopkins	9001	22.0	3480	215	63.6	0	0.00	30.49	0.00	Tradewater River
Hopkins	9001	24.9	3480	131	75.7	0	0.00	41.81	0.00	ICRR
Hopkins	9001	33.9	3550	260	47.3	0	0.00	26.84	0.00	Oak Hills Road, ICRR
Hopkins	9001	40.3	3550	415	67.1	0	0.00	20.49	0.00	Drakes Creek
Hopkins	9001	42.8	3550	165	69.1	0	0.00	35.54	0.00	Pond River Relief
Muhlenberg	9001	43.6	3590	165	60.4	0	0.00	35.29	0.00	Pond River Relief
Muhlenberg	9001	48.0	3590	235	56.1	0	0.00	28.33	0.00	KY I 75; ICRR
Muhlenberg	9001	52.5	3590	179	52.5	0	0.00	33.51	0.00	KY 181
Muhlenberg	9001	55.5	3590	263	60.4	0	0.00	26.48	0.00	ICR R
Muhlenberg	9001	57.6	3590	169	49.7	0	0.00	34.75	0.00	L & N Railroad
Ohio	9001	69.7	3650	120	83.1	0	0.00	42.93	0.00	Lewis Creek
Ohio	9001	72.4	3650	186	55.3	0	0.00	32.38	0.00	KY 369
Ohio	9001	74.6	3650	128	77.9	0	0.00	41.14	0.00	US 231
Grayson	9001	103.9	3640	156	52.1	0	0.00	36.25	0.00	KY 187
Hardin	9001	130.9	5900	130	78.5	0	0.00	30.02	0.00	Rhodes Creek
Hardin	9001	136.5	8780	206	67.0	0	0.00	18.31	0.00	I 65
Hardin	9001	136.5	8780	206	59.7	0	0.00	18.31	0.00	I 65
Hardin	9002	0.0	3390	226	55.2	0	0.00	30.04	0.00	I 65
Nelson	9002		3360	300	62.4	0	0.00	25.47	0.00	Rolling Fork River
Nelson	9002	9.5	3360	108	76.6	0	0.00	49.32	0.00	KY 52
Nelson	9002	10.2	3360	166	62.4	0	0.00	36.67	0.00	L & N Railroad
Nelson	9002	11.9	3360	313	61.4	0	0.00	24.84	0.00	Beech Fork River
Nelson	9002	23.4	3360	109	75.1	0	0.00	48.39	0.00	Bardstown-Loretto Rd.
Nelson	9002	27.3	3390	159	67.0	0	0.00	37.49	0.00	L & N Railroad
Washington	9002	42.1	3430	489	63.7	0	0.00	19.08	0.00	
Mercer	9002	56.3	4500	200	68.0	0	0.00	27.25	0.00	Salt River
Fulton	9003	0.0	3350	153	69.1	0	0.00	38.73	0.00	KY 116
Fulton	9003	0.9	3350	146	69.1	0	0.00	39.92	0.00	KY 166
Fulton	9003	1.8	3350	539	70.1	0	0.00	18.33	0.00	ICRR
Graves	9003	12.8	1580	127	93.0	0	0.00	73.83	0.00	Brush Creek
Graves	9003	16.7	1580	208	78.1	0	0.00	52.10	0.00	Obion Creek
Graves	9003	21.3	1580	208	53.8	0	0.00	52.10	0.00	Mayfield Bypass

Table 21. Analysis of Bridge Data. *(Continued).*

County	Route	Milepost	Volume	Bridge Length	Sufficiency Rating	Number of Accidents	Accident Rate	Critical Accident Rate	CRF	Underpass
Graves	9003	24.7	1910	283	77.0	0	0.00	37.42	0.00	US 45
Graves	9003	25.1	1910	172	78.1	0	0.00	52.12	0.00	ICRR
Graves	9003	25.4	1680	208	78.1	0	0.00	49.96	0.00	Mayfield Creek
Graves	9003	25.6	1680	97	78.1	0	0.00	86.03	0.00	Mayfield Creek Overflow
Graves	9003	25.8	1680	97	78.1	0	0.00	86.03	0.00	Mayfield Creek Overflow
Graves	9003	31.4	1680	189	78.1	0	0.00	53.35	0.00	Panther Creek
Graves	9003	31.6	1680	97	78.1	0	0.00	86.03	0.00	Panther Creek Overflow
Graves	9003	33.5	1680	97	78.1	0	0.00	86.03	0.00	Clarks River Overflow
Graves	9003	33.7	1680	208	78.1	0	0.00	49.96	0.00	West Fork Clarks River
Graves	9003	34.0	1680	108	78.1	0	0.00	79.47	0.00	Clarks River Overflow
Marshall	9003	42.7	1610	158	73.1	0	0.00	62.29	0.00	LC & STL Railroad
Marshall	9003	43.3	1610	291	73.7	0	0.00	41.06	0.00	Clarks River Relief
Marshall	9003	43.6	1610	591	73.5	0	0.00	28.50	0.00	East Fork Clarks River
Marshall	9003	43.9	1610	387	68.5	0	0.00	34.17	0.00	Clarks River Relief
Christian	9004	6.8	6040	247	78.9	0	0.00	20.35	0.00	US 41A
Christian	9004	7.5	6040	155	94.5	0	0.00	26.61	0.00	L & N Railroad
Christian	9004	7.9	6040	203	95.0	0	0.00	22.73	0.00	US 41
Christian	9004	8.6	6040	151	94.6	0	0.00	27.03	0.00	South Fork Little River
Christian	9004	9.7	6040	64	79.4	0	0.00	46.66	0.00	First Street
Hopkins	9004	30.3	10710	165	78.3	0	0.00	18.54	0.00	Crab Orchard Creek
Hopkins	9004	31.3	10710	99	84.1	0	0.00	24.72	0.00	Pleasant Hill Road
Hopkins	9004	48.8	6630	144	76.7	0	0.00	26.30	0.00	Otter Creek
Hopkins	9004	54.1	6690	174	77.2	0	0.00	23.42	0.00	KY 138
Webster	9004	60.5	4770	166	64.8	0	0.00	29.44	0.00	KY 370
Henderson	9004	65.4	5450	183	90.8	0	0.00	25.63	0.00	Access Road
Henderson	9004	75.4	5450	141	76.8	0	0.00	29.99	0.00	Elam Ditch
Henderson	9005	6.3	3140	70	76.5	0	0.00	69.13	0.00	Lick Creek
Daviess	9005	22.7	3140	140	73.5	0	0.00	42.82	0.00	Worthington Road
Daviess	9005	23.4	3140	189	55.8	0	0.00	35.25	0.00	Owensboro Beltline
Laurel	9006	0.8	3750	217	79.7	0	0.00	28.96	0.00	L & N Railroad
Laurel	9006	3.4	3750	85	84.7	0	0.00	53.21	0.00	Little Laurel River
Laurel	9006	4.2	3750	168	79.9	0	0.00	34.19	0.00	Sallys Branch Road
Laurel	9006	6.4	3750	126	81.9	0	0.00	40.84	0.00	KY 1305
Laurel	9006	7.6	3750	126	81.5	0	0.00	40.84	0.00	Lick Creek Road
Laurel	9006	8.6	3140	130	81.5	0	0.00	44.99	0.00	KY 488
Clay	9006	10.8	3140	190	77.9	0	0.00	35.13	0.00	Little Goose Creek Road
Clay	9006	13.9	3140	147	60.4	0	0.00	41.47	0.00	Minton Road
Clay	9006	16.1	3140	150	77.9	0	0.00	40.92	0.00	Hooker Road
Clay	9006	20.8	2400	229	79.8	0	0.00	37.02	0.00	Coal Dock Road, L & N
Clay	9006	21.5	2400	213	82.5	0	0.00	38.79	0.00	KY 80, US 421
Clay	9006	21.7	2400	495	70.3	0	0.00	23.14	0.00	Ham Brook Road; Goose Creek
Clay	9006	22.0	2400	203	74.7	0	0.00	40.03	0.00	Paces Creek Road
Clay	9006	26.3	2400	219	63.7	0	0.00	38.10	0.00	KY 149
Clay	9006	33.6	2400	618	69.9	0	0.00	20.41	0.00	Red Bird River
Clay	9006	34.2	2400	221	61.7	0	0.00	37.88	0.00	KY 66
Leslie	9006	48.1	2090	836	74.7	0	0.00	18.66	0.00	KY 257; KY 1021; KY River
Perry	9006	56.0	2790	586	75.0	0	0.00	19.35	0.00	KY 80, Big Creek
Perry	9006	57.2	2790	646	76.1	0	0.00	18.35	0.00	KY 80; L & N; KY River
Warren	9007	0.0	4630	210	58.2	0	0.00	26.02	0.00	I 65
Warren	9007	3.6	4040	206	62.2	0	0.00	28.56	0.00	US 31-W
Warren	9007	3.8	4040	194	72.2	0	0.00	29.63	0.00	L & N Railroad
Warren	9007	4.9	4040	277	71.0	0	0.00	23.96	0.00	US 68
Butler	9007	22.6	2960	228	66.3	0	0.00	32.50	0.00	Little Muddy Creek
Ohio	9007	43.8	2870	237	69.4	0	0.00	32.34	0.00	ICRR
Ohio	9007	44.1	2870	135	79.9	0	0.00	46.59	0.00	Muddy Creek
Ohio	9007	44.5	2870	227	69.5	0	0.00	33.23	0.00	US 62
Ohio	9007	49.3	2870	245	66.1	0	0.00	31.68	0.00	Rough River
Ohio	9007	58.2	2870	168	73.9	0	0.00	40.30	0.00	KY 764
Daviess	9007	62.4	2880	170	73.4	0	0.00	39.90	0.00	South Fork Panther Creek
Daviess	9007	62.7	2880	155	67.2	0	0.00	42.39	0.00	South Fork Panther Creek

Table 21. Analysis of Bridge Data. *(Continued).*

County	Route	Milepost	Volume	Bridge Length	Sufficiency Rating	Number of Accidents	Accident Rate	Critical Accident Rate	CRF	Underpass
Daviess	9007	62.9	2880	155	67.2	0	0.00	42.39	0.00	South Fork Panther Creek
Daviess	9007	67.2	2880	155	63.5	0	0.00	42.39	0.00	North Fork Panther Creek
Daviess	9007	67.4	2880	180	72.0	0	0.00	38.44	0.00	North Fork Panther Creek
Daviess	9007	67.7	2880	155	67.2	0	0.00	42.39	0.00	North Fork Panther Creek
Barren	9008	0.0	2350	276	58.2	0	0.00	33.32	0.00	I 65
Barren	9008	8.1	2350	285	66.5	0	0.00	32.66	0.00	Beaver Creek
Barren	9008	11.4	2430	211	66.6	0	0.00	38.72	0.00	US 31-E
Barren	9008	11.4	2430	165	82.2	0	0.00	45.53	0.00	South Fork Beaver Creek
Barren	9008	11.5	2430	134	82.2	0	0.00	52.43	0.00	Beaver Creek
Barren	9008	11.5	2430	194	66.4	0	0.00	40.90	0.00	South Fork Creek
Barren	9008	18.2	1420	216	65.6	0	0.00	54.64	0.00	Mount Pisgah Road
Metcalfe	9008	28.0	1420	298	66.4	0	0.00	43.92	0.00	South Fork Little Barren
Metcalfe	9008	34.2	1420	210	69.5	0	0.00	55.72	0.00	East Fork Little Barren
Adair	9008	48.1	1440	209	81.6	0	0.00	55.36	0.00	Petty's Fork
Adair	9008	50.0	1440	291	72.1	0	0.00	44.21	0.00	Russell Creek
Adair	9008	56.2	1440	265	67.5	0	0.00	47.07	0.00	Russell Creek

Table 22. Summary of Accidents by Type of Collision.*

Type of Collision	Percent of Total			
	Mainline	Bridge	Inter-change	All
Other Motor Vehicle	21.8	14.0	52.0	24.1
Pedestrian	0.5	0.0	1.3	0.5
Animal	7.9	0.0	0.0	6.8
Fixed Object				
Light support/utility pole	0.9	0.0	2.2	1.0
Guardrail	13.4	21.5	9.4	13.4
Crash cushion	1.1	0.0	0.0	1.0
Sign post	2.1	0.0	4.0	2.2
Tree	0.4	0.0	0.0	0.4
Building/wall	0.5	0.8	0.0	0.4
Curbing	0.4	0.0	2.7	0.6
Fence	1.1	0.8	0.9	1.1
Bridge structure	1.1	43.0	0.9	3.1
Culvert/head wall	1.0	0.0	0.9	1.0
Median/barrier	8.2	7.4	1.8	7.6
Snow embankment	1.1	0.0	0.4	1.0
Earth embankment/rock cut/ ditch	15.5	3.3	8.1	14.3
Fire Hydrant	0.0	0.0	0.0	0.0
Other fixed object	1.7	0.0	1.8	1.6
Noncollision				
Overturned	11.6	3.3	10.8	11.1
Fire/explosion	3.5	0.8	0.0	3.1
Submersion	0.0	0.8	0.0	0.0
Ran off roadway (only)	3.3	3.3	1.3	3.1
Other	2.8	0.8	1.3	2.6

*One accident could involve more than one collision.

Table 23 contains a listing of locations with three or more animal-related (primarily deer) accidents in a 2-mile (3.2-km) length of road. Dividing this total by the number of 2-mile (3.2-km) sections gave the average number of accidents in 2 miles (3.2 km). Using Equation 1, a critical number of three accidents in 2 miles (3.2 km) was determined. The analysis was used to locate other hazardous locations. Summary tables of the results are shown in APPENDIX B. Critical numbers of accidents in a given section length were also determined for speed-related accidents, injury and fatal accidents, accidents during darkness, accidents on snow or ice, accidents involving a guardrail, and accidents on a wet pavement.

Summary tables of accident characteristics shown in Table 4 are given in APPENDIX C. Most tables were summarized by the three categories of accidents previously used (mainline, interchange-related, and bridge-related) and for all toll-road accidents.

A separate fatal-accident analysis was made spanning a ten-year (1970-1979) period. The largest number of fatal accidents involved collisions with fixed objects (Table 24). The most common involved guardrail. The second most common fixed-object-type involved a bridge pier. Each fatal accident was also classified into a category shown in Table 25. Data from these tables indicated the general type of improvements that would reduce fatal accidents. For example, replacing blunt and buried guardrail ends would eliminate fatalities resulting from a blunt guardrail end penetrating a vehicle or a vehicle jumping a buried end and overturning. Also, there were several fatal accidents involving exposed bridge piers or nonbreakaway sign supports. Such accidents illustrated the need for safety improvements in these areas.

A list of locations which had the highest number of fatal accidents was prepared. A critical number of four fatal accidents in 5.0 miles (8.0 km) or two accidents in 0.3 mile (0.5 km) was determined. Those lists are given in APPENDIX D. The highest number of fatal accidents at any given milepost in the 10-year period was three, and these occurred on the Green River Parkway exit ramp (westbound exit) to the US 60 bypass in Owensboro. Several other summary tables are given in APPENDIX D. A summary by route indicated that the highest number of fatal accidents occurred on the Mountain and Western Kentucky Parkways. The peak number of fatal accidents occurred in 1973. The peak accident months were

Table 23. Locations with Three or More Animal-Related (Primarily Deer) Accidents in Two Miles (3.2-km).

Parkway	Beginning Milepost	Ending Milepost	Number of Accidents
Mtn	31.0	33.0	4
WKy	25.9	27.4	3
	31.2	33.0	5
	44.4	46.0	5
	51.5	53.2	3
	93.0	94.6	3
	113.0	115.0	4
Pen	24.0	25.5	3
	26.2	28.1	4
	37.1	38.4	5
	48.9	50.2	3
	51.2	52.9	3
	57.3	58.4	3
	64.3	65.5	5
GR	11.0	12.9	3
	19.3	20.6	5
	23.0	24.4	4
	26.4	27.8	4
	28.7	30.7	4
	31.5	33.2	4
	34.6	36.0	4
	41.0	42.6	3
	51.1	51.3	3
	53.8	55.6	3
	56.0	57.1	4

Table 24. General Description of Fatal Accidents.

Description	Number	Percent of Total
Other Motor Vehicle	38	32
Pedestrian	5	4
Ran-Off-Road or Overturned (No Collision)	18	15
Fixed Object (all)	59	49
Guardrail	23	19
Bridge pier	13	11
Bridge	8	7
Sign	5	4
Culvert	3	3
Rock cut	2	2
Other	5	4

August, July, and November. A high percentage of fatal accidents occurred during darkness (46 percent). The major human contributing factor was speeding; this was followed by alcohol involvement and falling asleep. Vehicular factors were not listed very often, but the most common factor was tire failure. The major environmental factor was a slippery pavement. Summaries by hour, road surface condition, vehicle type, type of location, and type of fixed object are also given. In addition, an investigation of seatbelt usage was made. In the 121 fatal accidents, there were 137 fatalities. Only one of the persons killed was coded as wearing a seatbelt. This fatality resulted when the driver fell asleep and hit an exposed bridge pier. Of the instances in which ejection from the vehicle was coded on the accident reports, 36 percent of the fatalities involved ejection. Increased seatbelt usage would have decreased drastically the percentage of people ejected and probably would have prevented many of the fatalities.

Accident rates were calculated for segments of the roads in each county (Table 26). The highest accident rates were for the Daniel Boone Parkway in Laurel County, the Mountain Parkway in Morgan and Clark Counties, the Purchase Parkway in Marshall County, and the Bluegrass Parkway in Hardin County.

A comparison of accidents on bridges with and without full-width shoulders was made (Table 27). It was found that bridges with full-width shoulders had a 35-percent lower accident rate and 64 percent fewer accidents per bridge compared to bridges without full-width shoulders.

At-grade intersections had much higher accident rates than any of the interchange types (Table 28). The lowest rates were at cloverleafs, and the highest rates were at "T" or trumpet interchanges.

A comparison was also made to determine if there was a relationship between the adequacy rating assigned to a bridge and accident rate (Table 29). The adequacy rating includes condition elements (substructure, superstructure, floor condition, and safe loading), safety

Table 25. Detailed Description of Fatal Accidents.

Description	Number	Percent of Total
Pedestrian		
Not occupant of other motor vehicle	3	3
Disabled vehicle	1	1
Previous accident	1	1
Total	5	4
Guardrail-Related		
General	7	6
Blunt end punctured vehicle	5	4
Through guardrail	1	1
Overturned	7	6
Jumped over buried end	3	3
Total	23	19
Rear End		
General	4	3
Slow moving truck	3	3
Vehicle on emergency strip	5	4
Exit ramp (vehicle backing)	2	2
Total	14	12
Bridge Related		
Hit bridge abutment	3	3
Gap between parallel bridges	2	2
Bridge railing	3	3
Total	8	7
Wrong Way Head-On	4	3
Run-Off-Road (No Collision)	18	15
Median Crossover Related	1	1
Hit Bridge Pier	13	11
Hit Culvert	3	3
Hit Sign	5	4
Hit Rock Cut	2	2
Head-On (Two-Lane Road)	13	11
Opposite Direction Sideswipe (Two-Lane Road)	1	1
Lost Control on Exit Ramp	3	3
At-Grade Intersection on Parkway	3	3
Passenger Fell from Vehicle	3	3
Hit Deer	1	1

elements (clear roadway width, approach alignment, and traffic safety features), and service elements (clear roadway height, waterway, and remaining life). A maximum of 100 points may be assigned, and a high point total indicates the bridge is in good condition. It was shown that bridges with the highest adequacy rating had the lowest accident rates.

Table 26. Accident Rate by Toll Road and County.

	Accident Rate (Accidents/100 mvm)								
					Parkway				
County	Mtn	WKy	BG	Pur	Pen	Aud	DB	GR	Cum
Clark	108								
Magoffin	70								
Morgan	115								
Powell	70								
Wolfe	94								
Butler		50							
Caldwell		59							
Grayson		87							
Hardin		75							
Hopkins		78							
Lyon		73							
Muhlenberg		76							
Ohio		66							
Anderson			89						
Hardin			110						
Mercer			15						
Nelson			90						
Washington			53						
Woodford			57						
Fulton				43					
Graves				84					
Hickman				35					
Marshall				115					
Christian					80				
Henderson					78				
Hopkins					91				
Webster					74				
Daviess						59			
Henderson						78			
Clay							82		
Laurel							128		
Leslie							81		
Perry							94		
Butler								93	
Daviess								57	
Ohio								74	
Warren								89	
Adair									44
Barren									40
Metcalfe									37
Pulaski									64
Russell									26

Field Inventory

The field inventory involved a survey of all toll roads. The roadway features included in the inventory are listed in Table 5. Photographs of many of the roadway features inventoried were taken and are presented in APPENDIX A. The photographs show both desirable and undesirable roadway features.

A summary of the number of different guardrail end treatments is given in Table 30. The majority of guardrail ends were buried (70 percent), but a significant percentage were blunt (29 percent). Almost all guardrail ends on the Western Kentucky Parkway were blunt. Very few guardrail ends had been upgraded by installing the breakaway cable terminal or flared end.

The number of underpasses on the toll roads was 238. A summary of underpasses is presented in Table 31. A summary of the types of protectors at median and shoulder piers is given in Table 32. The two most common types of protective devices for shielding or cushioning the impact of a collision with a median bridge pier are guardrail (42 percent) and earth mound (22 percent). A significant number had no protector (19 percent); 17 percent were shielded only with shrubs. The Mountain Parkway had the highest percentage of exposed median bridge piers; shrubs were the only protectors at median piers on the Western Kentucky Parkway. For the shoulder pier, guardrail was the only protective device used. In a few cases, the design was such that there was no shoulder pier. The shoulder pier was exposed 40 percent of the time. The Western Kentucky and Mountain Parkways had

Table 27. Comparison of Accident Data on Bridges With and Without Full-Width Shoulders

	Number of Bridges	Number of Accidents per Year	Exposure (mvm)	Accident Rate (ACC/mvm)	Percent Decrease for Full-Width Shoulder	Accidents per Bridge per Year	Percent Decrease for Full-Width Shoulder
Not Full Width	128	28	9.4389	2.97	35	0.22	64
Full Width	65	5	2.5760	1.94		0.08	

Table 28. Accidents Associated with Types of Interchanges.*

Type	Number	Total Accidents (1976-1978)	Average Daily Volume per Interchange	Accident Rate (Accidents per million vehicles)
Diamond	32	48	5280	0.26
Toll booth	18	25	3930	0.32
Partial diamond	13	21	5630	0.26
T or Trumpet	12	36	4710	0.58
At-grade intersection	14	57	3660	1.02
Cloverleaf	4	7	6390	0.25
Partial cloverleaf	3	3	6150	0.15

*Did not include a few driveways which existed on Daniel Boone Parkway.

Table 29. Relationship Between Adequacy Rating and Accident Rates for Bridges.

Sufficiency Rating	Accident Rate Accidents/ Bridge	Accidents/ mvm
80-100	0.17	4.4
70-80	0.40	7.8
Below 70	0.63	7.9

the largest number of exposed shoulder piers. In 48 percent of the cases, the guardrail was not attached to the pier.

The summary of bridge inventory data is given in Table 33. There are 196 bridges, and only one in three (34 percent) have full-width shoulders. Protection at the gap between twin bridges has been shown to be an accident problem.[7]

In most cases, there is an opening between bridges which must not be left exposed; in some instances, a wall connects the bridges. Some type of barrier existed in all instances. The most common barrier involved a guardrail alone or in conjunction with shrubs or an earth mound. The guardrail varied, with some of the older installations offering very little capacity for arresting vehicles. Shrubs alone were provided at almost all bridges on the Western Kentucky Parkway. Almost all bridges had a curb rather than the New-Jersey-type bridge rail and breakaway-cable end treatment. Fifty percent of the guardrail transitions to the bridge were rated as being equivalent to present standards; 69 percent of the approach guardrails were rated as good. The bridge inventory file rated the condition of the bridge decks and listed

Table 30. Summary of Numbers of Different Guardrail End Treatments.

Guardrail End-Treatment	Parkway Mtn	WKy	BG	Pur	Pen	Aud	DB	GR	Cum	Total
Blunt	327	706	12	27	89	8	9	7	5	1190
Buried	345	67	433	235	263	88	498	409	520	2858
Breakaway Cable Terminal	3	3	0	5	1	0	0	0	1	13
Flared	4	1	0	0	0	0	0	0	3	8

Table 31. Number of Underpasses on Toll Roads.

Parkway	Number of Underpasses
Mtn	23
WKy	45
BG	28
Pur	32
Pen	33
Aud	9
DB	6
GR	25
Cum	37
All	238

23 bridge decks in need of major repair.

A summary of interchange inventory data is given in Table 34. Almost one-half of the interchanges were lighted. Some were lighted only in the gore areas. Slightly over one-third of the gores were classified as clear. Major features in the gore areas which should be removed or replaced were signs, guardrail, and curbs. Many exit signs in the gore areas were supported by back-to-back channel posts which are not breakaway.

Of 281 crossovers, 210 were marked and 60 were paved (Table 35). Crossovers are warranted at county lines and on either side of interchanges or toll booths. Using this criterion, 139 crossovers would remain. All remaining crossovers should be paved and signed. Therefore, signing was recommended at 31 crossovers, and paving was recommended at 101 crossovers. Scale drawings showing the locations of all median crossovers are given in APPENDIX E. The drawings also give the location of all interchanges and county lines.

Table 32. Summary of Median and Shoulder Pier Protection.

Type of Protection	Parkway									
	Mtn	WKy	BG	Pur	Pen	Aud	DB	GR	Cum	Total
Median Pier										
Guardrail	1	2	26	0	10	0	NA	21	35	95
Earth mound	0	0	0	28	13	8	NA	0	0	49
Crash cushion	0	0	0	0	0	0	NA	0	0	0
Shrubs	0	38	0	1	0	0	NA	0	0	39
None	18	5	2	3	10	1	NA	3	2	44
Shoulder Pier										
Guardrail	11	4	52	1	17	0	12	40	65	202
Unprotected	31	86	4	3	2	0	0	4	4	134
Guardrail—Unattached	11	2	9	3	11	0	6	20	35	97

Table 33. Summary of Bridge Inventory Data.

Data Item	Parkway									
	Mtn	WKy	BG	Pur	Pen	Aud	DB	GR	Cum	Total
Number of bridges	41	32	16	23	23	5	20	21	15	196
Shoulder										
Full width	4	8	3	16	14	2	16	1	1	65
Not full width	37	22	13	7	9	3	4	20	14	129
Gap between bridges protection										
Guardrail	16	1	14	13	8	4	NA	20	12	88
Shrubs	0	25	0	0	0	0	NA	0	0	25
Guardrail and shrubs	0	2	0	0	0	0	NA	0	0	2
Guardrail and earth mound	0	0	0	10	14	0	NA	0	0	24
None	0	0	0	0	0	0	NA	0	0	0
Curb										
Yes	40	25	14	23	21	5	20	21	15	184
No	1	4	2	0	1	0	0	0	0	8

Table 33. Summary of Bridge Inventory Data. *(Continued).*

Data Item	Mtn	WKy	BG	Parkway Pur	Pen	Aud	DB	GR	Cum	Total
Percent of given safety feature rated as good (up to standard)										
Bridge rail	0	0	0	0	0	0	0	0	0	0
Transition	58	0	100	83	0	60	85	67	33	50
Approach guardrail	68	44	100	83	86	60	85	67	33	69
End treatment	0	0	0	0	0	0	0	0	0	0
Number of decks in need of major repair	7	5	6	0	1	0	1	3	0	23

Table 34. Summary of Interchange Inventory Data.

Inventory Item	Mtn	WKy	BG	Parkway Pur**	Pen	Aud	DB	GR	Cum	Total
Number of interchanges*	14	12	10	13	18	3	10	9	10	99
Number lighted	2	5	5	4	8	2	7	7	8	48
Number of gore areas	20	23	16	24	31	4	4	18	13	153
Number with given gore area feature										
Clear	3	7	1	12	9	2	0	11	10	55
Exit sign***							0	0	0	27
Other breakaway signs	2	8	11	4	5	0	0	0	0	30
Light poles	2	2	2	0	0	0	2	0	0	8
Curb	5	0	0	14	13	0	0	0	0	32
Guardrail	4	11	2	6	6	2	2	7	3	43

*Includes at-grade intersections.
**Includes new interchanges where no accident data were available.
***Back-to-back channel posts.

Table 35. Summary of Median Crossovers.

Information	Mtn	WKy	BG	Parkway* Pur	Pen	Aud	GR	Cum	Total
Number of crossovers									
Marked	13	60	23	14	56	8	20	16	210
Unmarked	13	1	11	6	4	3	7	26	71
Total	26	61	34	20	60	11	27	42	281
Number paved	3	3	19	0	2	0	11	22	60
Number related to county line	2	6	6	3	3	1	3	4	28
Number related to interchange or toll booth	12	18	16	10	28	4	12	14	114

Table 35. Summary of Median Crossovers *(Continued)*.

Information	Parkway*								
	Mtn	WKy	BG	Pur	Pen	Aud	GR	Cum	Total
Number recommended removing	12	36	14	8	30	6	13	23	142
Number remaining	14	25	20	12	30	5	14	19	139
Number signing recommended	6	1	4	4	1	0	3	12	31
Number paving recommended	10	26	7	12	30	5	6	6	101

*Does not include Daniel Boone Parkway since it is a two-lane highway.

Table 36. Summary of Various Roadway Features Inventoried.

Inventory Item	Parkway									
	Mtn	WKy	BG	Pur	Pen	Aud	DB	GR	Cum	Total
Number of signs										
Breakaway	0	23	24	9	18	6	1	36	47	164
Protected	46	55	69	54	76	18	33	55	44	450
Nonbreakaway and unprotected	27	50	4	4	22	3	0	0	0	110
Number of breakaway lighting standards	30	80	0	0	0	0	0	0	0	110
Total length of rock outcroppings (miles)	2.0	1.6	0.8	0	0.3	0	0.2	0.1	0.9	5.9
Total length of rock cuts (miles)	3.9	14.4	10.8	0	5.5	0	15.0	5.6	17.9	73.1
Number of small culvert headwalls to replace	4	96	3	18	15	7	15	38	9	205

A total of 724 signs were counted (Table 36), and it was determined that 110 needed to be replaced with breakaway posts. A less desirable alternative would be to divert the vehicle away with guardrails. Almost half of the signs in need of replacement were on the Western Kentucky Parkway. A total of 110 nonbreakaway lighting standards were counted.

On some toll roads, the Western Kentucky Parkway in particular, it was common practice to install small sections of guardrail to shield culvert headwalls. Exposed headwalls should be replaced with sloped headwalls, and the area around the new headwall should be contour graded. In addition, short sections of guardrail should be removed. A total of 205 such culverts were counted.

The lengths of rock outcroppings and rock cuts were also summarized. Reducing the accident potential associated with rock outcroppings and rock cuts is very expensive, and solutions are not readily available. Alternatives range from eliminating the rock cuts to installing guardrail or barrier walls to shield vehicles from the rock cuts.

Recommended Improvements

Recommended improvements for the toll roads can be divided into two categories: specific, high-accident locations and systemwide safety features. The first category was for improvement of specific high-accident locations. Lists of high-accident spots, sections, interchanges or intersections, and bridges were obtained. These locations were investigated and inspected, and appropriate improvements are recommended. A list of recommended safety improvements at high-accident, 0.3-mile (0.5-km) spots, which were ordered by critical rate factor, is given in Table 37. Another list for 1.0-mile (1.6-km) sections is given in Table 38. Many locations appeared on both lists, including many toll-booth locations. Also, a section of the Pennyrile Parkway between mileposts 30 and 45 accounted for a significant portion of the lists. Paving the shoulder on this section of parkway was recommended. Toll-booth improvements and paving the shoulder on the section of the Pennyrile Parkway were the two major improvements recommended at the high-accident spots and 1.0-mile (1.6-km) sections. Other recommended improvements involved signing and deslicking. Improvements are also recommended at high-accident interchanges and intersections (Table 39) and bridges (Table 40). Interchanges with six or more accidents and bridges with three or more accidents are listed. Only four intersections and no bridges had critical rate factors of one or more. Recommendations at high-accident interchanges and intersections vary from construction of a grade-separated interchange to pavement markings and signing. Recommendations at bridges are either an "ice on bridge" warning system or additional delineation. The "ice on bridge" warning system would consist of a sensor in each bridge deck to detect ice and a sign on each approach.

The second improvement category is systemwide upgrading of a safety feature. As a guide, a list of types of highway safety improvements included in the interstate cost estimate was used (Table 41).

A list of 42 specific improvement alternatives is recommended in Table 42. The number of each type of improvement recommended is given for the "general upgrading." The specific locations are listed for the other improvements. The numbers of accidents which would be affected by the improvements were determined by various methods. A description of the accidents included when determining percentage reduction is given for each improvement in APPENDIX F. The estimated percentage reduction was determined using past studies and accident analyses. In some cases, estimates were made based on engineering judgment. The percentage reductions in accidents were given separately for fatal, injury, and property-damage-only accidents. This was done because some improvements will reduce accident severity but not affect the number of accidents. In such cases, total accidents may remain unchanged, but injury and fatal accidents will be reduced. Thus, the number of property-damage-only accidents will show a negative percent reduction because some injury and fatal accidents would become property-damage-only accidents after improvements are made.

Improvement costs were taken primarily from average unit bid prices for past projects awarded by the Kentucky Department of Transportation. A tabulation of the unit costs used for the recommended

Table 37. Recommended Safety Improvements at High Accident Locations — 0.3-Mile (0.5-km) Spots (In Order by Critical Rate Factor).

County	Parkway	Beginning Milepost	Ending Milepost	Number of Accidents	CRF	Recommended Improvements
43	WKy	106.9	107.1	14	2.18	Replace nonbreakaway posts; transverse stripes (toll booth)
99	Mtn	32.8	33.0	15	1.54	Rumble strips; breakaway posts; crash-cushions; transverse stripes; escape ramp
119	Mtn	38.0	38.2	12	1.47	Deslicking; curve warning signs
3	BG	58.7	58.9	10	1.29	Transverse stripes (toll booth)
114	GR	7.4	7.6	7	1.19	Transverse stripes (toll booth)

Table 37. Recommended Safety Improvements at High Accident Locations — 0.3-Mile (0.5-km) Spots (In Order by Critical Rate Factor) *(Continued)*.

County	Parkway	Beginning Milepost	Ending Milepost	Number of Accidents	CRF	Recommended Improvements
77	Mtn	72.2	72.4	6	1.12	Curve warning sign
89	WKy	57.9	58.1	7	1.10	Rumble strips; transverse stripes (toll booth)
79	Pur	42.6	42.8	5	1.09	Crash cushion; transverse stripes (toll booth)
63	DB	7.0	7.2	7	1.08	Transverse stripes (toll booth)
117	Pen	62.5	62.7	7	0.96	Transverse stripes (toll booth)
89	WKy	63.9	64.1	6	0.94	N.I.R.*
51	Aud	10.1	10.3	5	0.83	Transverse stripes (toll booth)
54	Pen	37.0	37.2	9	0.82	Pave Shoulder
99	Mtn	21.0	21.2	6	0.82	N.I.R.
54	WKy	24.3	24.5	5	0.79	Replace nonbreakaway posts; transverse stripes (toll booth)
54	WKy	32.9	33.1	5	0.79	Deer signs; deer fence
43	WKy	91.8	92.0	5	0.78	N.I.R.
92	WKy	75.0	75.2	5	0.78	N.I.R.
120	BG	63.0	63.2	6	0.78	N.I.R.
26	DB	33.8	34.0	4	0.75	Transverse stripes (toll booth)
66	DB	42.0	42.2	4	0.75	Deslicking
66	DB	43.9	44.1	4	0.75	Rumble strips; transverse stripes (toll booth)
119	Mtn	53.9	54.1	4	0.74	Deslicking
16	GR	28.7	28.9	4	0.70	Deer fence; deer signs
99	Mtn	14.6	14.8	4	0.70	Transverse stripes (toll booth)
99	Mtn	15.0	15.2	6	0.70	Transverse stripes (toll booth)
26	DB	14.8	15.0	4	0.67	Curve warning sign
54	Pen	28.9	29.1	5	0.65	N.I.R.
90	BG	9.5	9.7	4	0.65	Transverse stripes (toll plaza)
90	BG	11.5	11.7	4	0.65	Improve snow and ice removal
43	WKy	18.8	19.0	4	0.64	N.I.R.
47	BG	3.0	3.2	4	0.64	Improve snow and ice removal
54	Pen	38.9	39.1	7	0.64	Pave shoulder
54	Pen	39.7	39.9	7	0.64	Pave shoulder
90	BG	36.9	37.1	4	0.64	N.I.R.
115	BG	41.7	41.9	4	0.64	N.I.R.
54	Pen	54.9	55.1	5	0.63	Remove one crossover (MP 55.1)
89	WKy	45.9	46.1	4	0.63	N.I.R.
43	WKy	99.0	99.2	4	0.62	N.I.R.
43	WKy	112.8	113.0	4	0.62	N.I.R.
43	WKy	115.0	115.2	4	0.62	Deer fence; deer signs

Table 37. Recommended Safety Improvements at High Accident Locations — 0.3-Mile (0.5-km) Spots (In Order by Critical Rate Factor) *(Continued)*.

County	Parkway	Beginning Milepost	Ending Milepost	Number of Accidents	CRF	Recommended Improvements
43	WKy	118.3	118.5	4	0.62	Improve snow and ice removal
43	WKy	75.5	75.7	4	0.62	Directional left-exit sign
24	Pen	7.3	7.2	5	0.61	Concrete barrier with delineation
24	Mtn	36.8	37.0	5	0.61	Deslicking
119	Mtn	38.3	38.5	5	0.61	Deslicking
25	Mtn	4.9	5.1	5	0.59	N.I.R.
25	Mtn	7.3	7.5	5	0.59	N.I.R.
25	Mtn	10.2	10.4	5	0.59	Deslicking
24	Pen	14.0	14.2	4	0.58	N.I.R.
99	Mtn	19.9	20.1	5	0.58	N.I.R.
99	Mtn	26.9	27.1	5	0.58	N.I.R.
51	Pen	77.2	77.4	5	0.57	N.I.R.
24	Pen	20.2	20.4	4	0.55	N.I.R.
54	Pen	32.7	32.9	6	0.55	Pave shoulder
54	Pen	40.2	40.4	6	0.55	Pave shoulder
54	Pen	41.8	42.0	6	0.55	Pave shoulder
117	Pen	59.6	59.8	4	0.55	Replace median drainage inlets
117	Pen	64.2	64.4	4	0.55	N.I.R.
51	Pen	64.2	64.4	4	0.55	N.I.R.
54	Pen	29.5	29.7	4	0.52	Pave shoulder
3	BG	59.0	59.2	4	0.51	Transverse stripes (toll booth)
99	Mtn	35.2	35.4	4	0.51	Deslicking
99	Mtn	35.8	36.0	4	0.51	Deslicking
47	WKy	120.3	120.5	4	0.50	Improve snow and ice removal
47	WKy	134.3	134.5	4	0.50	N.I.R.
25	Mtn	11.8	12.0	4	0.47	N.I.R.
54	Pen	50.6	50.8	4	0.55	N.I.R.
54	Pen	35.7	35.9	5	0.46	Pave shoulder
54	Pen	36.4	36.6	5	0.46	Pave shoulder; replace nonbreakaway signs
54	Pen	36.7	36.9	5	0.46	Pave shoulder
54	Pen	38.2	38.4	5	0.46	Pave shoulder
54	Pen	40.9	41.1	5	0.46	Pave shoulder
54	Pen	42.1	42.3	5	0.46	Pave shoulder
54	Pen	42.4	42.6	5	0.38	Pave shoulder
54	Pen	30.9	31.1	4	0.36	Pave shoulder
54	Pen	37.3	37.5	4	0.36	Pave shoulder
54	Pen	37.6	37.8	4	0.34	Pave shoulder
54	Pen	42.9	43.1	4	0.30	Pave shoulder
54	Pen	43.4	43.6	4	0.30	Pave shoulder

*No improvement recommended.

improvements is given in APPENDIX G. Service lives and annual maintenance costs were selected for each project based on information obtained from other sources. The average annual benefits were determined using National Safety Council accident costs. Accident savings were the only benefits considered. Given the service life for each improvement, an interest rate of 10 percent, and an exponential growth-rate factor for traffic of six percent, the present worth of the benefits was determined and a benefit-cost ratio was calculated.

A separate listing by toll road was made of the systemwide type of improvements (Table 43). The number of each improvement needed is summarized for each toll road. This table shows which toll roads are in the greater need of safety upgrading.

A summary of the improvement costs in various benefit-cost ratio ranges is given in Table 44. The

Table 38. Recommended Safety Improvements at High Accident Locations — 1.0-Mile (1.6-km) Sections (In Order by Critical Rate Factor).

County	Route	Beginning Milepost	Ending Milepost	Number of Accidents	CRF	Recommended Improvements
43	WKy	106.9	107.8	16	1.36	Replace nonbreakaway posts; Transverse stripes (toll booth)
119	Mtn	37.4	38.3	19	1.21	Deslicking; curve warning signs
3	BG	58.7	59.6	16	1.08	Transverse stripes (toll booth)
66	DB	43.4	44.3	9	0.97	Rumble strips; transverse stripes (toll booth)
99	Mtn	32.1	33.0	14	0.94	Rumble strips; crash cushions; breakaway poles; transverse stripes; escape ramp
89	WKy	57.2	58.1	9	0.77	Rumble strips; transverse stripes (toll booth)
54	Pen	37.1	38.0	17	0.76	Pave shoulder; deer fence
54	Pen	28.9	29.8	11	0.75	Pave shoulder
63	DB	7.0	7.9	9	0.75	Transverse stripes (toll booth)
114	GR	6.8	7.7	9	0.72	Transverse stripes (toll booth)
54	Pen	41.5	42.4	16	0.71	Pave shoulder; remove crossover
92	WKy	75.1	76.0	8	0.68	Directional left-exit sign
54	Pen	36.1	37.0	15	0.67	Pave shoulder
117	Pen	61.8	62.7	9	0.66	Transverse stripes (toll booth)
54	Pen	38.2	39.1	14	0.62	Pave shoulder
24	Pen	27.9	28.8	9	0.61	Improve snow and ice removal
25	Mtn	9.5	10.4	10	0.61	Deslicking
120	BG	63.0	63.9	9	0.61	N.I.R.*
54	Pen	39.3	40.2	13	0.53	Pave shoulder
117	Pen	59.6	60.5	8	0.58	Remove crossovers
119	Mtn	36.4	37.3	9	0.57	Deslicking
25	Mtn	1.0	1.9	9	0.55	N.I.R.
54	Pen	49.9	50.8	9	0.54	Remove crossover

Table 38. Recommended Safety Improvements at High Accident Locations — 1.0-Mile (1.6-km) Sections (In Order by Critical Rate Factor) *(Continued)*.

County	Route	Beginning Milepost	Ending Milepost	Number of Accidents	CRF	Recommended Improvements
99	Mtn	15.0	15.9	9	0.54	Transverse stripes (toll booth)
99	Mtn	20.5	21.4	9	0.54	N.I.R.
99	Mtn	35.2	36.1	8	0.54	Deslicking
24	Pen	9.1	10.0	8	0.51	Screen on bridge over parkway
119	Mtn	42.0	42.9	8	0.51	Remove crossover
25	Mtn	0.0	0.9	8	0.49	N.I.R.
25	Mtn	8.3	9.2	8	0.49	N.I.R.
54	Pen	40.4	41.3	10	0.44	Pave shoulder
54	Pen	34.0	34.9	9	0.40	Pave shoulder
54	Pen	35.1	36.0	9	0.36	Pave shoulder
54	Pen	33.0	33.9	8	0.36	Pave shoulder
54	Pen	42.5	43.4	8	0.28	Pave shoulder

*No improvement recommended.

Table 39. Recommended Safety Improvements at High Accident Interchanges and Intersections.*

County	Parkway	Milepost	Cross Road	Number of Accidents	CRF	Recommended Improvement
Laurel	DB	3.0	KY 472	13	1.49	Grade-separated interchange or vehicle-actuated warning device
Pulaski	Cum	87.5	Ringo Road	10	1.40	Grade-separated interchange or vehicle-actuated warning device
Laurel	DB	0.0	US 25	12	1.11	Transverse stripes
Marshall	Pur	52.3	US 62	5	1.02	Vehicle-actuated warning device
Daviess	Aud	23.5	US 60 Bypass	7	0.83	Additional directional signing; transverse stripes
Hardin	WKy	136.6	I-65	11	0.74	Gore improvements
Christian	Pen	7.0	US 41A	8	0.68	N.I.R.
Clark	Mtn	0.0	I-64	7	0.58	Lighting; additional delineators; transverse stripes
Daviess	GR	70.2	US 60 Bypass	6	0.51	Transverse stripes
Hardin	W Ky	136.8	US 31W	6	0.43	Additional directional signing
Hopkins	Pen	44.3	KY 281	9	0.43	Transverse stripes (exit ramps); gore improvements
Hopkins	Pen	42.4	KY 70	8	0.39	Transverse stripes (exit ramps); gore improvements

*Six or more accidents.

Table 40. Recommended Safety Improvements at High-Accident Bridges.*

County	Parkway	Milepost	Bridge Over	Number of Accidents	CRF	Recommendations
Ohio	WKy	76.8	Green River Pkwy	4	0.78	Ice on bridge warning system
Anderson	BG	62.6	Kentucky River	9	0.71	Delineation; ice on bridge warning system
Hopkins	Pen	43.4	L and N Railroad	4	0.64	Delineation; ice on bridge warning system
Hopkins	Pen	32.3	White Plains Road	4	0.60	Delineation
Nelson	BG	39.2	Chaplin River	3	0.54	Delineation; ice on bridge warning system
Butler	GR	32.6	Green River	4	0.54	Delineation; ice on bridge warning system
Hopkins	Pen	32.6	ICRR, Pleasant Run	3	0.35	Delineation
Henderson	Aud	15.8	Green River	3	0.34	Delineation

*Three or more accidents.

Table 41. Types of Highway Safety Improvement Work Included in Interstate Cost Estimate.

1. Eliminate unnecessary signs.
2. Place signs on otherwise required structures such as bridges, lighting poles, and other sign supports.
3. Relocate signs laterally 30 feet or more from the pavement edge.
4. Relocate signs longitudinally to where they cannot be hit, such as behind otherwise required guardrail.
5. Convert supports to breakaway design.
6. Convert existing overhead supports to ground-mount breakaway design when feasible.
7. Provide protective guardrail around overhead sign supports.
8. Relocate lighting supports from highly vulnerable locations, such as gores.
9. Convert lighting supports to breakaway design.
10. Eliminate unnecessary median u-turn openings.
11. Eliminate small rock outcrops and boulders in an otherwise clear area along the roadside.
12. Round ditches.
13. Flatten ditch dikes and median u-turn openings.
14. Flatten and regrade slopes in gores and around adjusted drainage structures.
15. Regrade slopes in median or on side to permit the elimination of short sections of guardrail.
16. Remove gore curb.
17. Relocate minor drainage headwalls to the edge of clear roadside area.
18. Convert catch basins and headwalls to a design that allows vehicles to safely pass over.
19. Provide guardrail along large drainage structures.
20. Eliminate unwarranted guardrail.
21. Add additional guardrail or median barrier posts and blockouts or otherwise upgrade the existing rail to one of acceptable standard.
22. Replace a guardrail that deflects a lateral distance greater than the space available.
23. Anchor guardrail terminals and adjust them to reduce chance of impalement.
24. Strengthen guardrail in advance of and rigidly attach it to bridge parapets and walls.
25. Upgrade hazardously substandard bridge rail.
26. Install guardrail and median barrier along bridge piers, at overhead sign supports, or in narrow medians.
27. Place energy absorption barriers in gores where large fixed objects cannot be relocated.
28. Provide skid resistant overlays and pavement grooving.
29. Implement other less frequent types of safety work: add glare screens; add rail screens on pedestrian bridges; update signing and lighting at interchanges; revise striping at ramp terminals; lengthen speed change lanes; correct lane drops by signing and/or other minor work.

Table 42. Recommended Improvement Alternatives.

No.	Improvement	Accident Severity (3-Year Period) No.	Fatal	Injury	PDO	Percent Reduction Fatal	Injury	PDO	Improvement Costs ($)	Maintenance Costs ($)	Average Annual Benefits ($)	Benefit Cost Ratio	Life (yrs)
1.	Curve warning sign DBP MP 14.9	1	1	2(3)*	2	20	20	20	500	0	11,000	185.95	10
2.	Curve warning sign MTP MP 38.1	1	0	6(10)	6	20	20	20	500	0	4,200	69.02	10
3.	Curve warning sign MTP MP 72.3	1	0	3(5)	2	20	20	20	500	0	2,000	33.58	10
4.	Fasten seatbelt signs at entrance ramps and intersections	184	39	674(1011)	1330	2	0	0	38,800	0	39,000	8.69	10
5.	Deer crossing signs	24	1	3(4)	48	5	5	5	5,000	0	3,600	5.85	10
6.	Additional directional signing JJAP–US60 WKP–US31W WKP–Beaver Dam Rest Area	3	0	2(4)	5	50	50	50	7,500	0	4,600	5.00	10
7.	Additional signing for exit ramp from GRP–NB to WKP–WB	1	0	1(1)	1	20	20	20	1,000	0	400	3.64	10
8.	Replace rigid lightpoles	110	1	6(9)	1	75	75	-500	220,000	0	49,000	3.10	20
9.	Vehicle-actuated warning devices DBP–KY 472 CP–Ringo Rd. JPP–US 62	3	1	9(15)	19	20	20	20	45,000	500	17,000	3.01	10
10.	Replace rigid signs	110	2	8(12)	10	75	75	-70	440,000	0	90,000	2.85	20
11.	Median crossover improvements: Removing Signing Paving	142 31 101	4	7(11)	11	50	50	50	610,000	0	112,000	2.55	20
12.	Actuated warning sign MTP MP 32.9	1	0	2(3)	5	20	20	20	5,000	100	1,400	2.25	10
13.	Transverse stripes DBP–US 25 JJAP–US 60 MTP–I 64 GRP–US 60 PP–KY 281 PP–KY 70	6	2	8(10)	17	15	15	15	24,000	0	19,000	2.16	3
14.	Additional delineators JJAP–US 60 MTP–I 64	2	0	0	5	15	15	15	1,000	0	200	1.74	10
15.	Guardrail transition to bridge end (98 bridges)	392	1	7(11)	3	75	50	-170	392,000	0	47,000	1.65	20
16.	Upgrade gap between bridges: install guardrail and shrubs	25	1	2(3)	2	90	60	-100	400,000	5,000	48,000	1.55	20
17.	Concrete barrier wall (500 ft.) PP MP 7.1	8	0	2(4)	2	50	50	-50	19,000	0	3,000	1.55	10
18.	Flashing beacons DBP–KY 636 DBP–KY 1769 DBP–KY 754 DBP–KY 118 MTP–KY 191 MTP–KY 114 CP–KY 80	88	0	5(9)	1	10	10	10	7,000	700	1,800	1.46	10
19.	Screen on bridge over Pen Pkwy MP 9.3 and M P 9.5	1	0	0	3	100	100	100	4,000	200	800	1.44	10
20	Delineation for wrong-way accidents	153	1	2(3)	1	20	20	20	23,000	0	11,000	1.36	3
21.	Replace and upgrade delineator posts: Replace post and lens Replace lens	3400 6800	7	122(183)	236	2	2	1	71,400	5,000	15,000	1.26	10

Table 42. Recommended Improvement Alternatives *(Continued)*.

No.	Improvement	No.	Accident Severity (3-Year Period) Fatal	Injury	PDO	Percent Reduction Fatal	Injury	PDO	Improvement Costs ($)	Maintenance Costs ($)	Average Annual Benefits ($)	Benefit Cost Ratio	Life (yrs)
22.	Ice on bridge sensor and sign WKP–MP 76.8 BGP–MP 62.6 PP–MP 43.4 BGP–MP 39.2 GRP–MP 32.8 WKP–MP 65.4 CP–MP 84.3 JJAP–MP 15.8	8	0	3(7)	17	50	50	50	96,000	1,000	9,200	1.24	20
23.	Delineation for shoulders approaching bridges without full-width shoulders	258	1	15(23)	29	10	10	5	38,700	0	10,000	1.14	5
24.	Toll booth improvements Crash cushions (7) Rumble strips (11) Transverse stripes (25)	25	0	22(33)	96	30	30	20	105,000	0	25,000	1.05	5
25.	Paving shoulder: Pen Pkwy (MP 30.0–45.0)		0	14(20)	6	90	90	90	330,000	0	36,000	1.05	12
26.	Change guardrail end-treatments to B.C.T.	4048	4	34(51)	19	90	60	-180	3,036,000	0	229,000	1.05	20
27.	Median and shoulder pier protection: Shoulder pier unprotected Median pier unprotected Guardrail at shoulder pier unattached	 134 83 97	4	9(14)	10	90	60	-100	2,641,000	0	193,000	1.02	20
28.	Clear gore area: Remove rigid signs Move light standard Replace dual channel post Remove guardrail Remove curb	 30 8 27 43 32	0	6(9)	15	75	50	25	134,000	0	10,000	1.01	20
29.	Deer fence (37.4 miles of fence) WKP 31.2–33.0, 44.4–46.0 113.0–115.0 GRP 19.3–20.6, 26.4–27.8 28.7–30.7, 31.5–33.2 34.6–36.0, 56.0–57.1 26.2–28.1, 37.1–38.4 64.3–65.5		1	3(4)	48	100	100	100	987,000	2,000	71,000	0.98	20
30.	Deslicking: (17.2 lane mi.) MTP 9.5–10.4, 35.2–38.3, 53.9–54.1 DBP 42.0–42.2		1	10(15)	14	50	50	50	206,000	0	41,000	0.90	5
31.	Culvert/Headwall improvements: Replace headwall Remove guardrail (100 ft. avg. length) Improve slope contour (1,000 cu. yd. avg.) Replace substandard median drainage inlets (750)	205	1	16(24)	8	90	60	0	1,283,000	0	73,000	0.79	20
32.	Upgrade gap between gridges: Plant shrubs behind guardrail	112	1	2(3)	2	75	50	-100	784,000	20,000	40,000	0.49	20
33.	Shield rock cuts (73.1 miles)		2	17(26)	19	90	60	-60	4,000,000	0	117,000	0.41	20
34.	Remove rock outcroppings (5.9 miles) moving back 10 feet at an average 10 feet high		0	2(3)	2	100	100	50	346,000	0	6,100	0.26	20
35.	Retrofit safety curbs with New Jersey barrier	184	1	16(24)	31	75	75	50	5,190,000	0	77,000	0.20	20
36.	Paving shoulder: DBP (MP 0–59.1)		1	25(37)	29	20	20	20	1,300,000	0	26,000	0.19	12
37.	Grade-separated interchange: DBP–KY 472	1	1	5(10)	8	100	75	75	5,000,000	0	66,000	0.18	20
38.	Bridge deck repair	23	1	26(39)	49	10	10	10	1,725,000	0	14,000	0.11	20

Table 42. Recommended Improvement Alternatives *(Continued)*.

No.	Improvement	Accident Severity (3-Year Period) No.	Fatal	Injury	PDO	Percent Reduction Fatal	Injury	PDO	Improvement Costs ($)	Maintenance Costs ($)	Average Annual Benefits ($)	Benefit Cost Ratio	Life (yrs)
39.	Interchange lighting: MTP–I 64	1	0	0	4	50	50	50	100,000	500	600	0.04	20
40.	Truck escape ramp: MTP MP 32.9	1	1	2(3)	5	75	75	75	750,000	1,000	5,400	0.04	20
41.	Bridge widening: For bridges without full-width shoulders	231	1	15(23)	29	50	50	50	3,100,000	0	51,000	0.03	20
42.	Grade-separated interchange CP–Ringo Rd.	1	0	2(3)	8	100	75	75	5,000,000	0	4,600	0.01	20

*Two injury accidents resulting in three injuries.

Table 43. Numbers and Types of Improvements by Route for System Improvements.

Safety Improvement	Mtn	WKy	BG	Pur	Parkways Pen	Aud	DB	GR	Cum	Total
Clear gore area										
Remove rigid signs	2	8	11	4	5	0	0	0	0	30
Move light standard	2	2	2	0	0	0	2	0	0	8
Replace dual channel post	14	7	1	2	3	0	0	0	0	27
Remove guardrail	4	11	2	6	6	2	2	7	3	43
Remove curb	5	0	0	14	13	0	0	0	0	32
Replace rigid signs	27	50	4	4	22	3	0	0	0	110
Replace rigid lightpoles	30	80	0	0	0	0	0	0	0	110
Remove rock outcroppings (Miles)	2.0	1.6	0.8	0	0.3	0	0.2	0.1	0.9	5.9
Shield Rock Cuts (Miles)	3.9	14.4	10.8	0	5.5	0	15.0	5.6	17.9	73.1
Culvert Headwall Improvements	4	96	3	18	15	7	15	38	9	205
Replace Substandard Median Drainage Inlets	150	0	220	160	220	0	0	0	0	750
Toll Booth Improvements										
Crash Cushion	1	0	1	2	0	0	3	0	0	7
Rumble Strips	4	1	1	0	0	0	3	1	1	11
Transverse Strips	4	4	3	2	2	1	3	3	3	25
Bridge Widening	51	44	26	14	18	6	4	40	28	231
Change Guardrail End Treatment to BCT	672	773	445	262	352	96	507	416	525	4048
Median Crossover Improvements										
Remove	12	38	14	8	29	6	DNA	13	24	144
Sign	4	1	4	4	1	0	DNA	3	12	29
Pave	9	24	7	12	31	5	DNA	6	6	100
Guardrail transition to bridge end	68	128	0	16	92	8	12	28	40	392
Median and shoulder pier protection										
Add shoulder pier protection	31	86	4	3	2	0	0	4	4	134
Protect median pier	18	43	2	4	10	1	DNA	3	2	83
Attach guardrail to shoulder pier	11	2	9	3	11	0	6	20	35	97

Table 43. Numbers and Types of Improvements by Route for System Improvements *(Continued).*

Safety Improvement	Mtn	WKy	BG	Pur	Parkways Pen	Aud	DB	GR	Cum	Total
Bridge Deck Repair	7	5	6	0	1	0	1	3	0	23
Upgrade Gap Between Bridges										
Install guardrail and shrubs	0	25	0	0	0	0	DNA	0	0	25
Plant shrubs behind guardrail	16	1	14	23	22	4	DNA	20	12	112
Install Fasten Seatbelt Signs	24	27	18	19	32	6	20	20	18	184
Delineation for Shoulders Approaching Bridges Without Full-Width Shoulders	74	44	26	14	18	6	8	40	28	258
Delineation for Wrong Way Accidents	20	25	18	17	33	6	2	20	12	153
Replace and Upgrade Delineator Posts										
Replace post and lens	400	700	375	275	375	125	310	370	470	3400
Replace lens	800	1400	750	550	750	250	620	740	940	6800
Retrofit Safety Curbs with New Jersey Barrier	40	25	14	23	21	5	20	21	15	184

Table 44. Summary of Cost by Benefit-Cost Ratio (BCR).

BCR	Number of Projects	Total Cost
.01-.25	9	$42,511,000
.26-.50	2	4,784,000
.51-.75	0	0
.76-.99	3	2,476,000
1.00-1.25	7	6,380,700
1.26-1.50	4	105,400
1.50-2.00	4	812,000
2.00-2.99	4	1,079,000
3.00-4.99	3	266,000
5.00-9.99	3	49,300
10 or more	3	1,500
All	42	$58,464,900

total cost for all projects was $58.5 million. Of that total, $8.7 million were for projects having a benefit-cost ratio of 1.0 or above. There was a wide range in benefit-cost ratios from 0.01 for a grade-separated interchange to 185 for a curve warning sign. A significant portion of the cost for projects with very low ratios was for bridge widening, which would cost $23.1 million and would have a benefit-cost ratio of 0.03. Alternate improvements are recommended when one type of improvement was shown not to be economically feasible. For example, delineation of shoulders approaching bridges without full-width shoulders was proposed as an alternative to bridge widening.[7] It had a benefit-cost ratio of 1.14 and would provide some relief to the problem. Two projects for grade separation, with a cost of $10 million, also had very low benefit-cost ratios. Vehicle-actuated warning devices are recommended at these locations as a less expensive alternative. The less expensive alternative would address the problem; however, the potential for improvement would be reduced. The projects with very high benefit-cost ratios tended to be low-cost improvements at high-accident locations. Three other projects with a total cost of about $2.5 million had benefit-cost ratios close to 1.0 (0.79 to 0.98).

Priority Ranking

To priority rank improvement projects, construction costs and monetary benefits resulting from accident reductions must be known. Also, such information as interest rate, expected traffic volume growth rate, and annual maintenance costs is needed to perform an economic analysis; and priority ranking may be accomplished according to benefit-cost ratios. Given a budget, projects can be selected by dynamic programming. The dynamic programming model, as applied to Kentucky's High-Accident Spot Improvement Program, has been used to set priorities for improvement projects for various budgets.[6] Some changes in these computer programs were made for the Interstate Safety Improvement Program.[2] These revised programs were used in this study.

Input into the program included numbers of injuries, fatalities, and property-damage-only (PDO) accidents for each project location during the study period (three years). Percentage reductions for these accidents were also input along with improvement costs, annual maintenance costs, and assumed service life of each project. An interest rate of 10 percent and a volume growth rate of six percent per year were used. An example of output from the program is shown in Figure 1. The improvement involves replacing rigid sign supports over the entire toll-road system. The numbers of related fatalities (2), injuries (12), and property-damage-only accidents (10) are given first. Then a listing of costs ($440,000), service life (20 years), and annual maintenance costs (0) is given. The expected percentage reductions are given for various accident severities (75 percent reduc-

```
REF. NO.
   10                    REPLACE RIGID SIGNS

        ACCIDENT HISTORY  3.00YEARS.  MONTH  2.YEAR 80.  3 CAUSE.

ROADWAY                  NO.       NO.       NO.
CAUSE                    KILLED    INJURED   PDO
     1                     2.        0.        0.
     2                     0.       12.        0.
     3                     0.        0.       10.
 TOTALS                    2.       12.       10.

ALTERNATIVE     COST     LIFE    MAIN COST   EFFECT ON...      1      2      3
     1         440000.    20.        0.                     0.75   0.75  -0.70

  TOTAL BENEFITS AND COSTS

ALTERNATIVE          MAINTENANCE        COST        ACC BENEFIT
     1                       0.        440000.       1808333.

  BENEFIT/COST ANALYSIS. MAINTENANCE INCLUDED ***PRESENT WORTH METHOD***

ALTERNATIVE          MAINTENANCE        COST        ACC BENEFIT      BENEFIT/COST
     1                       0.        440000.       1253799.             2.85
```

Figure 1. Example output from dynamic programming with information about a safety improvement.

```
LOCATIONS, ALTERNATIVES, COSTS AND BENEFITS-ORDERED BY BENEFIT/COST RATIO

--LOCATION---LOCATION NAME----------------------------ALT-NUM--------COST------RETURN------B/C RATIO-----ACCUM COST--ACCUM RETURN
        1    CURVE WARNING SIGN DBP MP 14.9                1          500.       92476.      184.95          500.       92476.
        2    CURVE WARNING SIGN MTN PKWY MP 38.1           1          500.       34508.       69.02         1000.      126984.
        3    CURVE WARNING SIGN MTN PKWY MP 72.3           1          500.       16789.       33.58         1500.      143773.
        4    SEATBELT SIGNS AT ENT RAMPS AND INTERS        1        36800.     3199920.        8.69        38300.     4463693.
        5    DEER CROSSING SIGNS                           1         5000.       29258.        5.85        43300.      492951.
        6    ADD. DIRECTIONAL SIGNING 3 LOCATIONS          1         7500.       37529.        5.00        50800.      530480.
        7    ADD. SIGNING FOR EXIT RAMP GRP TO WKP         1         1000.        3637.        3.64        51800.      534117.
        8    REPLACE RIGID LIGHTPOLES                      1       220000.      681328.        3.10       271800.     1215444.
        9    VEHICLE-ACTUATED WARNING DEVICES 3 LOC        1        45000.      135368.        3.01       316800.     1350812.
       10    REPLACE RIGID SIGNS                           1       440000.     1253799.        2.85       756800.     2604611.
       11    MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES         1       610000.     1555751.        2.55      1366800.     4160362.
       12    ACTUATED WARNING SIGN MTN PKWY MP 32.9        1         5030.       11226.        2.25      1371800.     4171588.
       13    TRANSVERSE STRIPES SIX LOCATIONS              1        24000.       51902.        2.16      1395800.     4223490.
       14    ADD. DELINEATORS JJAP-US60 MTP-I64            1         1000.        1743.        1.74      1396800.     4225233.
       15    GUARDRAIL TRANSITION TO BRIDGE END            1       392000.      647423.        1.65      1788800.     4872656.
       16    UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS        1       400000.      621842.        1.55      2188800.     5494497.
       17    CONCRETE BARRIER WALL PP MP 7.1 500 FT        1        19000.       29394.        1.55      2207800.     5523892.
       18    FLASHING BEACONS SEVEN LOCATIONS              1         7000.       10205.        1.46      2214800.     5534096.
       19    SCREEN ON BRIDGE OVER PPKWY 2 LOC.            1         4000.        5744.        1.44      2218800.     5539840.
       20    DELINEATION FOR WRONG-WAY ACCIDENTS           1        23000.       31261.        1.36      2241800.     5571102.
       21    REPLACE AND UPGRADE DELINEATOR POSTS          1        71400.       90229.        1.26      2313200.     5661331.
       22    ICE ON SENSOR AND BRIDGE SIGN 8 LOC.          1        96000.      118715.        1.24      2409200.     5780046.
       23    DELINEATION FOR SHOULDERS APPR. BRIDGES       1        38700.       44164.        1.14      2447900.     5824210.
       24    TOLL BOOTH IMPROVEMENTS THREE KINDS           1       105000.      110125.        1.05      2552900.     5934336.
       25    CHANGE GUARDRAIL END-TREATMENT TO BCT         1     30360000.    31820339.        1.05      5588900.     9116675.
       26    PAVING SHOULDER P PKWY MP 30.0-45.0           1       330000.      345483.        1.05      5918900.     9461857.
       27    MEDIAN AND SHOULDER PIER PROTECTION 3         1      2641000.     2681952.        1.02      8559900.    12143809.
       28    CLEAR GORE AREA LIST OF FIVE                  1       134000.      135376.        1.01      8693900.    12279185.
       29    DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC        1       987000.      972145.        0.98      9680900.    13251330.
       30    DESLICKING MTN PKWY 3LOC DB PKWY 1LOC         1       206000.      185857.        0.90      9886900.    13437187.
       31    CULVERT/HEADWALL IMPROVEMENTS                 1      1283000.     1010065.        0.79     11169900.    14447251.
       32    UPGRADE GAP BETWEEN BRIDGES-SHRUBS            1       784000.      382094.        0.49     11953900.    14829346.
       33    SHIELD ROCK CUTS (73.1 MILES)                 1     40000000.    16214456.        0.41     51953900.    31043802.
       34    REMOVE ROCK OUTCROPPINGS.                     1       346000.       84357.        0.24     52299900.    31128159.
       35    RETROFIT SAFETY CURBS WITH NJ BARRIER         1      5190000.     1063476.        0.20     57489900.    32191635.
       36    PAVING SHOULDER DB PKWY (MP 0-59.1)           1      1300000.      246773.        0.19     58789900.    32438408.
       37    GRADE-SEPARATED INTERCHANGE DBP-KY472         1      5000000.      917989.        0.18     63789900.    33356397.
       38    BRIDGE DECK REPAIR                            1      1725000.      193143.        0.11     65514900.    33549540.
       39    TRUCK ESCAPE RAMP MTN PKWY MP 32.9            1       750000.       32487.        0.04     66264900.    33582027.
       40    INTERCHANGE LIGHTING MP I64                   1       100000.        3601.        0.04     66364900.    33585628.
       41    BRIDGE WIDENING (W/OUT FULL-WIDTH SHOU)       1     23100000.      711950.        0.03     89464900.    34297578.
       42    GRADE-SEPARATED INTERCHANGE CP-RINGORD        1      5000000.       63788.        0.01     94464900.    34361366.
```

Figure 2. Example output from dynamic programming showing a listing of projects in order by benefit-cost ratio.

tion for fatalities and injuries and 70 percent increase in property-damage-only accidents). Also, total benefits and costs are given along with present-worth values. A benefit-cost ratio of 2.85 could be realized from this improvement.

The program output includes a listing of all projects in order of benefit-cost ratio (Figure 2). The highest benefit-cost ratios were for low-budget improvements involving only signing. A total of 28 of the 42 projects had a benefit-cost ratio of 1.0 or higher. This listing provides a column of cumulative benefit-cost ratio.

The dynamic programming output was obtained for several assumed budgets ranging from one million to 30 million dollars in one-million-dollar increments. Lists of the recommended improvements for various budgets are given in APPENDIX H. An example of the type of output for each is shown in Figure 3. For this budget ($5 million), 16 projects were selected with a combined benefit-cost ratio of 1.64. The total costs and benefits of the selected projects are given. A summary of the costs and benefits for various budgets is given in Table 45. The combined benefit-cost ratio was over 1.0 up to a budget of $18 million, even though only $8.7 million of the individual projects had benefit-cost ratios over 1.0.

Table 45. Costs and Benefits for Various Budgets.

Budget (million)	Cost (million)	Benefit (million)	BCR
$ 3	$ 3.001	$ 6.223	2.07
6	5.998	9.361	1.56
9	9.000	12.350	1.37
12	11.954	14.829	1.24
15	15.001	15.712	1.05
17	16.400	16.539	1.01
18	17.700	16.786	0.95
21	20.996	17.331	0.83
24	23.640	17.881	0.76
27	26.590	18.520	0.70
30	29.615	18.960	0.64

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 5000000.

LOCATION #	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	319920.	8.69	8.69
5	DEER CROSSING SIGNS	1	5000.	29258.	349178.	5.85	8.35
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	352815.	3.64	8.24
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	10341142.	3.10	3.94
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	11695111.	3.01	3.80
10	REPLACE RIGID SIGNS	1	440000.	1253799.	24233310.	2.85	3.24
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	39790061.	2.55	2.93
12	ACTUATED WARNING WIGN MTN PKWY MP 32.9	1	5000.	11225.	39902886.	2.25	2.93
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	40042188.	2.16	2.91
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	40043931.	1.74	2.91
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	40691354.	1.65	2.64
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	53313196.	1.55	2.44
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	53342590.	1.55	2.43
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	53348334.	1.44	2.43
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	53379595.	1.36	2.42
22	ICE ON SENSOR AND BRIDGE SIGN 8 LOC.	1	96000.	118715.	53498311.	1.24	2.37
23	DELINEATION FOR SHOULDERS APPR. BRIDGES	1	38700.	44164.	53542475.	1.14	2.35
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	2681952.	82244427.	1.02	1.64
********** TOTALS **********			5001500.	8224427.	82244427.		1.64

10 ** (B X (A LOG UR) + C)
A LOG10 (ESUB)

Figure 3. Example output from dynamic programming showing the recommended list of improvements given a $5,000,000 budget.

Summary

This report presents proposed safety improvements for Kentucky's toll roads. The methodology used was based on a users' guide for preparation of a safety improvement program developed in an earlier report.[2] The primary methods of identifying needed improvements were an accident analysis and a field inventory. The accident analysis identified specific high-accident spots and sections. Also, accident rates were calculated for each toll road, and the types of accidents which had occurred in the three-year period were summarized. A separate 10-year analysis of fatal accidents was done. The field inventory was used to identify roadway features which are now substandard and in need of upgrading. Also, high-aceident spots and sections were investigated in the field. The benefits and costs for each improvement were estimated and used as input into a dynamic programming model which was used as a means of priority ranking the improvements.

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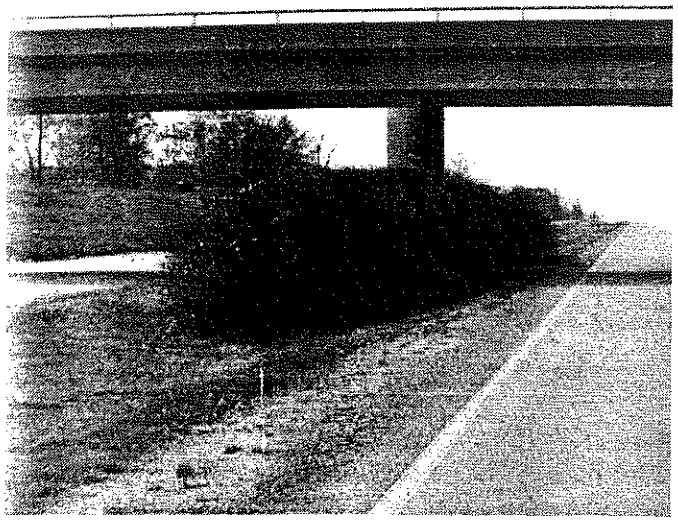
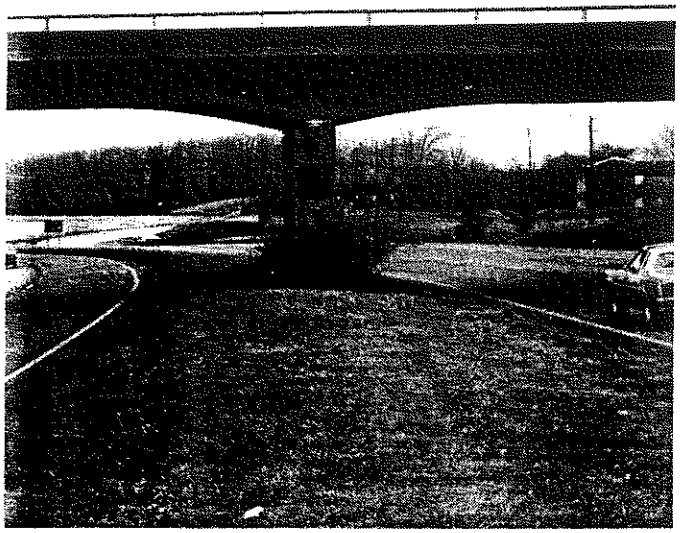
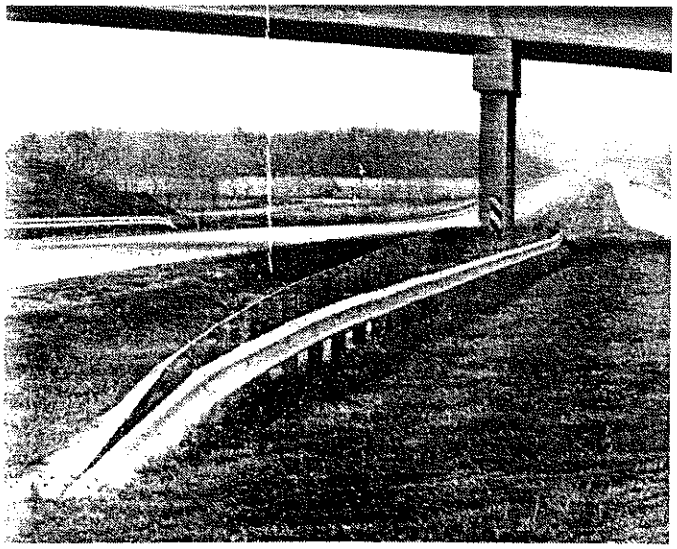
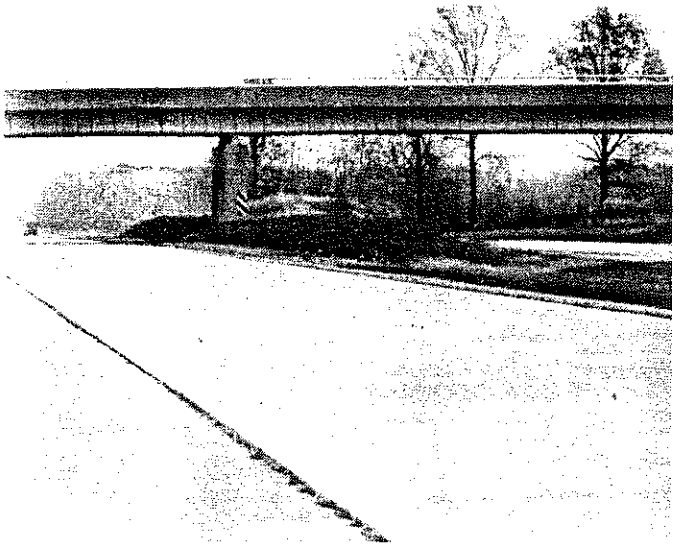
APPENDIX A

Photographs of Various Roadway Features









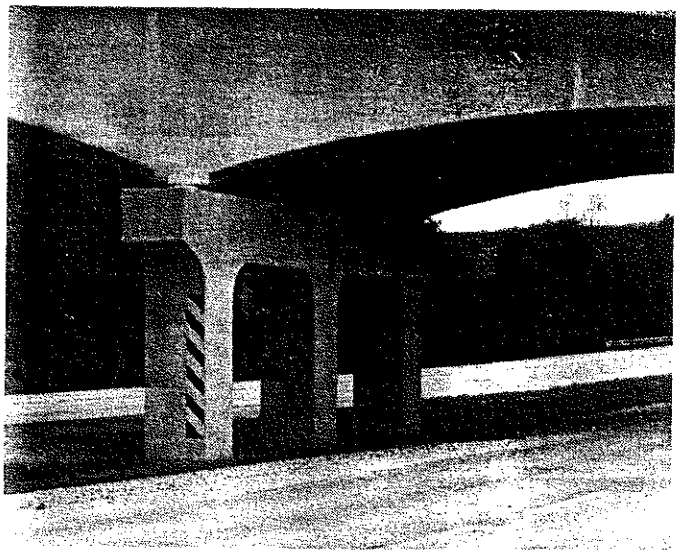


Figure A-1. Types of protectors at median-pier.

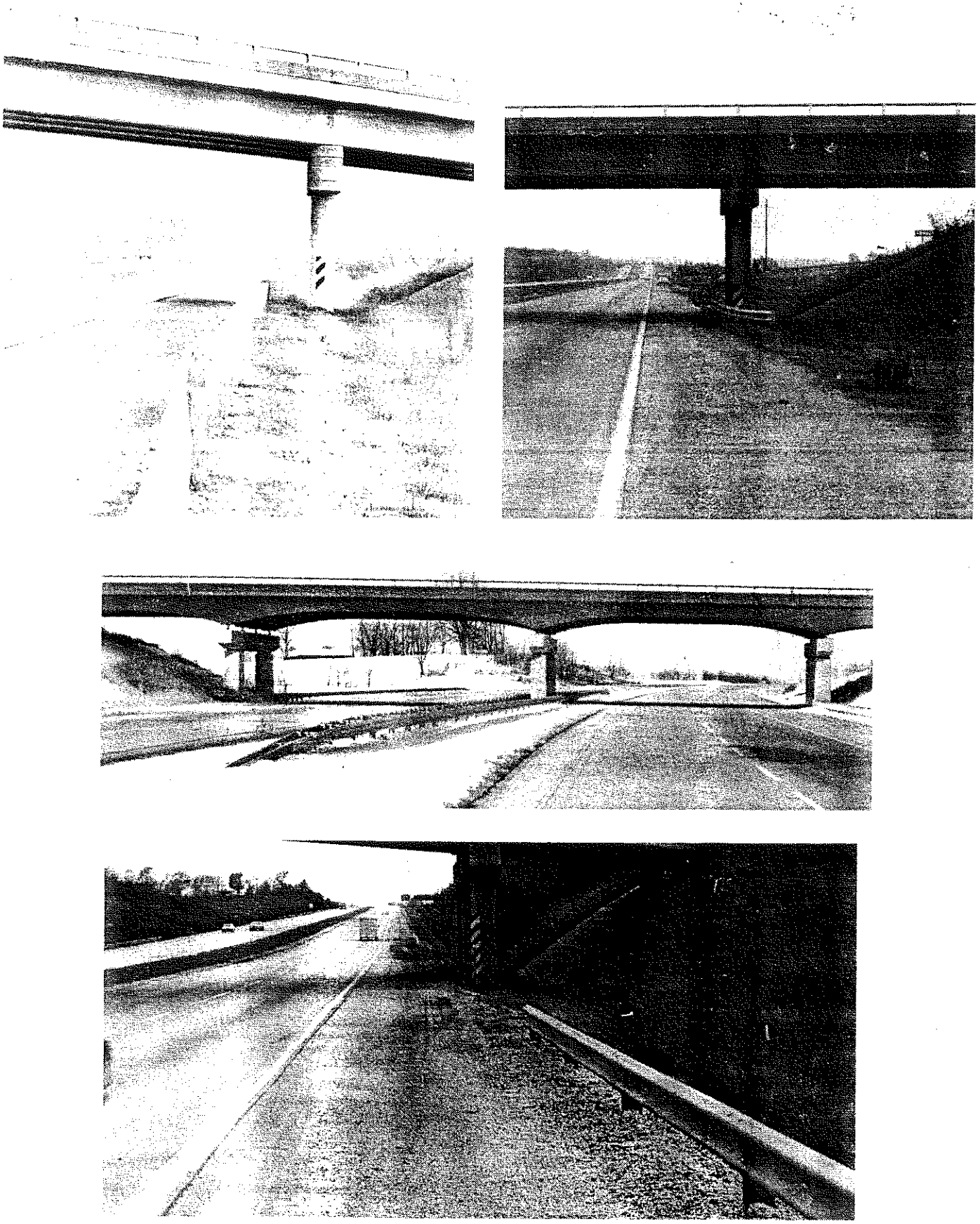


Figure A-2. Types of protectors at shoulder-pier.

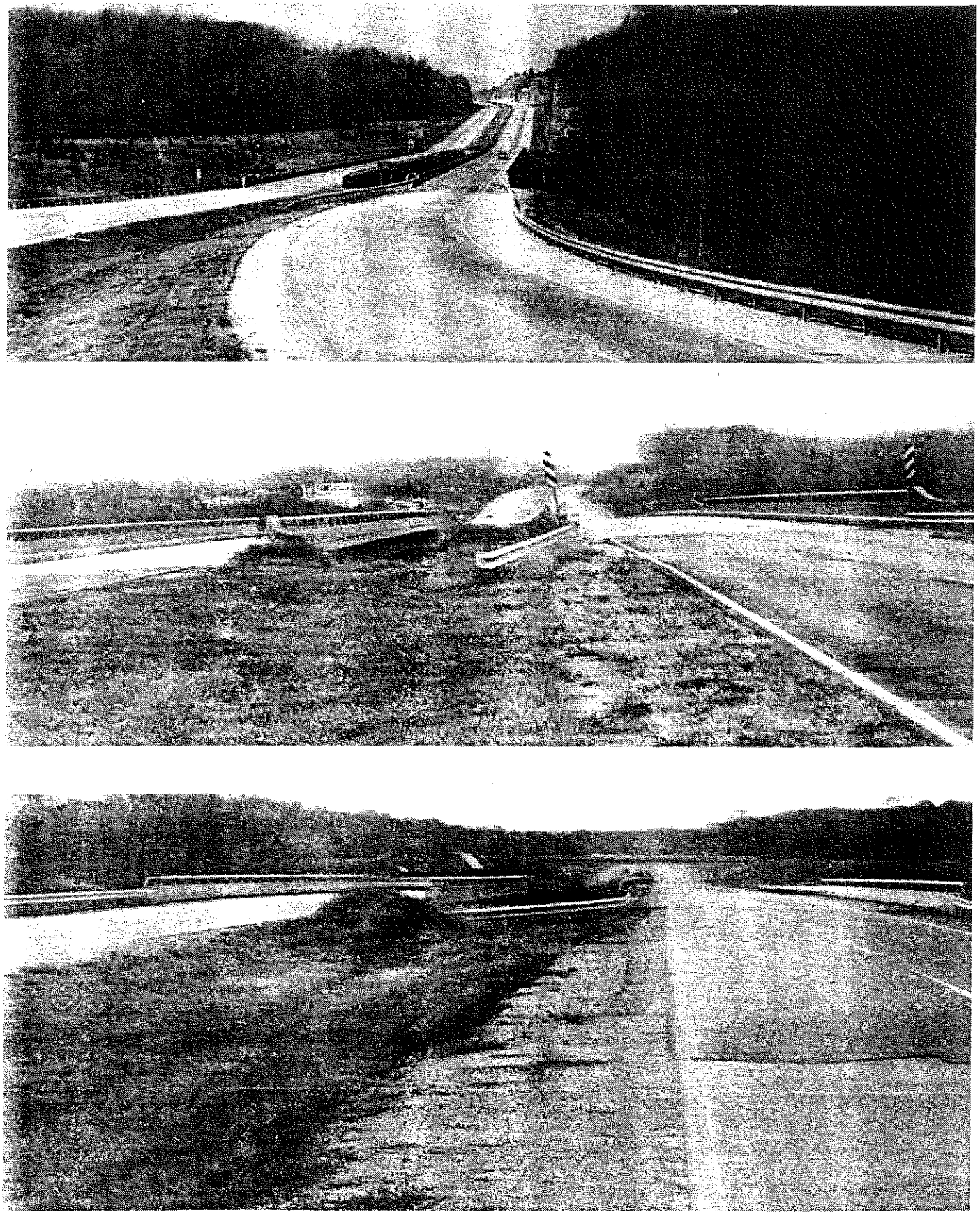


Figure A-3. Types of protections at gap between bridges.

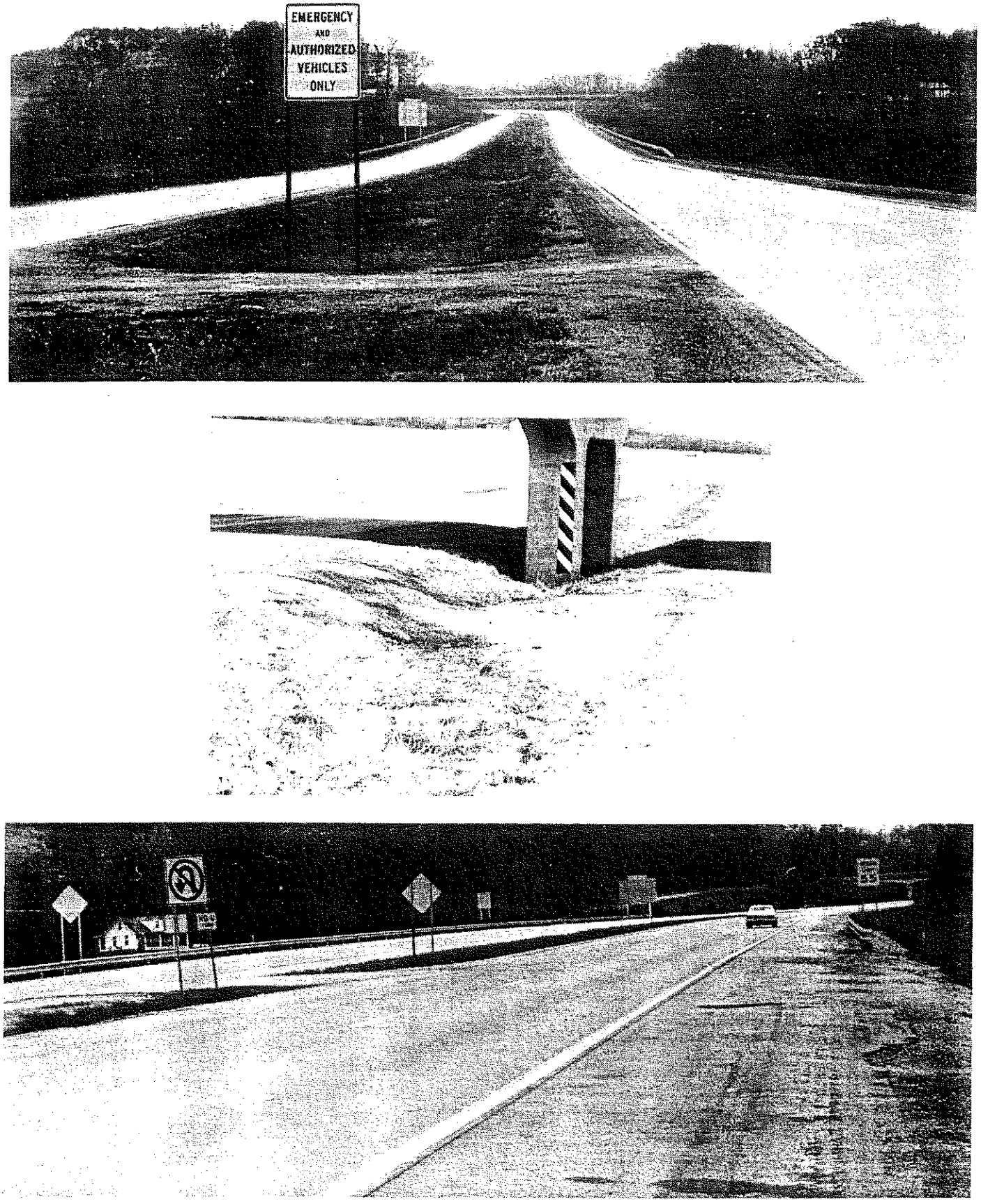


Figure A-4. Various types of median crossovers.

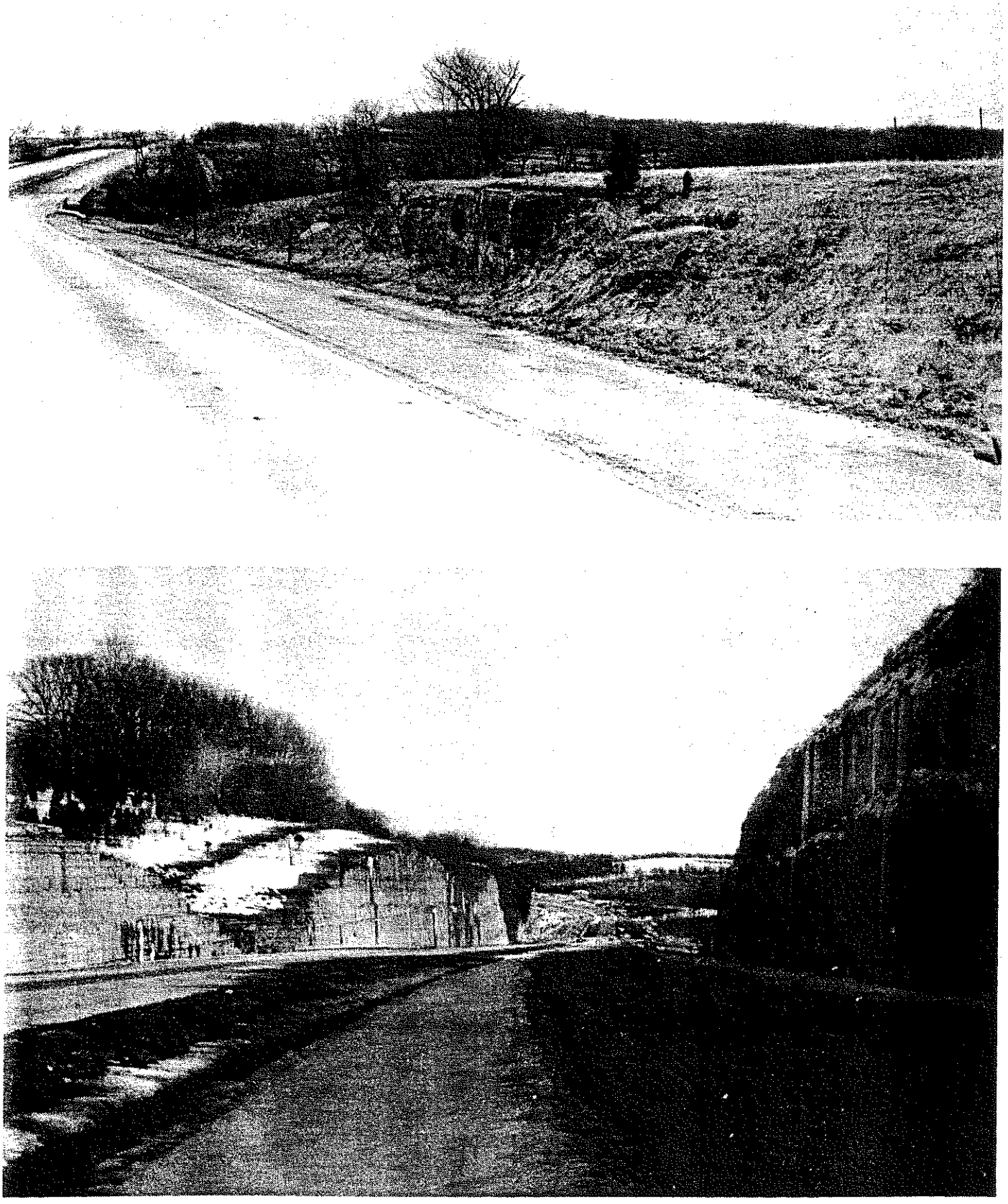


Figure A-5. Rock cut and rock outcropping.

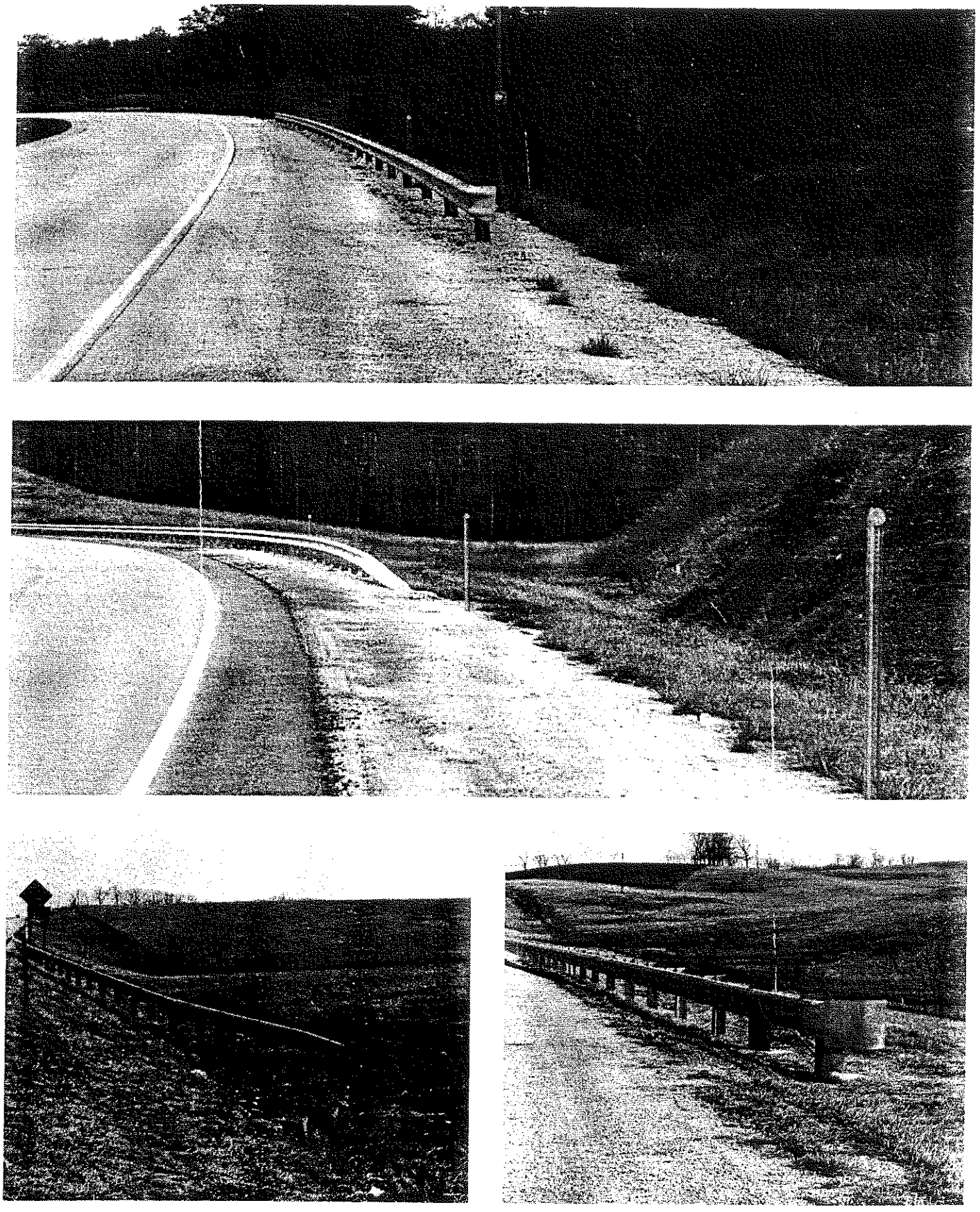


Figure A-6. Types of guardrail end treatments.

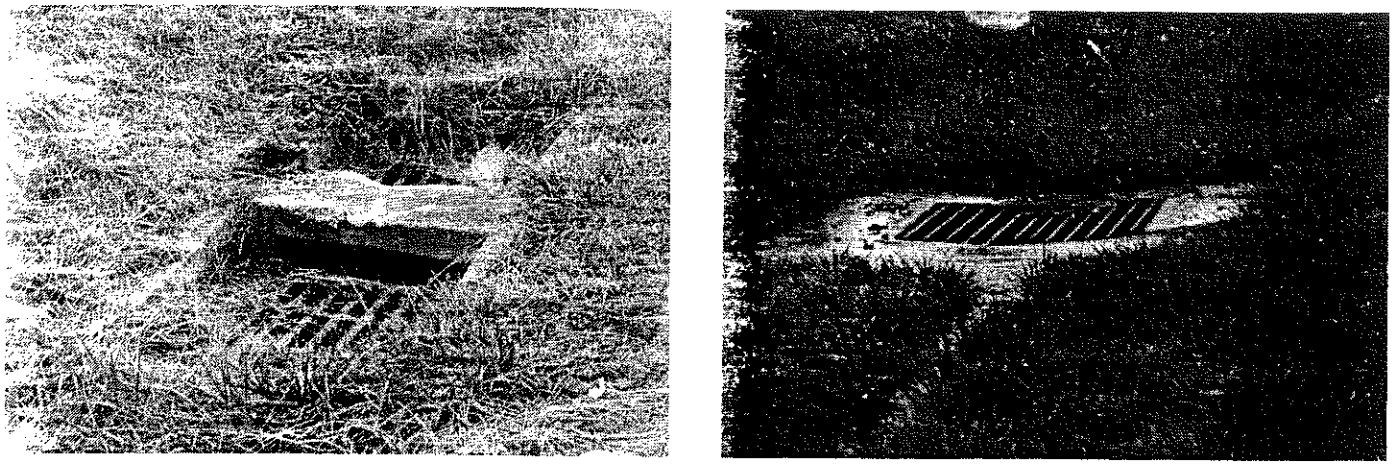


Figure A-7. Types of median drainage inlets.

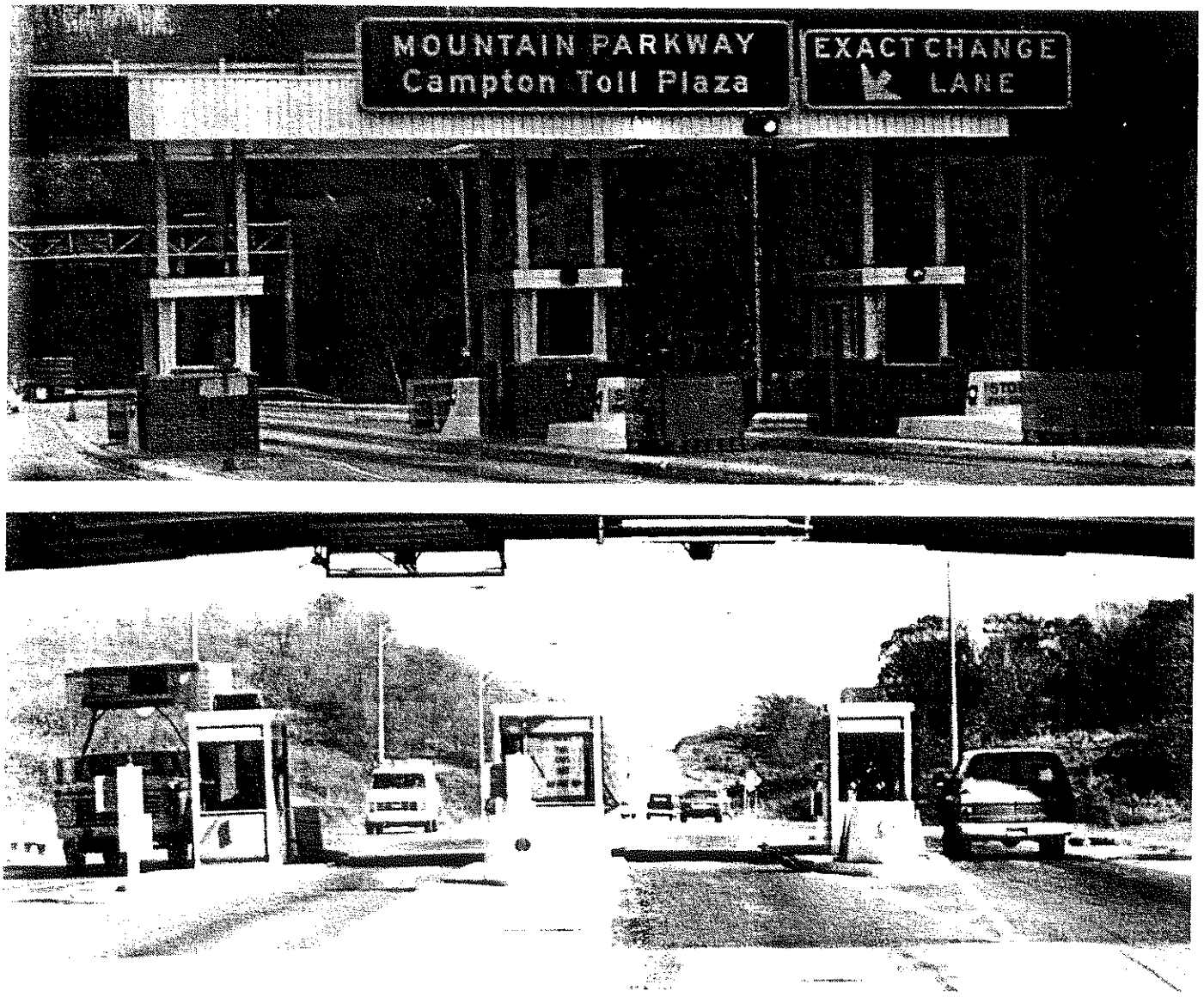


Figure A-8. Protected and unprotected toll booths.

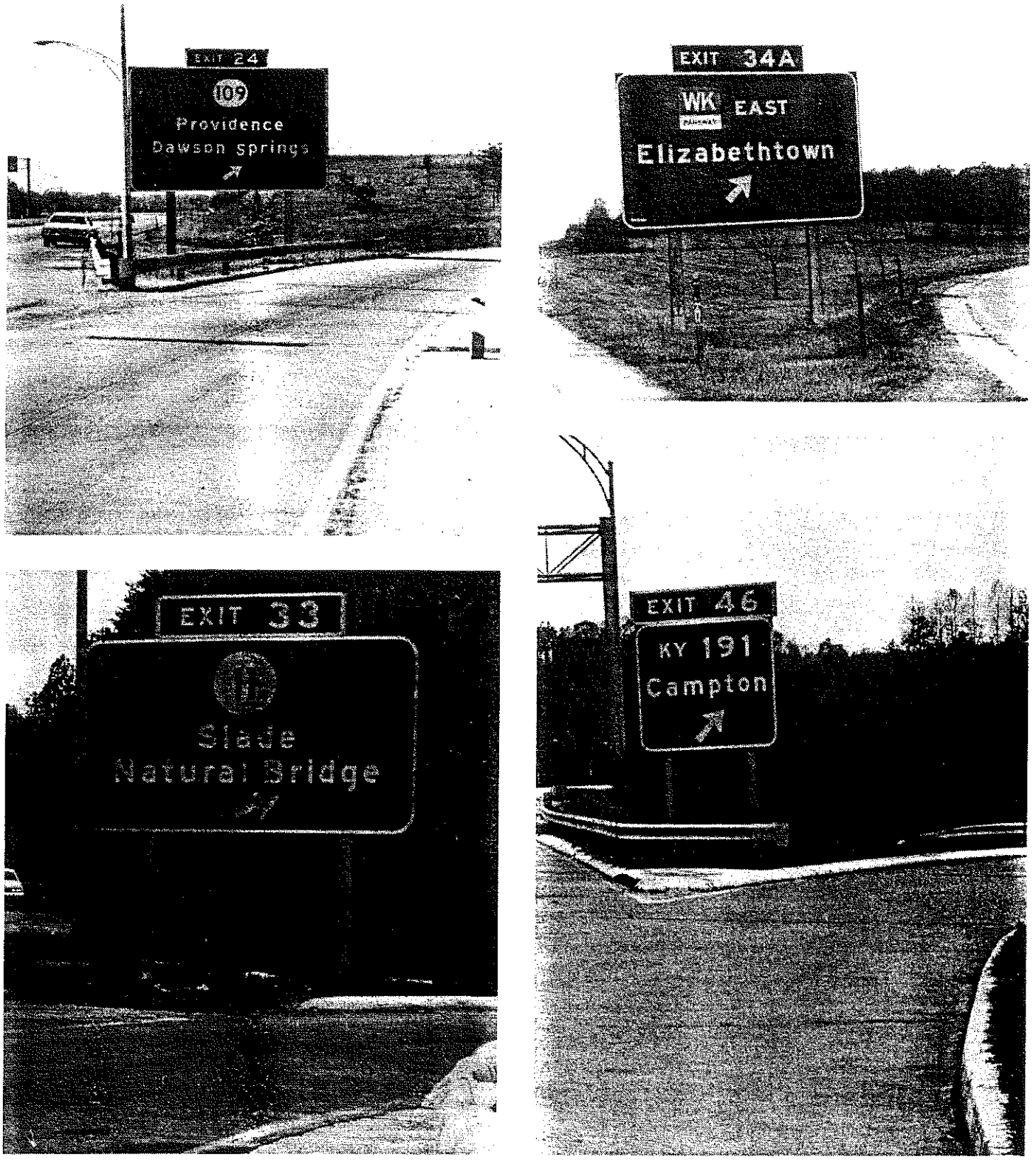


Figure A-9. Various obstructions in the gore.

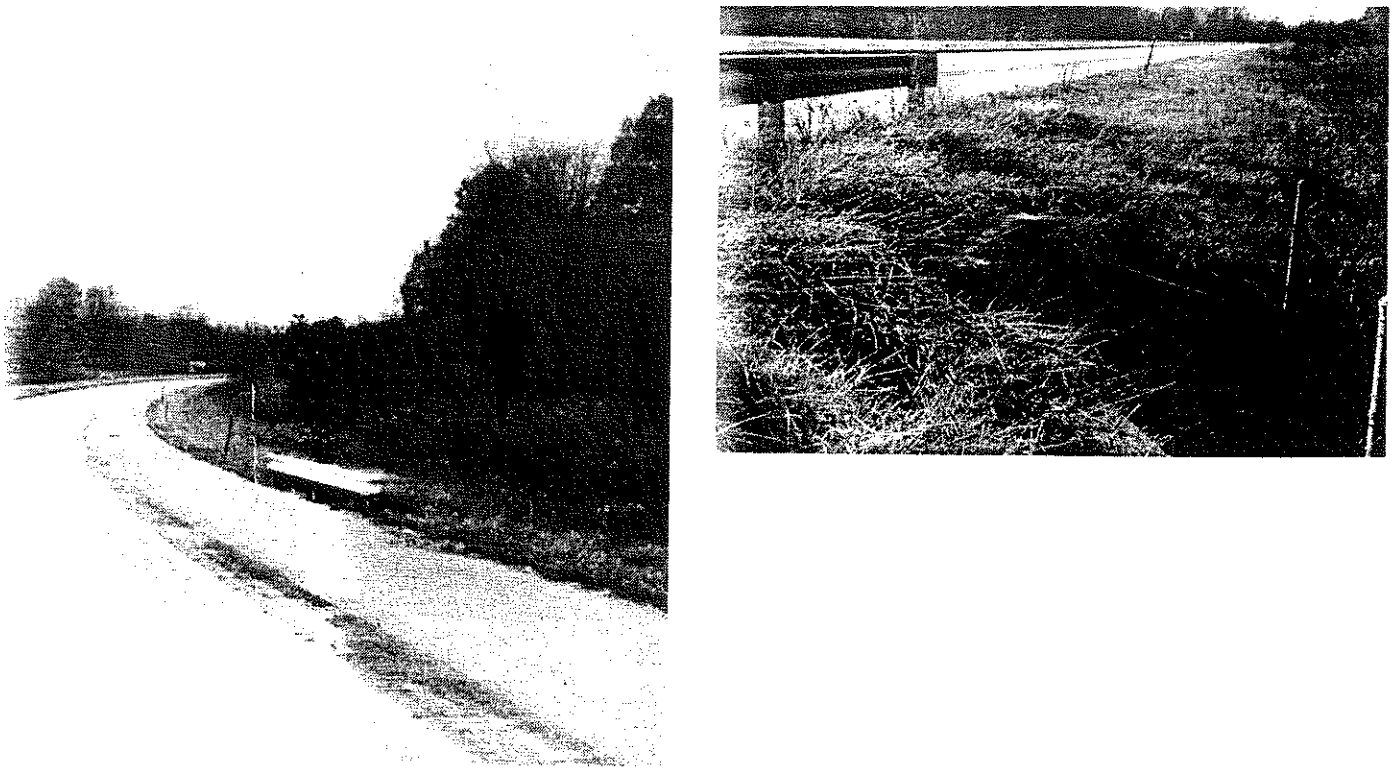


Figure A-10. Short section of guardrail at hazardous culvert headwall.

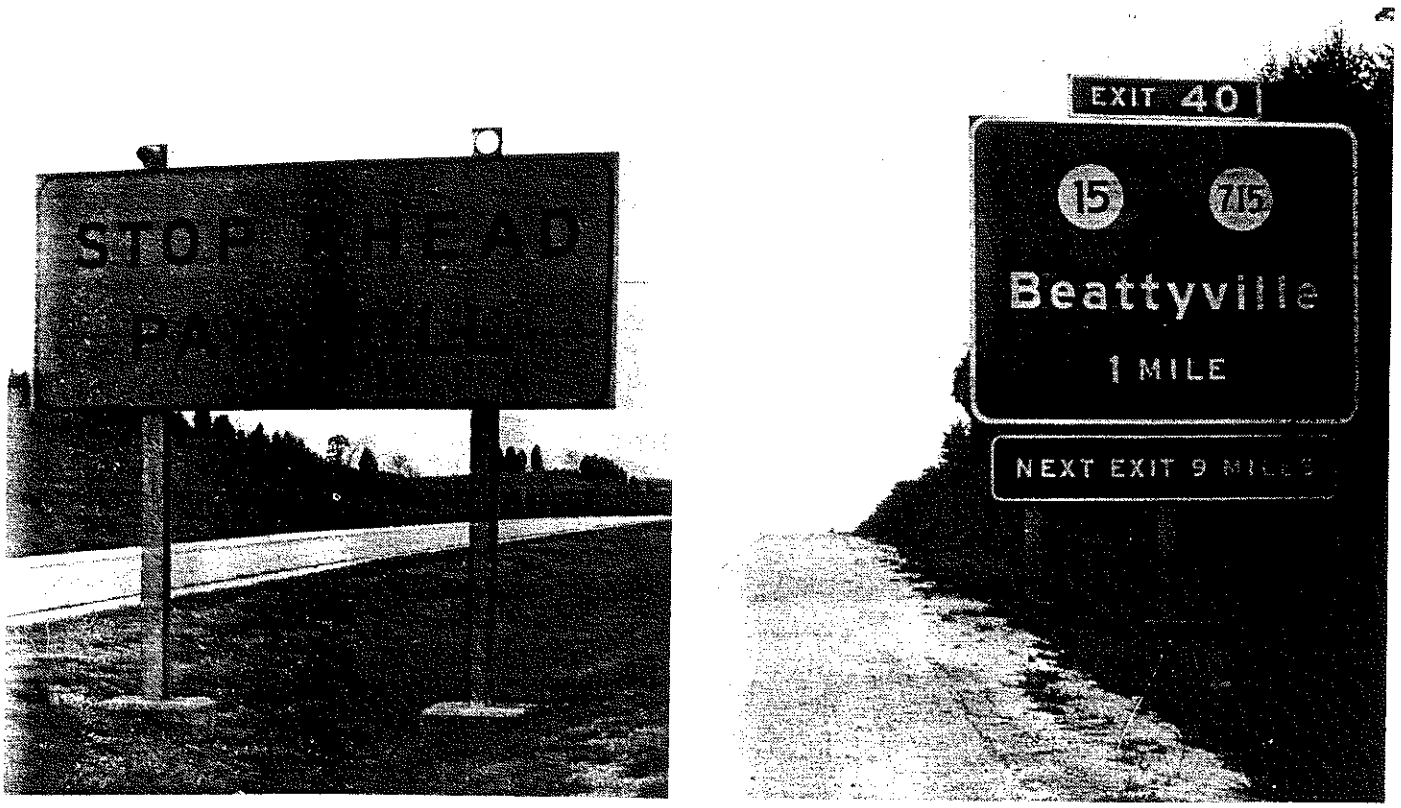


Figure A-11. Rigid sign supports.

Figure A-12. Breakaway sign supports.

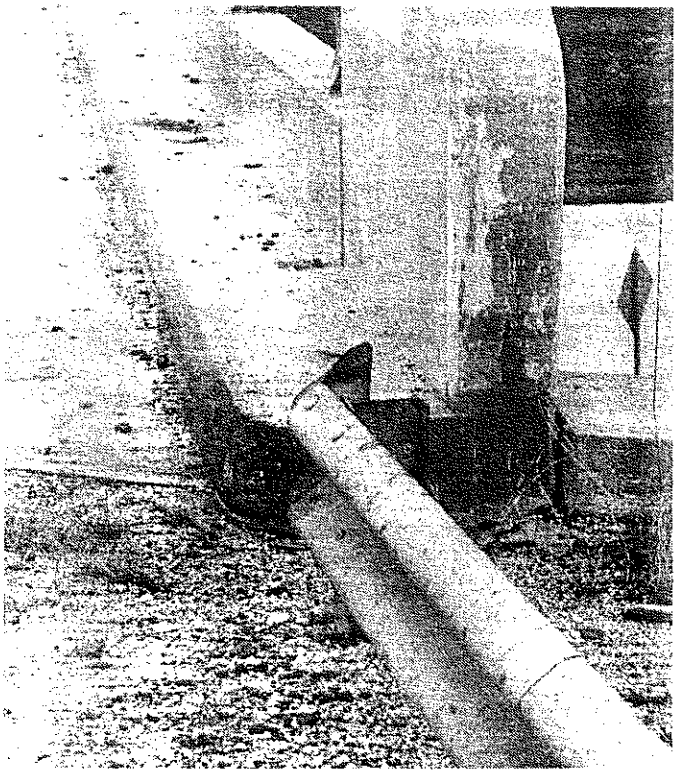


Figure A-13. Guardrail not attached to bridge.

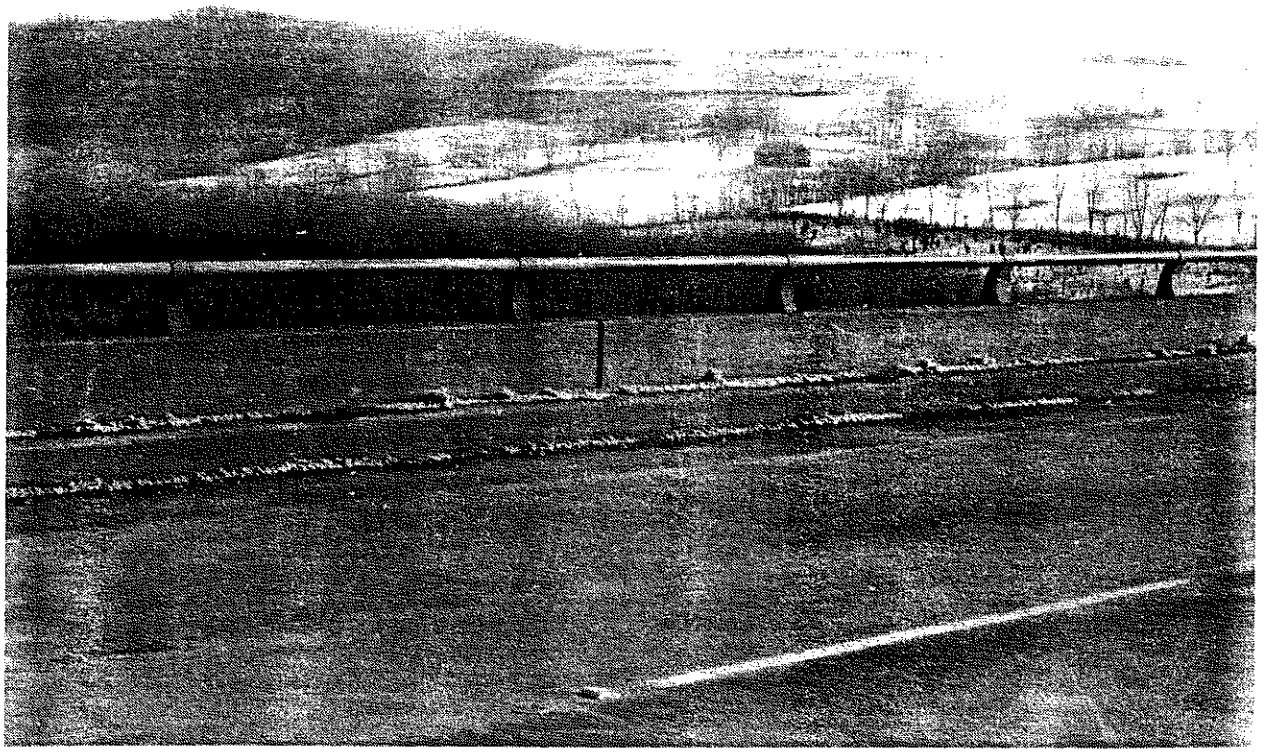


Figure A-14. Typical bridge rail and curb.

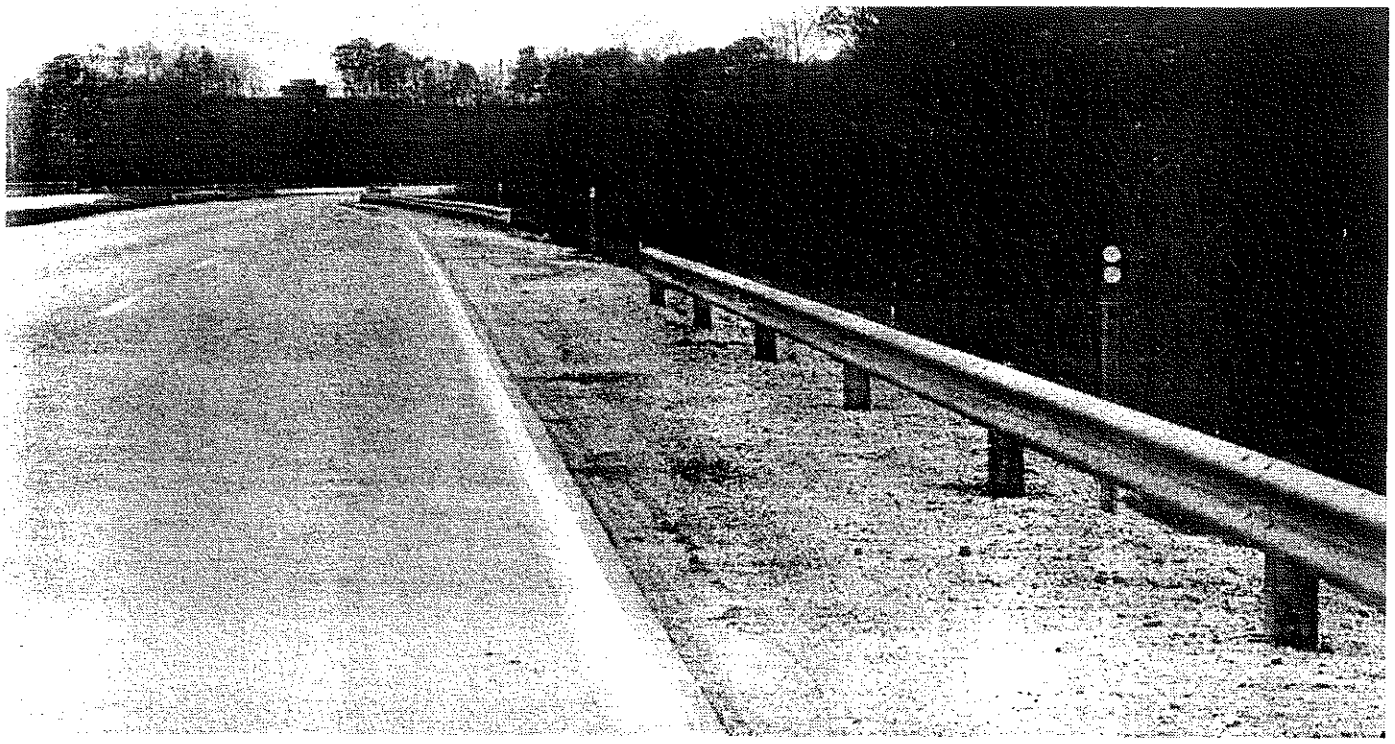


Figure A-15. Short gap between two sections of guardrail.

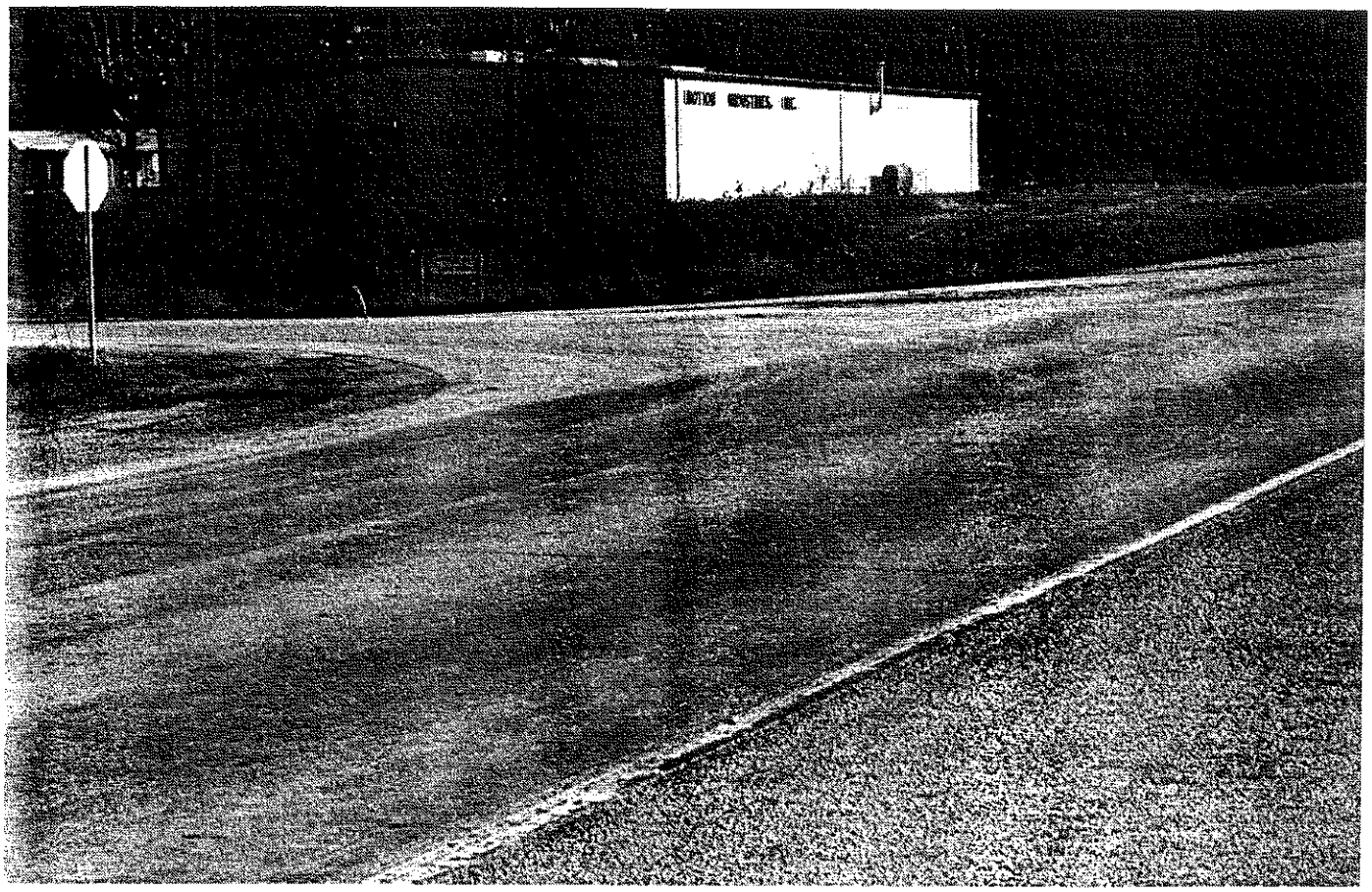


Figure A-16. Direct access permitted on Daniel Boone Parkway.

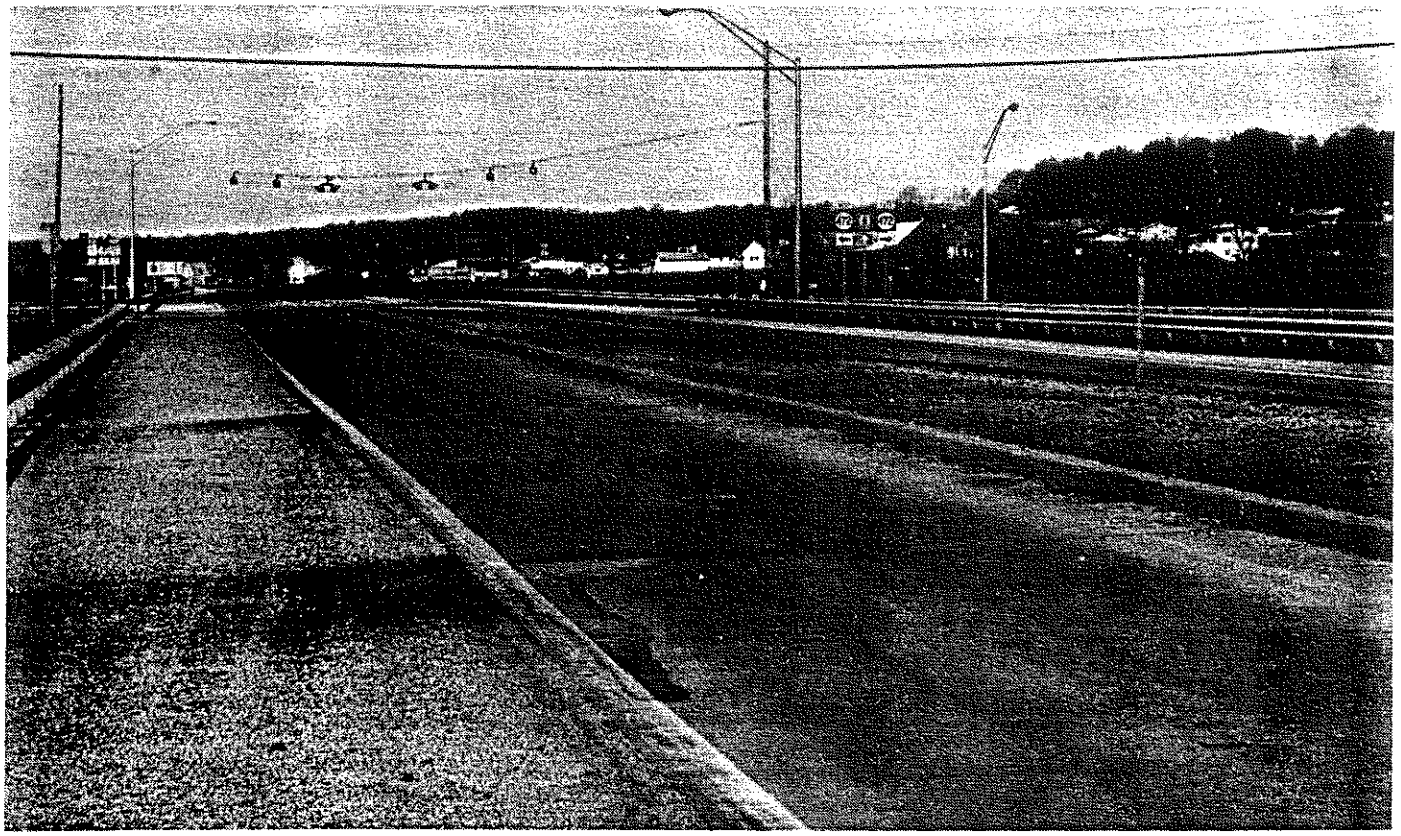


Figure A-17. High-accident location: intersection of Daniel Boone Parkway and KY 472.

Figure A-18. High-accident location: intersection of Cumberland Parkway and Ringo Road.

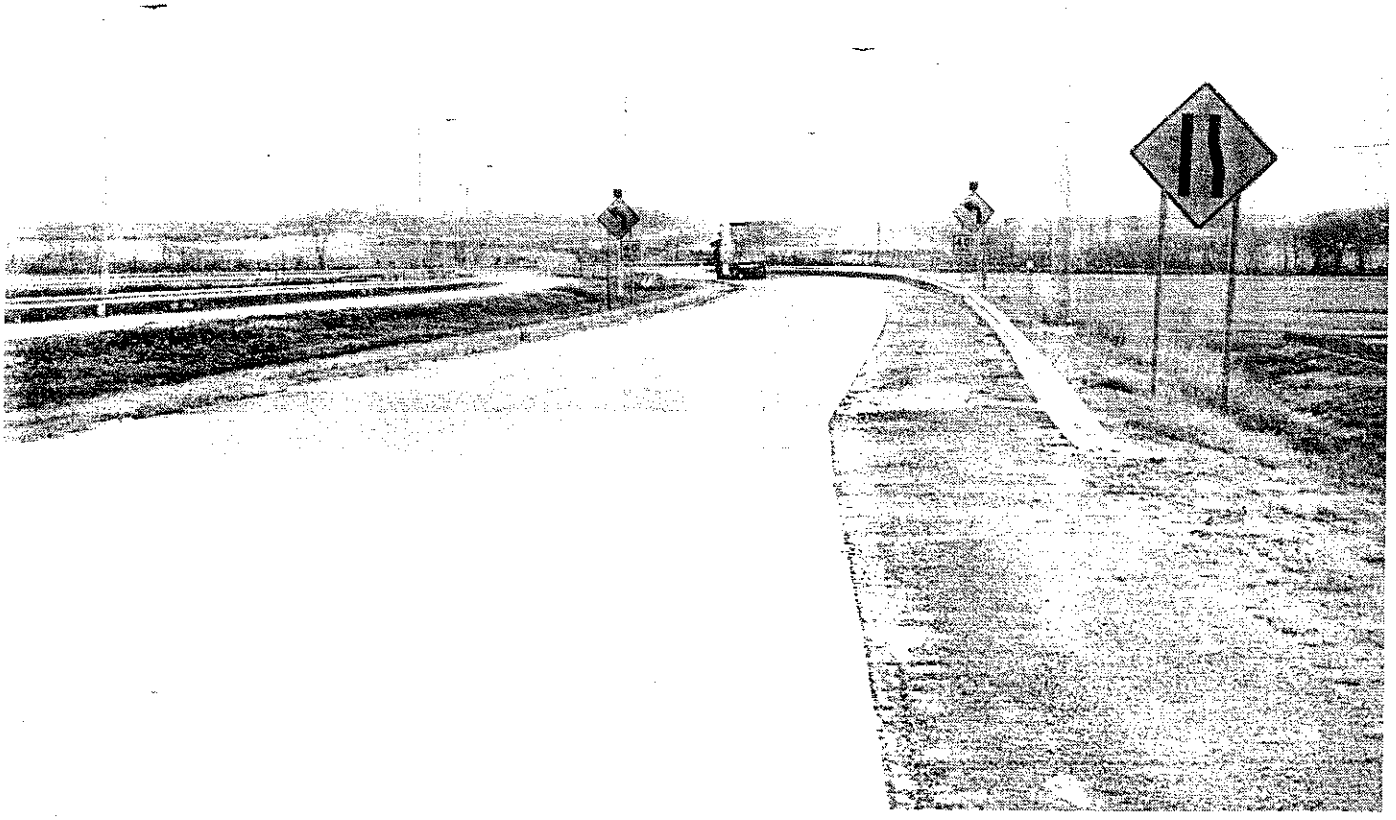


Figure A-19. High-fatality location: ramp from Green River Parkway to US 60 Bypass, westbound.

APPENDIX B

Summaries of Locations With High Numbers of Various Accident Types

Table B-1. Locations With Four or More Accidents Per Mile (1.6 km) During Darkness.

PARKWAY	BEGINNING MILEPOST	ENDING MILEPOST	NUMBER OF ACCIDENTS
MOUNTAIN	0.0	0.7	4
	9.7	10.4	6
	20.0	21.0	5
	26.9	27.6	5
	30.0	31.0	5
	32.8	33.4	4
	35.8	36.8	5
	37.2	38.2	5
WESTERN KENTUCKY	18.9	19.9	4
	44.4	45.3	4
	63.9	64.9	6
	71.6	72.6	5
	80.6	81.6	4
	93.0	94.0	4
	107.0	108.0	4
	114.4	115.0	4
	118.0	118.5	5
	120.3	120.8	4
	130.3	131.0	4
BLUEGRASS	3.3	4.3	4
	34.2	35.2	4
	60.9	61.3	4
PURCHASE	40.5	41.5	4
PENNYRILE	9.3	10.1	5
	20.2	20.8	4
	23.3	24.2	5
	26.2	27.0	4
	27.9	28.5	4
	29.0	29.7	7
	30.6	31.4	4
	32.0	32.9	4
	33.1	33.7	4
	34.2	34.8	6
	35.3	36.2	7
	36.4	37.4	16
	37.7	38.3	5
	38.8	39.8	8
	41.1	42.1	4
	43.4	44.0	5
	50.2	51.2	5
	51.5	52.2	6
	64.3	65.3	6
	66.8	67.6	5
	73.7	74.5	5
GREEN RIVER	23.0	23.6	4
	27.8	28.8	4
	31.5	32.3	5
	55.6	56.6	4

Table B-2. Locations With Three or More Guardrail Accidents In One Mile (1.6 km).

PARKWAY	BEGINNING MILEPOST	ENDING MILEPOST	NUMBER OF ACCIDENTS
MOUNTAIN	38.2	38.2	4
	42.4	43.4	3
	72.3	73.0	3
WESTERN KENTUCKY	22.0	23.1	4
	24.5	25.0	3
	37.0	37.8	3
	118.3	118.5	3
	120.3	121.2	3
BLUEGRASS	9.5	9.8	3
	11.1	11.8	4
	34.2	35.4	4
	36.0	37.0	3
PENNYRILE	25.9	26.9	4
	37.0	37.1	3
	44.3	45.3	7
	74.5	75.3	3
AUDUBON	15.7	16.4	3
DANIEL BOONE	2.3	3.0	3
	14.8	15.8	5
	29.7	30.6	3
	43.4	44.1	3
	56.3	56.9	3
	57.3	57.9	3
GREEN RIVER	1.7	2.7	3

Table B-3. Locations With Three or More Wet Pavement Accidents During Darkness In One Mile (1.6 km).

PARKWAY	BEGINNING MILEPOST	ENDING MILEPOST	NUMBER OF ACCIDENTS
MOUNTAIN	0.0	0.2	3
	10.2	10.6	4
	20.0	21.0	3
	26.9	27.5	3
	32.8	33.4	5
	33.9	34.5	4
	36.4	37.0	6
	38.0	38.6	10
	51.5	52.1	4
	53.9	54.1	3
	69.8	70.4	3
WESTERN KENTUCKY	94.1	95.0	3
	107.0	108.0	3
BLUEGRASS	4.6	5.5	3
PENNYRILE	34.0	34.7	3
	35.3	36.2	4
	36.5	37.5	4
	41.1	41.8	4
	42.2	43.1	4
	55.0	55.0	3
	59.0	59.9	4
	60.2	60.6	5
	62.6	62.6	4
	64.2	64.9	3
	67.4	67.9	3
	71.4	71.9	3
	75.8	76.8	3
DANIEL BOONE	2.3	2.3	4
	7.0	7.9	3
	24.5	24.8	3
	42.0	42.1	4

Table B-4. Locations With Five or More Wet Pavement Accidents In Two Miles (3.2 km).

PARKWAY	BEGINNING MILEPOST	ENDING MILEPOST	NUMBER OF ACCIDENTS
MOUNTAIN	10.1	10.9	7
	32.8	34.5	6
	35.2	36.0	5
	36.6	38.5	15
	52.0	54.0	5
WESTERN KENTUCKY	80.0	81.4	5
	83.2	85.2	6
	94.0	95.7	5
	118.0	119.8	8
	120.3	121.2	6
	134.3	135.9	6
BLUEGRASS	3.0	4.4	7
	9.5	11.5	8
	22.1	24.1	5
PENNYRILE	12.5	14.1	5
	28.3	29.5	8
	35.7	37.5	5
	60.6	62.6	5
DANIEL BOONE	42.0	43.9	5

Table B-5. Locations With Three or More Snow and Ice Accidents In One Mile (1.6 km).

PARKWAY	BEGINNING MILEPOST	ENDING MILEPOST	NUMBER OF ACCIDENTS
MOUNTAIN	10.1	10.9	7
	34.4	35.2	3
	36.0	36.9	3
	38.2	38.5	3
	40.7	41.3	3
	63.6	64.4	3
	72.3	72.4	3
WESTERN KENTUCKY	32.2	33.2	3
	63.9	64.0	3
	68.2	69.2	3
	71.8	72.1	3
	80.0	80.6	3
	83.2	84.0	3
	87.0	87.9	3
	118.3	119.3	5
	119.8	120.7	7
	127.0	127.8	3
	135.9	136.5	3
BLUEGRASS	3.0	3.6	5
	10.6	11.5	5
	23.2	24.1	4
	26.5	27.2	3
	39.0	39.6	3
	59.0	59.3	3
PENNYRILE	10.0	10.1	3
	28.3	29.2	8
	45.2	46.1	3
	50.1	50.8	4
	77.2	77.7	4
DANIEL BOONE	12.8	13.0	3
	26.9	27.4	3
	43.9	44.2	3
	56.0	56.6	3
GREEN RIVER	28.7	28.9	3
	42.1	43.0	3

Table B-6. Locations With Four or More Fatal or Injury Accidents In One Mile (1.6 km).

PARKWAY	BEGINNING MILEPOST	ENDING MILEPOST	NUMBER OF ACCIDENTS
MOUNTAIN	0.0	1.0	8
	1.2	1.8	4
	4.9	5.9	4
	7.0	7.5	4
	8.3	9.1	6
	14.7	15.7	4
	20.4	21.0	4
	35.8	36.8	4
	37.2	38.2	7
	38.3	39.1	5
	48.9	49.9	4
	71.4	72.4	5
WESTERN KENTUCKY	15.3	16.1	5
	32.1	33.1	4
	71.8	72.6	5
	87.9	88.7	4
	91.1	92.1	4
	107.0	108.0	6
	118.0	119.0	5
BLUEGRASS	3.6	4.6	4
	11.5	12.3	4
	29.2	29.9	4
PENNYRILE	7.0	8.0	4
	26.4	27.2	4
	27.6	28.5	4
	29.0	30.0	6
	30.1	39.0	5
	32.7	33.7	5
	36.1	37.1	8
	37.5	38.4	6
	39.0	39.8	6
	40.2	41.2	4
	41.3	42.2	4
	43.1	44.0	4
	51.2	52.2	5
DANIEL BOONE	14.8	15.8	5
	42.0	42.7	4
	43.4	44.2	4
	56.0	57.0	5
GREEN RIVER	1.9	2.3	4
	31.6	32.6	4

Table B-7. Locations With Eight or More Accidents In Five Miles (8.5 km) Due to Unsafe Speeds.

PARKWAY	BEGINNING MILEPOST	ENDING MILEPOST	NUMBER OF ACCIDENTS
MOUNTAIN	4.9	9.5	8
	10.1	12.0	10
	29.8	34.5	8
	35.2	38.5	17
WESTERN KENTUCKY	113.8	118.8	10
	119.0	123.5	12
PENNYRILE	7.0	12.0	8
	25.9	30.9	8
	32.7	37.5	11
	37.8	42.0	12
	43.1	47.3	8
	67.1	71.4	8
DANIEL BOONE	39.9	44.2	8

APPENDIX C

Analyses of Coded Accident Data

Table C-1. Number of Accidents by Year.

PARKWAY	YEAR 1976	1977	1978
MOUNTAIN	108	124	115
WESTERN KENTUCKY	117	151	170
BLUEGRASS	77	97	67
PURCHASE	29	31	26
PENNYRILE	113	153	180
AUDUBON	13	20	20
DANIEL BOONE	35	64	71
GREEN RIVER	52	72	63
CUMBERLAND	14	31	29
ALL	558	743	741

Table C-2. Summary of Accidents by Month.

MONTH	PERCENT OF TOTAL TYPE OF ACCIDENT MAINLINE	INTERCHANGE RELATED	BRIDGE RELATED	ALL
JANUARY	13.7	9.3	11.6	13.2
FEBRUARY	8.3	8.8	2.1	8.1
MARCH	5.7	7.2	5.3	6.5
APRIL	6.5	8.2	2.1	6.5
MAY	6.5	8.2	1.1	6.4
JUNE	7.5	7.2	6.3	7.5
JULY	8.3	6.7	7.4	8.0
AUGUST	9.3	6.2	7.4	8.9
SEPTEMBER	6.5	7.2	4.2	6.4
OCTOBER	9.2	12.9	6.3	9.4
NOVEMBER	11.7	11.9	27.4	12.4
DECEMBER	6.8	6.2	18.9	7.3

Table C-3. Summary of Accidents by Time of Accident.

TIME	PERCENT OF TOTAL TYPE OF ACCIDENT MAINLINE	INTERCHANGE RELATED	BRIDGES RELATED	ALL
MIDNIGHT-3AM	9.1	7.6	9.5	9.0
3AM-6AM	8.3	4.0	12.6	8.1
6AM-9AM	11.7	9.6	21.1	12.0
9AM-NOON	12.3	18.2	8.4	12.7
NOON-3PM	16.0	20.7	13.7	16.3
3PM-6PM	15.7	23.2	14.7	16.4
6PM-9PM	15.1	10.6	12.6	14.5
9PM-MIDNIGHT	11.8	6.1	7.4	11.1

Table C-4. Summary of Accidents by Road Surface Condition.

ROAD SURFACE CONDITION	PERCENT OF TOTAL TYPE OF ACCIDENT MAINLINE	INTERCHANGE RELATED	BRIDGE RELATED	ALL
DRY	63.9	72.4	36.1	63.4
WET	17.4	14.8	13.4	16.9
SNOW OR ICE	18.7	12.8	50.5	19.6

Table C-5. Summary of Accidents by Light Conditions.

LIGHT CONDITIONS	PERCENT OF TOTAL TYPE OF ACCIDENT MAINLINE	INTERCHANGE RELATED	BRIDGE RELATED	ALL
DAY	54.2	73.3	53.6	56.0
DAWN OR DUSK	4.6	2.6	5.2	4.4
DARKNESS (LIGHTED)	2.9	9.2	1.0	3.4
DARKNESS (NOT LIGHTED)	38.4	14.9	40.2	36.2
DARKNESS (ALL)	41.3	24.1	41.2	39.6

Table C-6. Severity of Accidents by Toll Road.

PARKWAY	SEVERITY INDEX	PERCENT INJURY ACCIDENTS	PERCENT FATAL ACCIDENTS
MOUNTAIN	2.74	37.4	2.6
WESTERN KENTUCKY	2.35	31.8	1.8
BLUEGRASS	2.21	30.0	0.4
PURCHASE	2.47	32.6	1.2
PENNYRILE	2.45	33.0	1.3
AUDUBON	3.02	47.2	1.9
DANIEL BOONE	2.80	34.7	4.7
GREEN RIVER	2.14	27.4	1.1
CUMBERLAND	3.78	52.3	4.5
ALL	2.49	33.5	1.9

Table C-7. Summary of Accidents by Most Severe Injury.

MOST SEVERE INJURY	PERCENT OF TOTAL TYPE OF ACCIDENT MAINLINE	INTERCHANGE RELATED	BRIDGE RELATED	ALL
FATALITY	2.0	0.5	2.1	1.9
INCAPACITATING	8.6	4.0	7.2	8.1
NON-INCAPACITATING INJURY	13.9	13.6	23.7	14.3
POSSIBLE INJURY	10.8	10.6	6.2	10.6
NONE	64.6	71.2	60.8	65.1

Table C-8. Summary of Accidents by Type.

TYPE	PERCENT OF TOTAL TYPE OF ACCIDENT MAINLINE	INTERCHANGE RELATED	BRIDGE RELATED	ALL
COLLISION WITH OTHER MOTOR VEHICLE	21.7	51.6	14.0	24.1
COLLISION WITH FIXED OBJECT	48.6	32.9	76.9	48.5
OTHER SINGLE VEHICLE	21.1	13.3	9.1	19.8

Table C-9. Summary of Accidents by Roadway Character.

ROADWAY CHARACTER	PERCENT OF TOTAL TYPE OF ACCIDENT MAINLINE	INTERCHANGE RELATED	BRIDGE RELATED	ALL
STRAIGHT & LEVEL	54.4	40.9	49.5	52.9
STRAIGHT & GRADE	27.4	22.2	32.0	27.1
STRAIGHT & HILLCREST	2.5	2.0	3.1	2.5
CURVE & LEVEL	4.7	6.1	2.1	4.7
CURVE & GRADE	10.0	27.3	12.4	11.8
CURVE & HILLCREST	1.0	1.5	1.0	1.0

Table C-10. Summary of Accidents with Given Human, Vehicular, or Environmental Factors.

TYPE OF FACTOR	SPECIFIC FACTOR	PERCENT OF TOTAL TYPE OF ACCIDENT MAINLINE	INTERCHANGE-RELATED	BRIDGE-RELATED	ALL
HUMAN	UNSAFE SPEED	18.0	15.2	20.9	17.8
	FAILURE TO YIELD RIGHT OF WAY	3.0	15.6	0.9	4.9
	FOLLOWING TOO CLOSE	1.7	2.6	2.7	1.9
	IMPROPER PASSING	0.8	0.3	0.9	0.5
	DISREGARD TRAFFIC CONTROLS	0.4	1.3	2.7	0.6
	TURNING IMPROPERLY	1.1	3.6	0.0	1.4
	ALCOHOL INVOLVEMENT	6.3	4.0	5.5	6.0
	SICK	0.2	0.0	0.0	0.2
	FELL ASLEEP	7.8	1.3	4.5	6.9
	LOST CONSCIOUSNESS	0.2	1.0	0.9	0.4
	DRIVER INATTENTION	10.7	11.6	15.5	11.0
	DISTRACTION	1.4	0.3	2.7	1.3
	PHYSICAL DISABILITY	0.3	0.0	0.0	0.3
	OTHER	4.6	4.0	9.1	4.7
VEHICULAR	BRAKES DEFECTIVE	2.2	3.0	3.1	1.9
	HEADLIGHTS DEFECTIVE	0.1	0.0	0.0	0.1
	OTHER LIGHTING DEFECTS	0.3	1.5	0.0	0.4
	STEERING FAILURE	1.2	0.5	0.0	1.1
	TIRE FAILURE/INADEQUATE	5.4	3.0	5.1	5.1
	TOW HITCH DEFECTIVE	1.0	1.0	2.0	1.1
	OVER OR IMPROPER LOAD	0.6	0.5	1.0	0.6
	OVERSIZE LOAD ON VEHICLE	0.7	0.5	1.0	0.7
	OTHER	5.6	1.5	1.0	5.0
ENVIRONMENTAL	ANIMAL'S ACTION	9.8	1.0	2.0	8.6
	GLARE	0.1	1.4	0.0	0.2
	VIEW OBSTRUCTED/LIMITED	0.9	1.9	0.0	1.0
	DEBRIS IN ROADWAY	1.2	0.5	0.0	1.2
	IMPROPER/NON-WORKING TRAFFIC CONTROLS	0.1	0.5	2.0	0.2
	SHOULDERS DEFECTIVE	0.6	0.0	1.0	0.5
	HOLES/DEEP RUTS/BUMPS	0.3	0.0	0.0	0.2
	ROAD UNDER CONSTRUCTION	1.2	0.0	6.1	1.3
	IMPROPERLY PARKED VEHICLES	0.5	0.0	0.0	0.4
	FIXED OBJECT	0.4	0.5	0.0	0.4
	SLIPPERY SURFACE	21.3	12.1	48.0	22.1
	WATER POOLING	1.4	0.0	1.0	1.2
	OTHER	2.5	1.0	2.0	2.3

APPENDIX D

Fatal Accident Analysis

Table D-1. Locations With Critical Number of Fatal Accidents.

CRITERIA	PARKWAY	MILEPOSTS	NUMBER OF FATAL ACCIDENTS
FOUR ACCIDENTS IN FIVE MILES (8.0 KM)	MOUNTAIN	56.4-61.4 72.0-74.9	4 4
	WESTERN KENTUCKY	41.0-45.3 50.2-55.6	4 5
	BLUEGRASS	22.9-27.6 65.1-39.5 45.2-50.0	4 4 5
	PENNYRILE	56.6-58.6	4
TWO ACCIDENTS IN 0.3 MILE (0.5 KM)	MOUNTAIN	6.4 31.2-31.3 72.0-72.1	2 2 2
	WESTERN KENTUCKY	50.2-50.5 76.2-76.4	3 2
	BLUEGRASS	27.4-27.6	2
	PENNYRILE	58.0	2
	AUDUBON	23.6	2
	DANIEL BOONE	3.0-3.1	2
	GREEN RIVER	0.0-0.2 70.3	2 3

Table D-2. Summary of Fatal Accidents by Route.

PARKWAY	NUMBER OF FATAL ACCIDENTS	PERCENTAGE OF TOTAL
MOUNTAIN	28	23
WESTERN KENTUCKY	27	22
BLUEGRASS	19	16
PURCHASE	2	2
PENNYRILE	16	13
AUDUBON	2	2
DANIEL BOONE	14	12
GREEN RIVER	9	7
CUMBERLAND	4	3

Table D-3. Summary of Fatal Accidents by Year.

YEAR	NUMBER OF FATAL ACCIDENTS	PERCENTAGE OF TOTAL
1970	13	11
1971	7	6
1972	13	11
1973	22	18
1974	8	6
1975	11	9
1976	10	8
1977	12	10
1978	12	10
1979	13	11

Table D-4. Summary of Fatal Accidents by Month.

MONTH	NUMBER OF FATAL ACCIDENTS	PERCENTAGE OF TOTAL
JANUARY	11	9
FEBRUARY	3	2
MARCH	6	5
APRIL	7	6
MAY	6	5
JUNE	12	10
JULY	17	14
AUGUST	18	15
SEPTEMBER	8	7
OCTOBER	7	6
NOVEMBER	17	14
DECEMBER	9	7

Table D-5. Summary of Fatal Accidents by Hour.

HOUR	NUMBER OF FATAL ACCIDENTS	PERCENTAGE OF TOTAL
MIDNIGHT-3AM	17	14
3AM-6AM	9	7
6AM-9AM	10	8
9AM-NOON	19	16
NOON-3PM(15)	17	14
3PM-6PM(18)	20	17
6PM-9PM(21)	18	15
9PM-MIDNIGHT	11	9

Table D-6. Summary of Fatal Accidents by Light Conditions.

LIGHT CONDITION	NUMBER OF ACCIDENTS	PERCENTAGE OF TOTAL
DAY	59	49
DAWN-DUSK	6	5
DARKNESS-NOT LIGHTED	55	45
DARKNESS-LIGHTED	1	1

Table D-7. Summary of Fatal Accidents by Road Surface Condition.

ROAD SURFACE CONDITION	NUMBER OF ACCIDENTS	PERCENTAGE OF TOTAL
DRY	91	77
WET	22	18
SNOW/ICE	5	4
SLUSH	1	1

Table D-8. Summary of Fatal Accidents by Contributing Factor.

TYPE	FACTOR	NUMBER OF ACCIDENTS	PERCENTAGE OF TOTAL
HUMAN	UNSAFE SPEED	32	19
	FAILED TO YIELD RIGHT-OF-WAY	10	6
	DISREGARD TRAFFIC CONTROLS	1	1
	TURNING IMPROPERLY	1	1
	ALCOHOL INVOLVEMENT	21	13
	FELL ASLEEP	22	13
	DRIVER INATTENTION	15	9
	DISTRACTION	2	1
	OTHER HUMAN FACTOR	10	6
VEHICULAR	BRAKES DEFECTIVE	1	1
	HEADLIGHTS DEFECTIVE	1	1
	OTHER LIGHTING DEFECTS	1	1
	TIRE FAILURE/INADEQUATE	4	2
	OVER OR IMPROPER LOAD	1	1
	OTHER VEHICULAR FACTOR	15	9
ENVIRONMENTAL	ANIMAL ACTION	1	1
	DEBRIS IN ROADWAY	1	1
	HOLES/DEEP RUTS/BUMPS	1	1
	CONSTRUCTION/MAINTENANCE	3	2
	SLIPPERY SURFACE	17	1
	WATER POOLING	1	1
	OTHER ENVIRONMENTAL FACTORS	6	4

Table D-9. Summary of Fatal Accidents by Vehicle Type.

VEHICLE TYPE	NUMBER OF ACCIDENTS	PERCENTAGE OF TOTAL
AUTOS OR PICKUP TRUCKS	94	79
SINGLE UNIT TRUCKS	5	4
COMBINATION TRUCKS	13	11
MOTORCYCLES	4	3
PEDESTRIANS	3	3

Table D-10. Summary of Fatal Accidents by Type of Location.

LOCATION	NUMBER OF ACCIDENTS	PERCENTAGE OF TOTAL
BRIDGE	14	12
INTERSECTION	12	10
MAINLINE	95	78

Table D-11. Types of Fixed Objects Most Frequently Involved In Fatal Accidents.

TYPE OF FIXED OBJECT	PERCENT OF ALL FIXED OBJECT FATAL ACCIDENTS
GUARDRAIL	39
BRIDGE PIER	22
BRIDGE	14
SIGN	8
CULVERT	5
ROCK CUT	3
OTHER	8

APPENDIX E

Locations of Median Crossovers, Interchanges, and County Lines

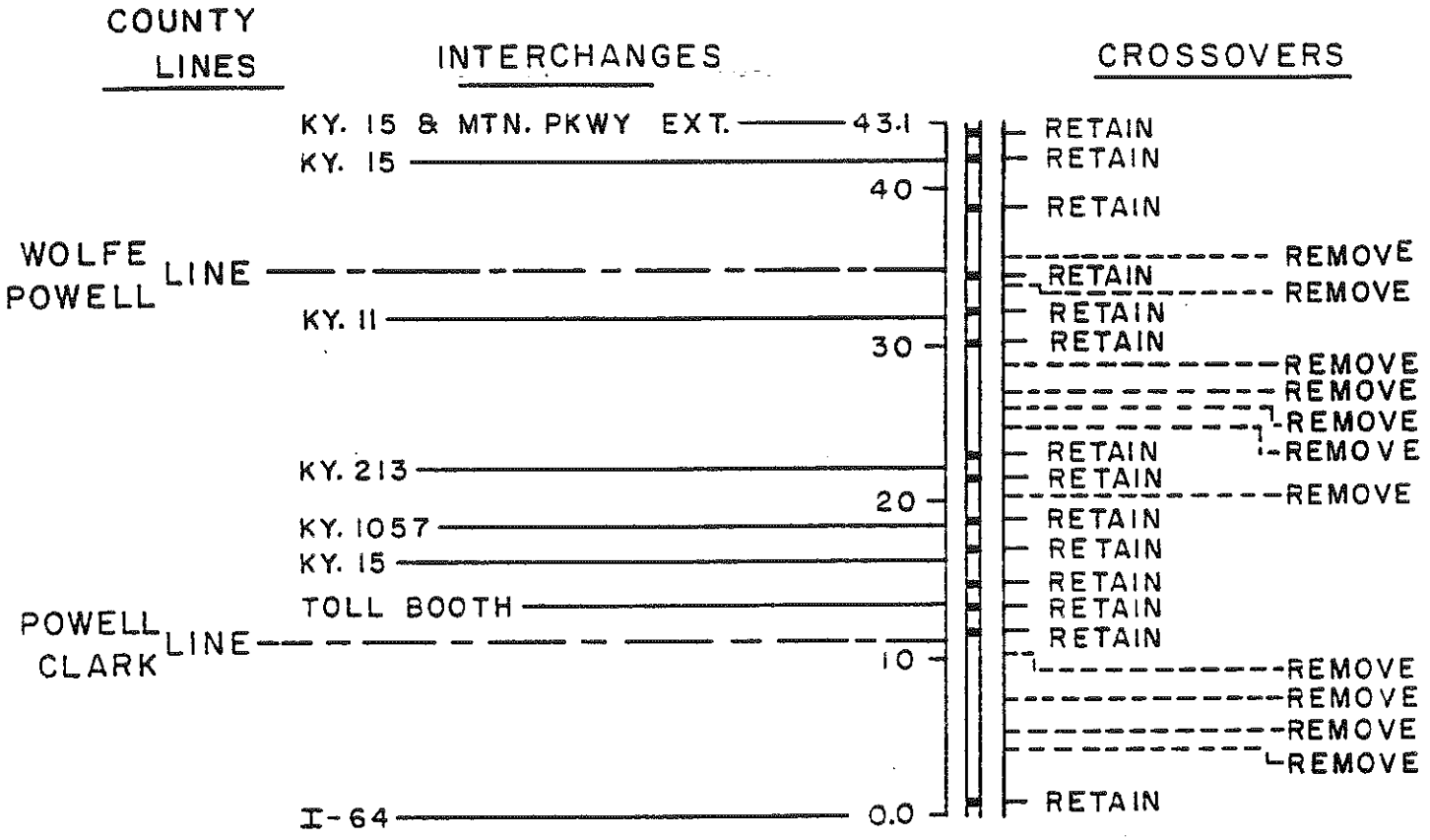


Figure E-1. Locations of median crossovers, interchanges, and county lines on the Mountain Parkway.

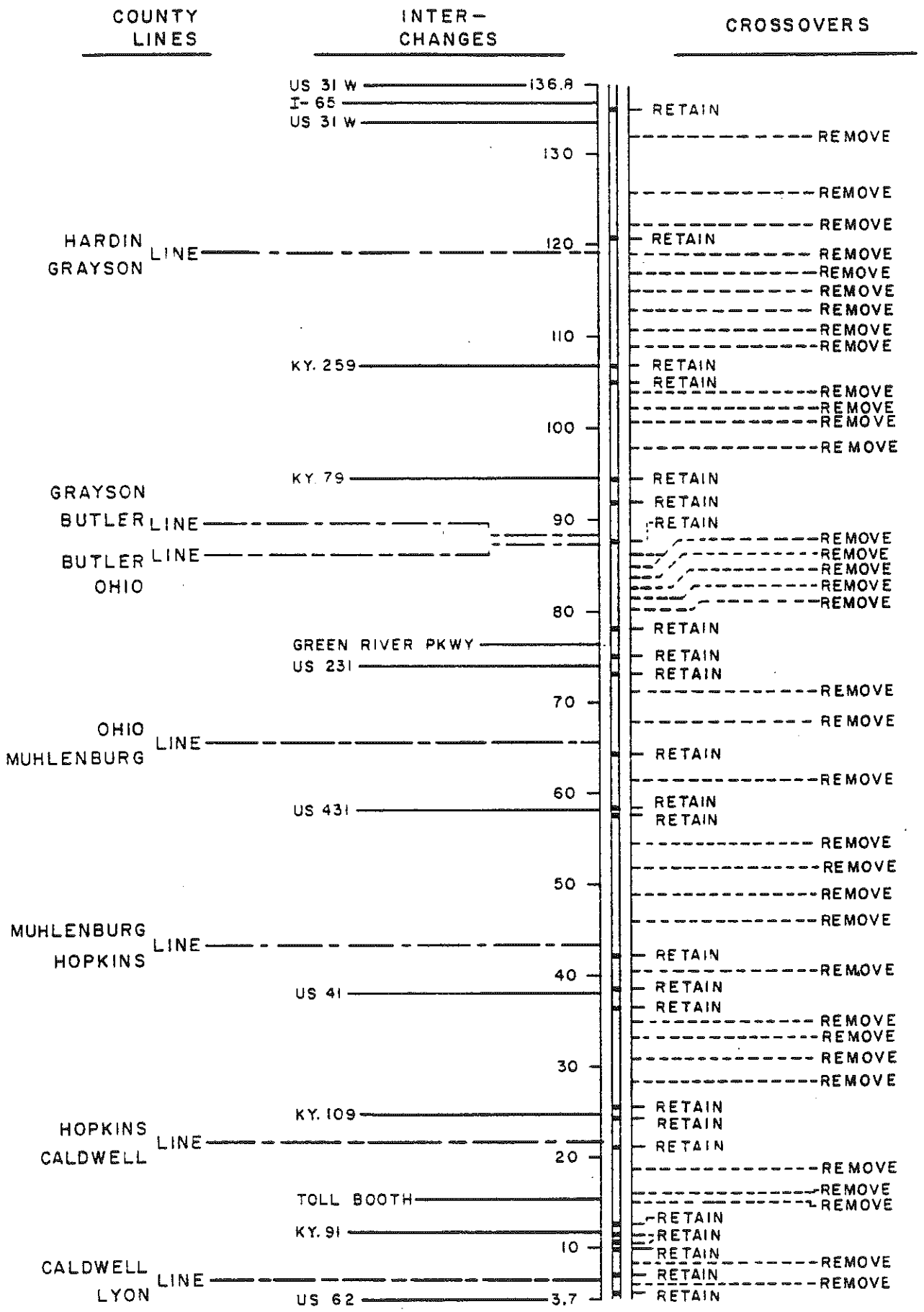


Figure E-2. Locations of median crossovers, interchanges and county lines on the Western Kentucky Parkway.

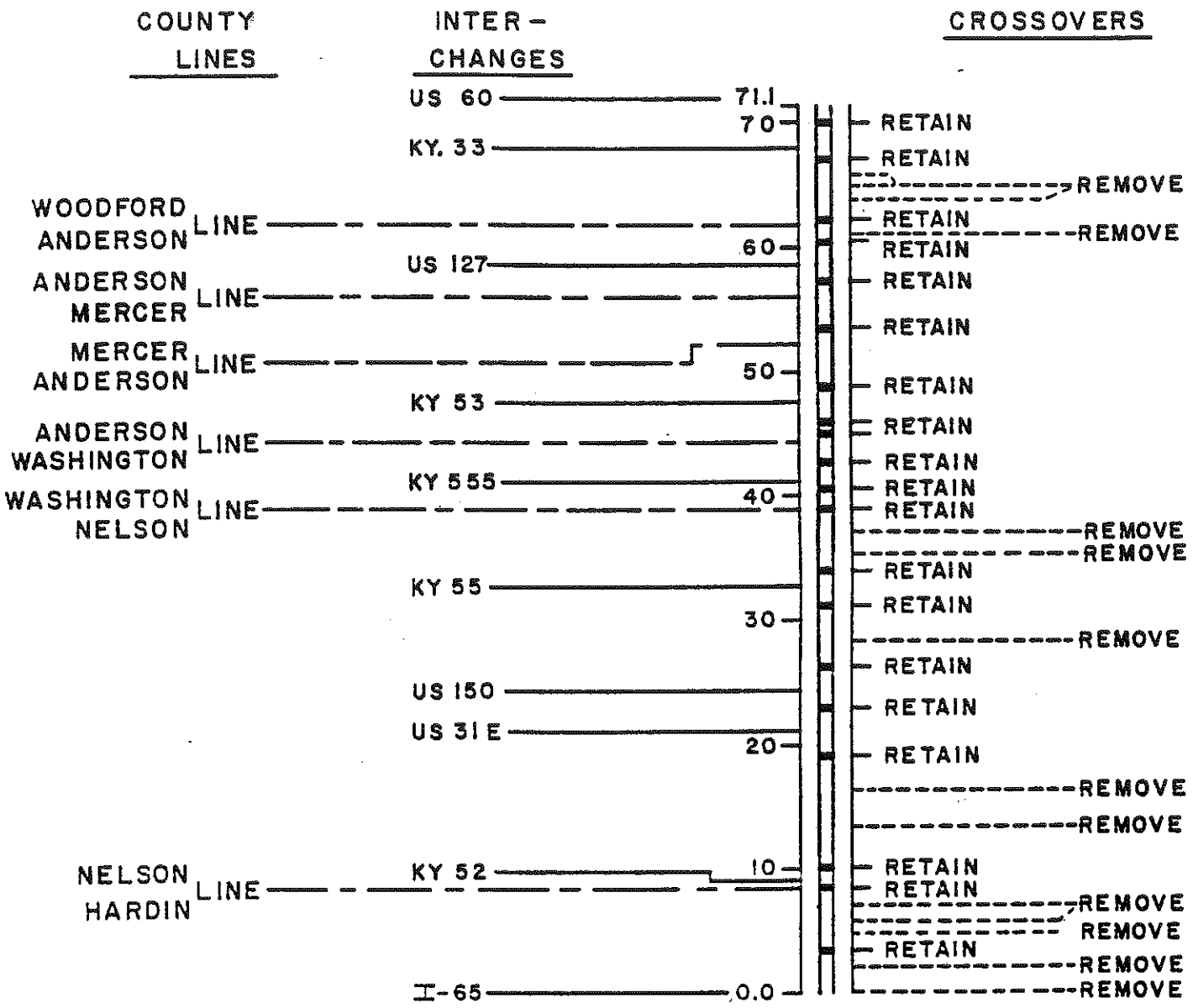


Figure E-3. Locations of median crossovers, interchanges, and county lines on the Bluegrass Parkway.

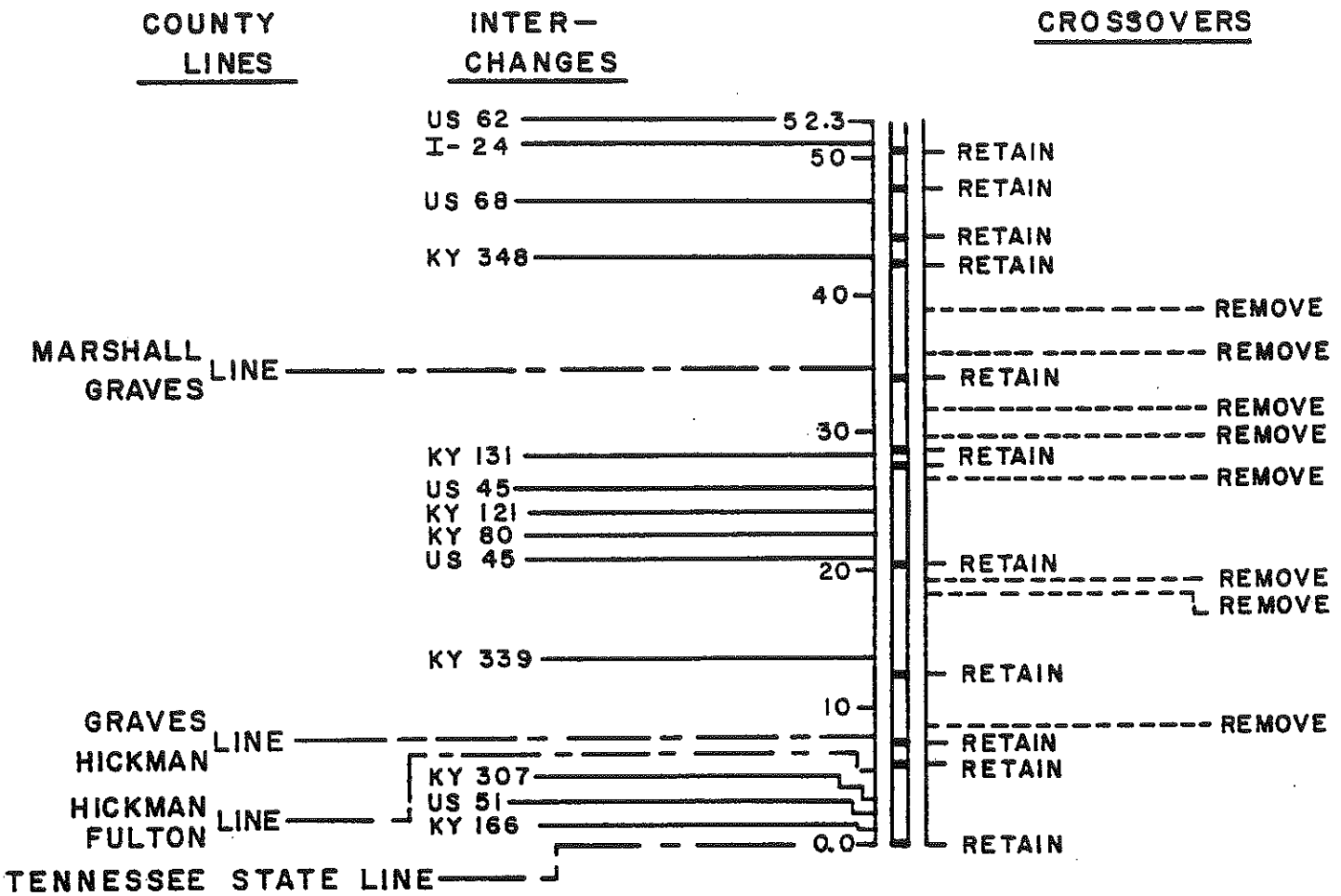


Figure E-4. Locations of median crossovers, interchanges, and county lines on the Purchase Parkway.

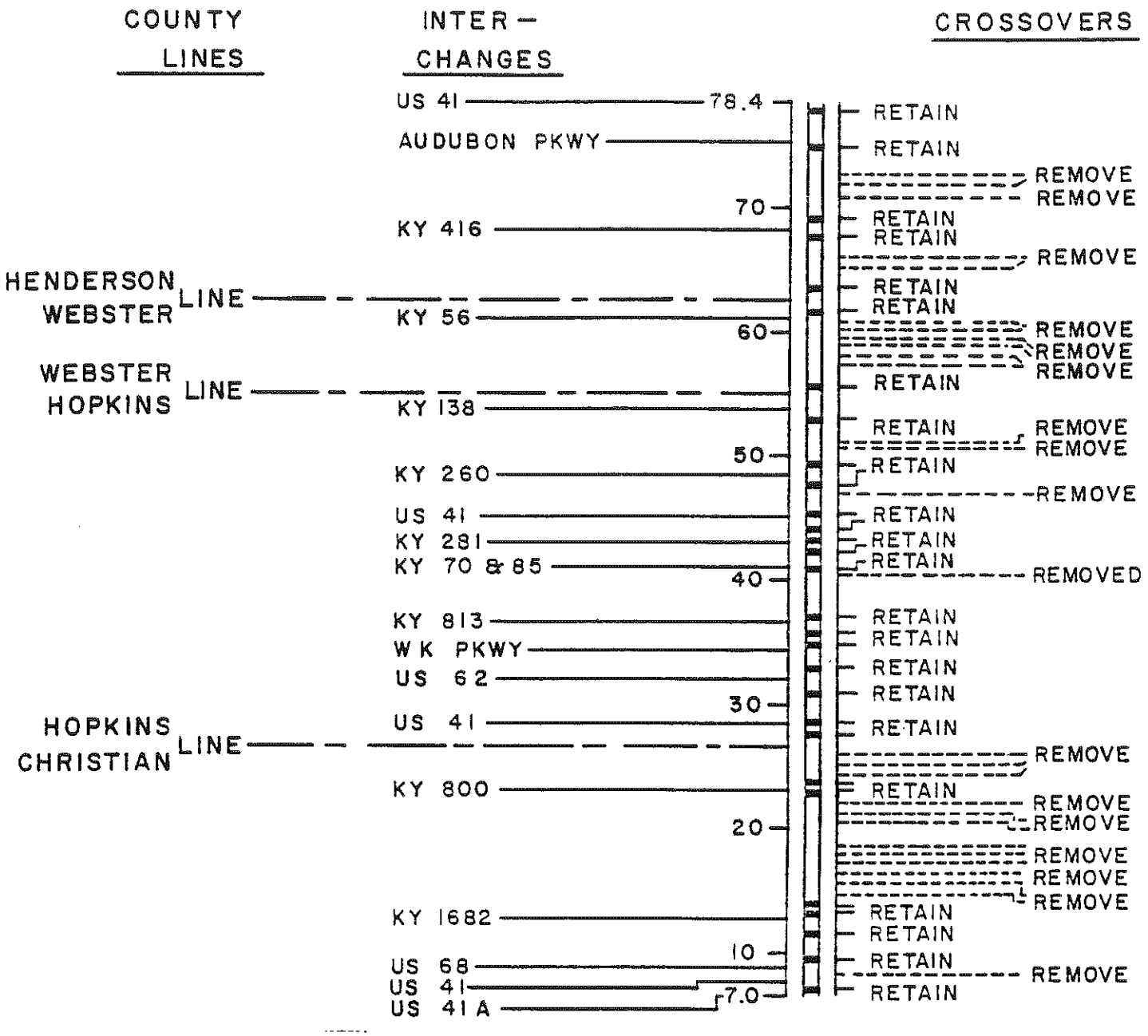


Figure E-5. Locations of median crossovers, interchanges and county lines on the Pennyrile Parkway.

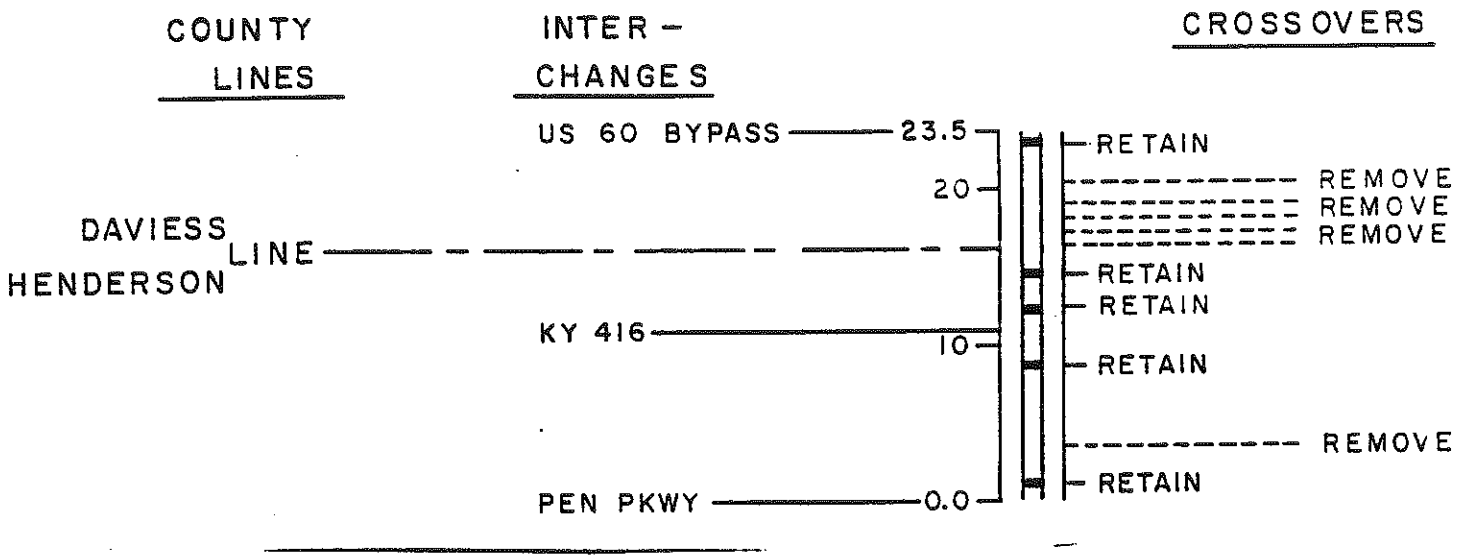


Figure E-6. Locations of median crossovers, interchanges and county lines on the Audubon Parkway.

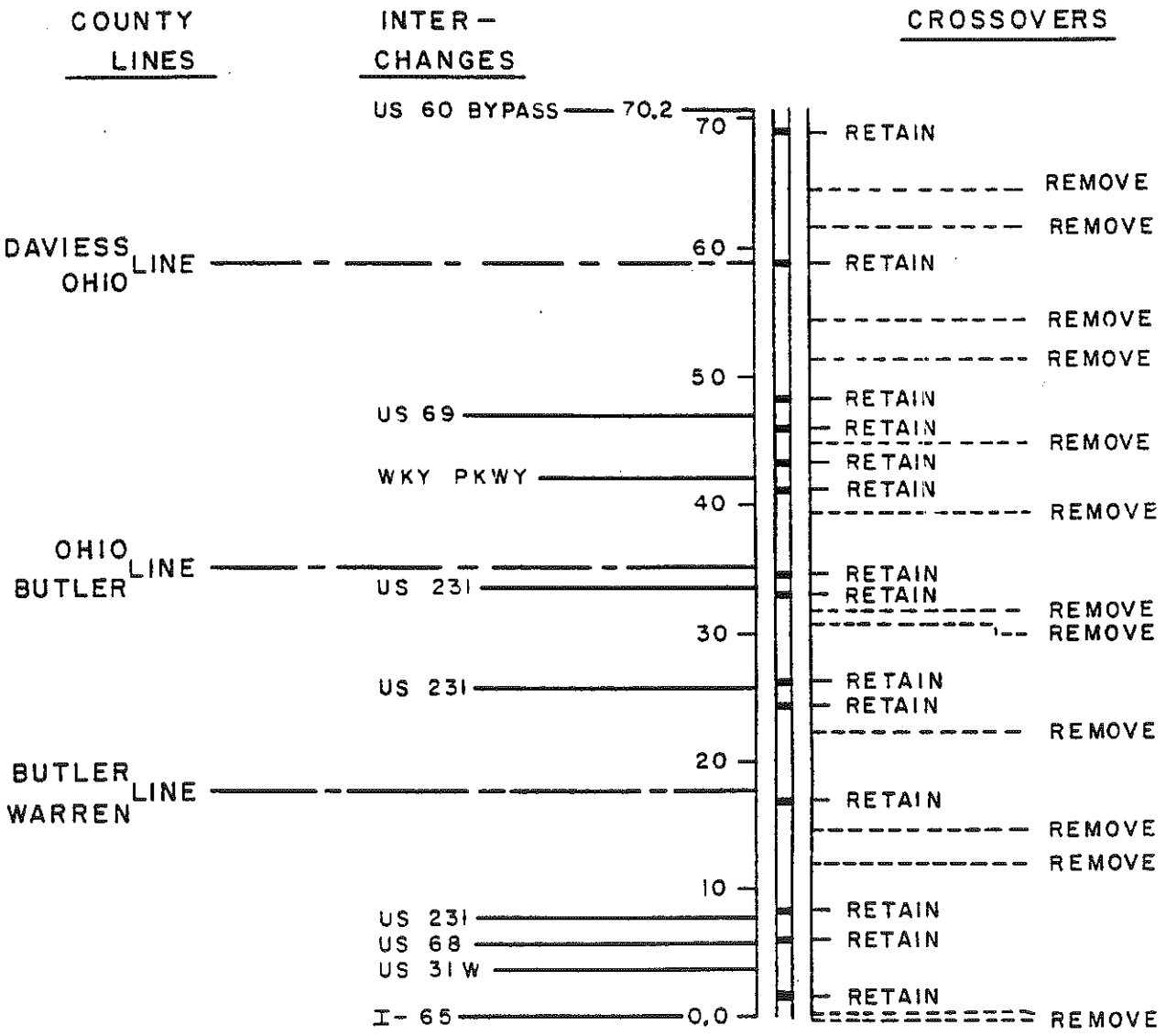


Figure E-7. Locations of median crossovers, interchanges and county lines on the Green River Parkway.

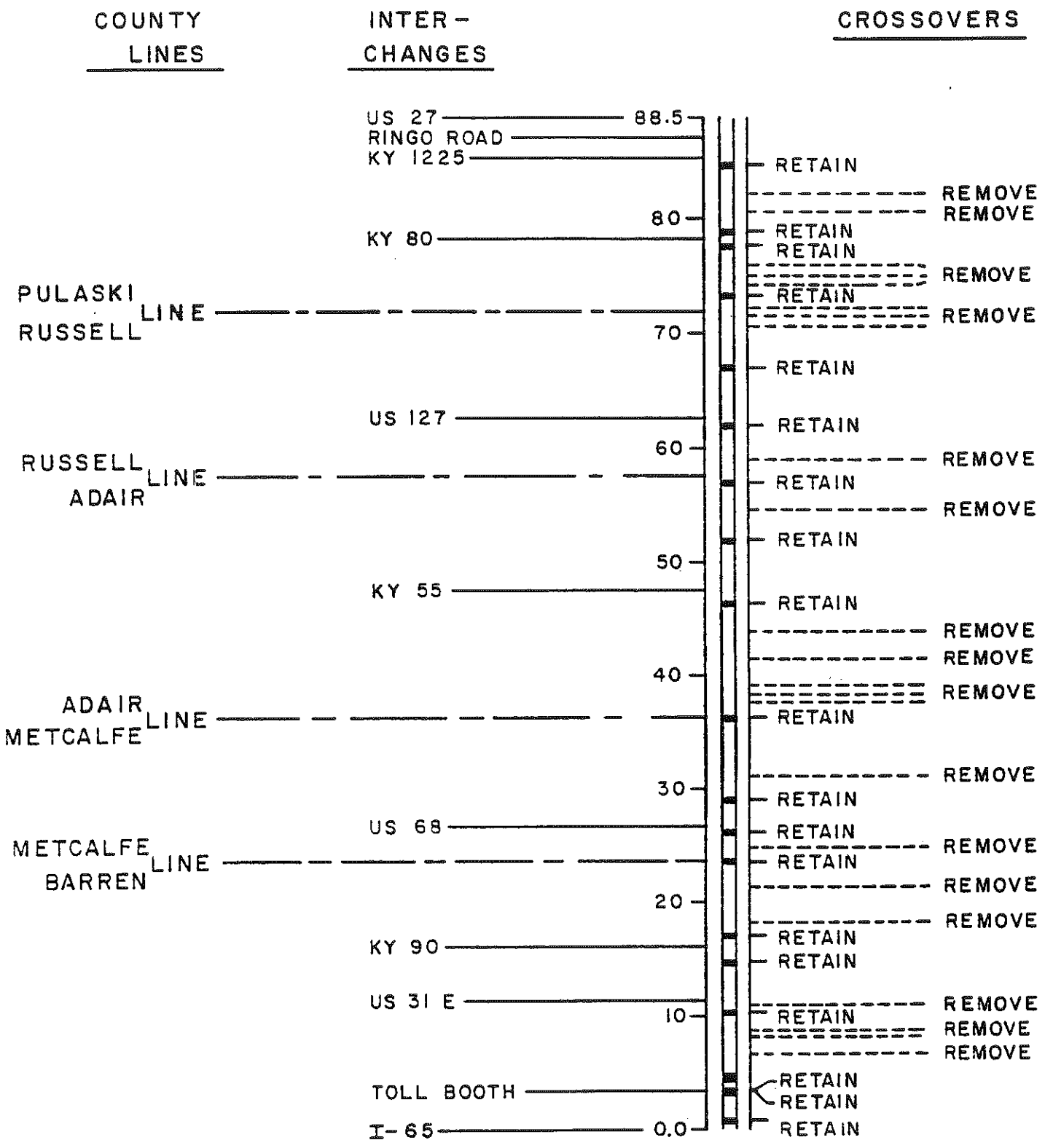


Figure E-8. Locations of median crossovers, interchanges and county lines on the Cumberland Parkway.

APPENDIX F

Accidents Included When Determining Percentage Reductions

IMPROVEMENT REFERENCE NUMBER		ACCIDENTS INCLUDED
1.	Curve Warning Sign	All related accidents at location.
2.	Curve Warning Sign	All related accidents at location.
3.	Curve Warning Sign	All related accidents at location.
4.	"Fasten Seatbelt" Signs	All parkway accidents.
5.	Deer Fence or Deer Crossing Sign	All accidents at locations involving deer.
6.	Directional Signs	All related accidents at location.
7.	Additional Signing for Exit Ramp	All accidents on ramp involved.
8.	Replace Rigid Light Supports	All accidents involving light supports.
9.	Vehicle Actuated Warning Device at Intersection	All related accidents at location.
10.	Replace Rigid Signs	Accidents involving sign.
11.	Median Crossover Improvements	All accidents involving median crossover.
12.	Actuated Warning Sign	Accidents involving brake failure.
13.	Transverse Stripes	All related accidents at location.
14.	Additional Delineation	All related accidents at location.
15.	Guardrail Connection to Bridge End	Bridge accidents involving collision with bridge abutment or approach guardrail.
16.	Bridge Gap Improvements	Accidents involving gap between bridges, including 10 year fatal accident history.
17.	Concrete median barrier replacing barrels	Accidents involving collision with barrels.
18.	Flashing Beacon	All related accidents at location.
19.	Screen on Bridge over Parkway	All accidents at bridge involving vehicle hit by thrown object.
20.	Delineation on ramps for wrong-way accidents	All wrong-way vehicle accidents.
21.	Replace and Upgrade Delineator Posts	All nighttime accidents.
22.	"Ice on Bridge" Warning System	All ice on bridge accidents at subject locations.
23.	Delineator for Shoulders Approaching Narrow Bridge (Not Full-Width Shoulder)	Bridge accidents involving bridge abutment or approach guardrail.
24.	Toll Booth Improvements	All toll booth related accidents.
25.	Change Guardrail end to Breakaway Cable Terminal (BCT)	All guardrail accidents multiplied by percent of all guardrail accidents involving guardrail end (8).
26.	Paving Shoulder	Pennyrile Parkway - Accidents involving soft shoulders as a contributing factor.

IMPROVEMENT REFERENCE NUMBER	ACCIDENTS INCLUDED
27. Median and Shoulder Pier Protection	All accidents involving collision with bridge pier. Included 10 year fatal accident history.
28. Clear Gore Area	All exit ramp interchange accidents involving hitting fixed object in gore.
29. Deer Fence or Deer Crossing Sign	All accidents at locations involving deer.
30. Deslicking	Wet pavement accidents at locations.
31. Improve Culvert	All accidents involving culvert including 10 year fatal accident history.
32. Bridge Gap Improvements	Accidents involving gap between bridges, including 10 year fatal accident history.
33. Shield Rock Cut	All accidents involving rock cut.
34. Remove Rock Outcropping	All accidents involving rock outcropping.
35. Retrofit Safety Curb with New Jersey Barrier	All accidents hitting, going through, or going over a bridge rail.
36. Paving Shoulder	Daniel Boone Parkway - All fixed object and ran-off-roadway accidents.
37. Grade Separation of At-Grade Intersection	All related accidents at location.
38. Bridge Deck Repair	All bridge accidents occurring after start of bridge.
39. Lighting	All related accidents at location.
40. Truck Escape Ramp	Accidents involving brake failure.
41. Widen Bridges	Bridge accidents involving hitting bridge abutment or approach guardrail.
42. Grade Separation of At-Grade Intersection	All related accidents at location.

APPENDIX G

Unit Costs for Recommended Improvements

IMPROVEMENT REFERENCE NUMBER		COST (DOLLARS)	UNIT
1.	Curve Warning Sign	250	Each
2.	Curve Warning Sign	250	Each
3.	Curve Warning Sign	250	Each
4.	"Fasten Seatbelt" Signs	200	Each
5.	Deer Crossing Sign	200	Each
6.	Directional Signs	2,500	Each
7.	Additional Signing for Exit Ramp	1,000	Ramp
8.	Replace Rigid Light Supports	2,000	Each
9.	Vehicle Actuated Warning Device at Intersection	15,000	Intersection
10.	Replace Rigid Signs	4,000	Each
11.	Median Crossover Improvements		
	Signing	400	Each
	Paving	1,000	Each
	Removing	3,500	Each
12.	Actuated Warning Sign	5,000	Each
13.	Transverse Stripes	4,000	Location
14.	Additional Delineation	16	per Delineator
15.	Guardrail Connection to Bridge End	1,000	Each
	Remove Guardrail	1	Linear Foot
16.	Bridge Gap Improvements -		
	Install Guardrail	9,000	per Bridge
	Plant Shrubs behind Guardrail	7,000	per Bridge
17.	Concrete Median Barrier (Replace Barriers)	32	Linear Foot
	-End Treatment	3,000	Each
18.	Flashing Beacon	1,000	Location
19.	Screen on Bridge over Parkway (5 foot height)	2,000	Bridge
20.	Delineation on ramps for wrong-way accidents (two arrows)	150	per Ramp
21.	Replace Shoulder Delineator Posts	16	Each
	-Lens	2	Each
22.	"Ice on Bridge"Warning System (2 signs and 2 sensors)	12,000	Bridge
23.	Delineation for Shoulders Approaching Narrow Bridge ($100-raised pavement markers) ($50-tape)	150	per Approach
24.	Toll Booth Improvements		
	Crash Cushion	3,000	Location
	Transverse Stripes	2,500	Location
	Rumble Strips	2,000	Location
25.	Change Guardrail End to Breakaway Cable Terminal (BCT)	750	Each

IMPROVEMENT REFERENCE NUMBER		COST (DOLLARS)	UNIT
26.	Paving Shoulder (10 foot shoulder-2 inches thick)	11,000	Mile
27.	Median and Shoulder Protection-		
	Shoulder Pier Unprotected	3,500	Each
	Shoulder Pier Guardrail Unattached	1,000	Each
	Median Pier Protection (GREAT crash cushion)	25,000	per Pier
28.	Clear Gore Area -		
	Remove Rigid Signs	1,000	Each
	Move Light Standard	2,000	Each
	Replace Dual Channel Post	500	Each
	Remove Guardrail	1,000	per Gore
	Remove Curb	1,000	per Gore
	Contour Grading	35,000	per Gore
29.	Deer Fence (8 foot height)	5	Foot
30.	Deslicking	12,000	Lane Mile
31.	Improve Culvert -		
	Replace Headwall	1,000	Each
	Remove Guardrail	100	Location
	Improve Grading	1.5	Cubic Yard
	Replace Median Drain Inlet	1,000	Each
32.	Bridge Gap Improvements - Plant Shrubs behind Guardrail	7,000	per Bridge
33.	Shield Rock Cuts - GM Barrier	30	Linear Foot
	Guardrail	10	Linear Foot
34.	Remove Rock Outcroppings	3	Cubic Yard
35.	Retrofit Safety Curb with New Jersey Barrier	30	Linear Foot
36.	Paving Shoulder (10 foot shoulder-2 inches thick)	11,000	Mile
37.	Grade Separation of At-Grade Intersection	5,000,000	Location
38.	Bridge Deck Repair	75,000	Location
39.	Lighting	2,000	Standard
40.	Truck Escape Ramp	750,000	Each
41.	Widen Bridges	100,000	Single Bridge
42.	Grade Separation of At-Grade Intersection	5,000,000	Location

APPENDIX H

Listing of Recommended Improvements for Various Budgets

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 3000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	319920.	8.69	8.69
5	DEER CROSSING SIGNS	1	5000.	29253.	349178.	5.85	8.35
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	352815.	3.64	8.24
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	1034142.	3.10	3.94
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	1169511.	3.01	3.80
10	REPLACE RIGID SIGNS	1	440000.	1253799.	2423310.	2.85	3.24
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	3979061.	2.55	2.93
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	3990286.	2.25	2.93
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	4042188.	2.16	2.91
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	4043931.	1.74	2.91
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	4691354.	1.65	2.64
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	5313196.	1.55	2.44
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	5342590.	1.55	2.43
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	5348334.	1.44	2.43
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	5379595.	1.36	2.42
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	5469824.	1.26	2.38
22	ICE ON SENSOR AND BRIDGE SIGN 8 LOC.	1	96000.	118715.	5588540.	1.24	2.34
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	38700.	44164.	5632704.	1.14	2.32
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	5742829.	1.05	2.26
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345483.	6088312.	1.05	2.12
28	CLEAR GORE AREA LIST OF FIVE	1	134000.	135376.	6223687.	1.01	2.07
**********	TOTALS **********		3000900.	6223687.	6223687.		2.07

Figure H-1. List of recommended improvements given a $3,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 6000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	319920.	8.69	8.69
5	DEER CROSSING SIGNS	1	5000.	29253.	349178.	5.85	8.35
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	352815.	3.64	8.24
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	1034142.	3.10	3.94
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	1169511.	3.01	3.80
10	REPLACE RIGID SIGNS	1	440000.	1253799.	2423310.	2.85	3.24
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	3979061.	2.55	2.93
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	3990286.	2.25	2.93
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	4042188.	2.16	2.91
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	4043931.	1.74	2.91
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	4691354.	1.65	2.64
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	5313196.	1.55	2.44
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	5342590.	1.55	2.43
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	5348334.	1.44	2.43
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	5379595.	1.36	2.42
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	5469824.	1.26	2.38
22	ICE ON SENSOR AND BRIDGE SIGN 8 LOC.	1	96000.	118715.	5588540.	1.24	2.34
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	5698665.	1.05	2.28
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	3036000.	3182039.	8880704.	1.05	1.60
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345483.	9226186.	1.05	1.57
28	CLEAR GORE AREA LIST OF FIVE	1	134000.	135376.	9361562.	1.01	1.56
**********	TOTALS **********		5998200.	9361562.	9361562.		1.56

Figure H-2. List of recommended improvements given a $6,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 9000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	319920.	8.69	8.69
5	DEER CROSSING SIGNS	1	5000.	349178.	29258.	5.85	8.35
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	352815.	3637.	3.64	8.24
8	REPLACE RIGID LIGHTPOLES	1	220000.	1034142.	681328.	3.10	3.94
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	1169511.	135368.	3.01	3.80
10	REPLACE RIGID SIGNS	1	440000.	2423310.	1253799.	2.85	3.24
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	3979061.	1555751.	2.55	2.93
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	3990286.	11225.	2.25	2.93
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	4042188.	51902.	2.16	2.91
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	4043931.	1743.	1.74	2.91
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	4691354.	647423.	1.65	2.64
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	5313196.	621842.	1.55	2.44
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	5342590.	29394.	1.55	2.43
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5348334.	5744.	1.44	2.43
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	5379595.	31261.	1.36	2.42
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	5469824.	90229.	1.26	2.38
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	38700.	5513989.	44164.	1.14	2.36
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	3036000.	8696028.	3182039.	1.05	1.62
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	11377980.	2681952.	1.02	1.42
29	DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC	1	967000.	12350124.	972145.	0.98	1.37
**********	TOTALS **********		8999900.	12350124.	12350124.		1.37

Figure H-3. List of recommended improvements given a $9,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 12000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
1	CURVE WARNING SIGN DBP MP 14.9	1	500.	92476.	92476.	184.95	184.95
2	CURVE WARNING SIGN MTN PKWY MP 38.1	1	500.	34508.	1269984.	69.02	126.98
3	CURVE WARNING SIGN MTN PKWY MP 72.3	1	500.	16789.	1433773.	33.58	95.85
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	1753693.	8.69	12.11
5	DEER CROSSING SIGNS	1	5000.	29258.	1782951.	5.85	11.38
6	ADD. DIRECTIONAL SIGNING 3 LOCATIONS	1	7500.	37529.	1820480.	5.00	10.44
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	1824117.	3.64	10.31
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	2505444.	3.10	4.47
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	2640812.	3.01	4.26
10	REPLACE RIGID SIGNS	1	440000.	1253799.	3894611.	2.85	3.44
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	5450362.	2.55	3.04
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	5461588.	2.25	3.04
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	5513490.	2.16	3.03
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	5515233.	1.74	3.02
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	5962656.	1.65	2.72
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	6584497.	1.55	2.51
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	6613892.	1.55	2.50
18	FLASHING BEACONS SEVEN LOCATIONS	1	7000.	10205.	6624096.	1.46	2.50
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	6629840.	1.44	2.50
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	6661102.	1.36	2.49
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	6661331.	1.26	2.45
22	ICE ON SENSOR AND BRIDGE SIGN 3 LOC.	1	96000.	118715.	6780046.	1.24	2.40
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	33700.	44164.	6824210.	1.14	2.38
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	6934336.	1.05	2.32
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	30036000.	31820039.	9116375.	1.05	1.63
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345483.	9461857.	1.05	1.60
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	2681952.	12143809.	1.02	1.42
28	CLEAR GORE AREA LIST OF FIVE	1	134000.	135376.	12279185.	1.01	1.41
29	DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC	1	987000.	972145.	13251330.	0.98	1.37
30	DESLICKING MTN PKWY 3LOC DB PKWY 1LOC	1	206000.	185857.	13437187.	0.90	1.36
31	CULVERT/HEADWALL IMPROVEMENTS	1	1283000.	1010065.	14447251.	0.79	1.29
32	UPGRADE GAP BETWEEN BRIDGES-SHRUBS	1	784000.	382094.	14829346.	0.49	1.24
	********** TOTALS **********		11953900.	14829346.	14829346.		1.24

Figure H-4. List of recommended improvements given a $12,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 15000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	319920.	8.69	8.69
5	DEER CROSSING SIGNS	1	5000.	29258.	349178.	5.85	8.35
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	352815.	3.64	8.24
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	1034142.	3.10	3.94
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	1169511.	3.01	3.80
10	REPLACE RIGID SIGNS	1	440000.	1253799.	2423310.	2.85	3.24
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	3979061.	2.55	2.93
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	3990286.	2.25	2.93
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	4042188.	2.16	2.91
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	4043931.	1.74	2.91
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	4691354.	1.65	2.64
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	5313196.	1.55	2.44
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	5318939.	1.44	2.44
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	5350201.	1.36	2.42
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	5440430.	1.26	2.39
22	ICE ON SENSOR AND BRIDGE SIGN 3 LOC.	1	96000.	118715.	5559145.	1.24	2.34
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	33700.	44164.	5603309.	1.14	2.32
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	5713435.	1.05	2.27
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	30036000.	31820039.	8895474.	1.05	1.60
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345433.	9240956.	1.05	1.57
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	2681952.	11922908.	1.02	1.40
29	DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC	1	987000.	972145.	12895053.	0.98	1.36
30	DESLICKING MTN PKWY 3LOC DB PKWY 1LOC	1	206000.	185857.	13080910.	0.90	1.35
31	CULVERT/HEADWALL IMPROVEMENTS	1	1283000.	1010065.	14090975.	0.79	1.23
33	SHIELD ROCK CUTS (73.1 MILES)	1	40000000.	1621456.	15712431.	0.41	1.05
	********** TOTALS **********		15000900.	15712431.	15712431.		1.05

Figure H-5. List of recommended improvements given a $15,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 17000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
1	CURVE WARNING SIGN DBP MP 14.9	1	500.	92476.	92476.	184.95	184.95
2	CURVE WARNING SIGN MTN PKWY MP 38.1	1	500.	34508.	126984.	69.02	126.98
3	CURVE WARNING SIGN MTN PKWY MP 72.3	1	500.	16789.	143773.	33.58	95.85
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	463693.	8.69	12.11
5	DEER CROSSING SIGNS	1	5000.	29258.	492951.	5.85	11.38
6	ADD. DIRECTIONAL SIGNING 3 LOCATIONS	1	7500.	37529.	530480.	5.00	10.44
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	534117.	3.64	10.31
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	1215444.	3.10	4.47
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	1350812.	3.01	4.26
10	REPLACE RIGID SIGNS	1	440000.	1253799.	2604611.	2.85	3.44
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	4160362.	2.55	3.04
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	4171588.	2.25	3.04
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	4223490.	2.16	3.03
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	4225233.	1.74	3.02
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	4872656.	1.65	2.72
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	5494497.	1.55	2.51
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	5523892.	1.55	2.50
18	FLASHING BEACONS SEVEN LOCATIONS	1	7000.	10205.	5534096.	1.46	2.50
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	5539840.	1.44	2.50
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	5571102.	1.36	2.49
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	5661331.	1.26	2.45
22	ICE ON SENSOR AND BRIDGE SIGN 8 LOC.	1	96000.	118715.	5780046.	1.24	2.40
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	38700.	44164.	5824210.	1.14	2.38
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	5934336.	1.05	2.32
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	3036000.	3182039.	9116375.	1.05	1.63
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345483.	9461857.	1.05	1.60
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	2681952.	12143809.	1.02	1.42
28	CLEAR GORE AREA LIST OF FIVE	1	134000.	135376.	12279185.	1.01	1.41
29	DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC	1	987000.	972145.	13251330.	0.98	1.37
30	DESLICKING MTN PKWY 3LOC DB PKWY 1LOC	1	206000.	185857.	13437187.	0.90	1.36
31	CULVERT/HEADWALL IMPROVEMENTS	1	1283000.	1010065.	14447251.	0.79	1.29
32	UPGRADE GAP BETWEEN BRIDGES-SHRUBS	1	784000.	382094.	14829346.	0.49	1.24
33	SHIELD ROCK CUTS (73.1 MILES)	1	4000000.	1621456.	16450802.	0.41	1.03
34	REMOVE ROCK OUTCROPPINGS	1	346000.	84357.	16535159.	0.24	1.01
39	INTERCHANGE LIGHTING MP I64	1	100000.	3601.	16538760.	0.04	1.01
	********** TOTALS **********		16399900.	16538760.	16538760.		1.01

Figure H-6. List of recommended improvements given a $17,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 18000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
1	CURVE WARNING SIGN DBP MP 14.9	1	500.	92476.	92476.	184.95	184.95
2	CURVE WARNING SIGN MTN PKWY MP 38.1	1	500.	34508.	126984.	69.02	126.98
3	CURVE WARNING SIGN MTN PKWY MP 72.3	1	500.	16789.	143773.	33.58	95.85
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	463693.	8.69	12.11
5	DEER CROSSING SIGNS	1	5000.	29258.	492951.	5.85	11.38
6	ADD. DIRECTIONAL SIGNING 3 LOCATIONS	1	7500.	37529.	530480.	5.00	10.44
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	534117.	3.64	10.31
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	1215444.	3.10	4.47
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	1350812.	3.01	4.26
10	REPLACE RIGID SIGNS	1	440000.	1253799.	2604611.	2.85	3.44
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	4160362.	2.55	3.04
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	4171588.	2.25	3.04
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	4223490.	2.16	3.03
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	4225233.	1.74	3.02
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	4872656.	1.65	2.72
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	5494497.	1.55	2.51
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	5523892.	1.55	2.50
18	FLASHING BEACONS SEVEN LOCATIONS	1	7000.	10205.	5534096.	1.46	2.50
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	5539840.	1.44	2.50
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	5571102.	1.36	2.49
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	5661331.	1.26	2.45
22	ICE ON SENSOR AND BRIDGE SIGN 8 LOC.	1	96000.	118715.	5780046.	1.24	2.40
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	38700.	44164.	5824210.	1.14	2.38
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	5934336.	1.05	2.32
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	3036000.	3182039.	9116375.	1.05	1.63
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345483.	9461857.	1.05	1.60
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	2681952.	12143809.	1.02	1.42
28	CLEAR GORE AREA LIST OF FIVE	1	134000.	135376.	12279185.	1.01	1.41
29	DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC	1	987000.	972145.	13251330.	0.98	1.37
30	DESLICKING MTN PKWY 3LOC DB PKWY 1LOC	1	206000.	185857.	13437187.	0.90	1.36
31	CULVERT/HEADWALL IMPROVEMENTS	1	1283000.	1010065.	14447251.	0.79	1.29
32	UPGRADE GAP BETWEEN BRIDGES-SHRUBS	1	784000.	382094.	14829346.	0.49	1.24
33	SHIELD ROCK CUTS (73.1 MILES)	1	4000000.	1621456.	16450802.	0.41	1.03
34	REMOVE ROCK OUTCROPPINGS	1	346000.	84357.	16535159.	0.24	1.01
36	PAVING SHOULDER DB PKWY (MP 0-59.1)	1	1300000.	246773.	16781932.	0.19	0.95
39	INTERCHANGE LIGHTING MP I64	1	100000.	3601.	16785533.	0.04	0.95
	********** TOTALS **********		17699900.	16785533.	16785533.		0.95

Figure H-7. List of recommended improvements given a $18,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 21000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
1	CURVE WARNING SIGN DBP MP 14.9	1	500.	92476.	92476.	184.95	184.95
2	CURVE WARNING SIGN MTN PKWY MP 38.1	1	500.	34508.	126984.	69.02	126.98
3	CURVE WARNING SIGN MTN PKWY MP 72.3	1	500.	16789.	143773.	33.58	95.85
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	463693.	8.69	12.11
5	DEER CROSSING SIGNS	1	5000.	29258.	492951.	5.85	11.38
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	496587.	3.64	11.21
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	1177915.	3.10	4.46
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	1313283.	3.01	4.25
10	REPLACE RIGID SIGNS	1	440000.	1253799.	2567082.	2.85	3.43
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	4122833.	2.55	3.03
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	4134059.	2.25	3.03
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	4185961.	2.16	3.02
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	4187704.	1.74	3.01
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	4835127.	1.65	2.71
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	5456968.	1.55	2.50
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	5486363.	1.55	2.49
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	5492106.	1.44	2.49
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	5523368.	1.36	2.48
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	5613597.	1.26	2.44
22	ICE ON SENSOR AND BRIDGE SIGN 8 LOC.	1	96000.	118715.	5732312.	1.24	2.39
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	38700.	44164.	5776477.	1.14	2.37
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	5886602.	1.05	2.32
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	3036000.	3182039.	9068641.	1.05	1.63
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345483.	9414123.	1.05	1.59
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	2681952.	12096075.	1.02	1.42
29	DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC	1	987000.	972145.	13068220.	0.98	1.37
30	DESLICKING MTN PKWY 3LOC DB PKWY 1LOC	1	206000.	185857.	13254077.	0.90	1.36
31	CULVERT/HEADWALL IMPROVEMENTS	1	1283000.	1010065.	14264142.	0.79	1.29
32	UPGRADE GAP BETWEEN BRIDGES-SHRUBS	1	784000.	382094.	14646236.	0.49	1.24
33	SHIELD ROCK CUTS (73.1 MILES)	1	4000000.	1621456.	16267692.	0.41	1.03
35	RETROFIT SAFETY CURBS WITH NJ BARRIER	1	5190000.	1063476.	17331168.	0.20	0.83
	********** TOTALS **********		20995400.	17331168.	17331168.		0.83

Figure H-8. List of recommended improvements given a $21,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 24000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
1	CURVE WARNING SIGN DBP MP 14.9	1	500.	92476.	92476.	184.95	184.95
2	CURVE WARNING SIGN MTN PKWY MP 38.1	1	500.	34508.	126984.	69.02	126.98
3	CURVE WARNING SIGN MTN PKWY MP 72.3	1	500.	16789.	143773.	33.58	95.85
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	463693.	8.69	12.11
5	DEER CROSSING SIGNS	1	5000.	29258.	492951.	5.85	11.38
6	ADD. DIRECTIONAL SIGNING 3 LOCATIONS	1	7500.	37529.	530480.	5.00	10.44
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	534117.	3.64	10.31
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	1215444.	3.10	4.47
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	1350812.	3.01	4.26
10	REPLACE RIGID SIGNS	1	440000.	1253799.	2604611.	2.85	3.44
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	4160362.	2.55	3.04
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	4171588.	2.25	3.04
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	4223490.	2.16	3.03
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	4225233.	1.74	3.02
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	4872656.	1.65	2.72
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	5494497.	1.55	2.51
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	5523892.	1.55	2.50
18	FLASHING BEACONS SEVEN LOCATIONS	1	7000.	10205.	5534096.	1.46	2.50
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	5539840.	1.44	2.50
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	5571102.	1.36	2.49
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	5661331.	1.26	2.45
22	ICE ON SENSOR AND BRIDGE SIGN 8 LOC.	1	96000.	118715.	5780046.	1.24	2.40
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	38700.	44164.	5824210.	1.14	2.38
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	5934336.	1.05	2.32
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	3036000.	3182039.	9116375.	1.05	1.63
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345483.	9461857.	1.05	1.60
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	2681952.	12143809.	1.02	1.42
28	CLEAR GORE AREA LIST OF FIVE	1	134000.	135376.	12279185.	1.01	1.41
29	DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC	1	987000.	972145.	13251330.	0.98	1.37
30	DESLICKING MTN PKWY 3LOC DB PKWY 1LOC	1	206000.	185857.	13437187.	0.90	1.36
31	CULVERT/HEADWALL IMPROVEMENTS	1	1283000.	1010065.	14447251.	0.79	1.29
32	UPGRADE GAP BETWEEN BRIDGES-SHRUBS	1	784000.	382094.	14829346.	0.49	1.24
33	SHIELD ROCK CUTS (73.1 MILES)	1	4000000.	1621456.	16450802.	0.41	1.03
34	REMOVE ROCK OUTCROPPINGS	1	346000.	84357.	16535159.	0.24	1.01
35	RETROFIT SAFETY CURBS WITH NJ BARRIER	1	5190000.	1063476.	17598635.	0.20	0.82
36	PAVING SHOULDER DB PKWY (MP 0-59.1)	1	1300000.	246773.	17845408.	0.19	0.78
40	TRUCK ESCAPE RAMP MTN PKWY MP 32.9	1	750000.	32487.	17877895.	0.04	0.76
39	INTERCHANGE LIGHTING MP I64	1	100000.	3601.	17881496.	0.04	0.76
	********** TOTALS **********		23639900.	17881496.	17881496.		0.76

Figure H-9. List of recommended improvements given a $24,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 27000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
1	CURVE WARNING SIGN DBP MP 14.9	1	500.	92476.	92476.	184.95	184.95
2	CURVE WARNING SIGN MTN PKWY MP 38.1	1	500.	34508.	1269984.	69.02	126.98
3	CURVE WARNING SIGN MTN PKWY MP 72.3	1	500.	16789.	1443773.	33.58	95.85
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	1463693.	8.69	12.11
5	DEER CROSSING SIGNS	1	5000.	29258.	1492951.	5.85	11.38
6	ADD. DIRECTIONAL SIGNING 3 LOCATIONS	1	7500.	37529.	1530480.	5.00	10.44
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	1534117.	3.64	10.31
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	1215444.	3.10	4.47
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	1350812.	3.01	4.26
10	REPLACE RIGID SIGNS	1	440000.	1253799.	2604611.	2.85	3.44
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	4160362.	2.55	3.04
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	4171588.	2.25	3.04
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	4223490.	2.16	3.03
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	4225233.	1.74	3.02
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	4872656.	1.65	2.72
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	5494497.	1.55	2.51
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	5523892.	1.55	2.50
18	FLASHING BEACONS SEVEN LOCATIONS	1	7000.	10205.	5534096.	1.46	2.50
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	5539840.	1.44	2.50
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	5571102.	1.36	2.49
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	5661331.	1.26	2.45
22	ICE ON SENSOR AND BRIDGE SIGN 8 LOC.	1	96000.	118715.	5780046.	1.24	2.40
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	38700.	44164.	5824210.	1.14	2.38
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	5934336.	1.05	2.32
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	3036000.	3182039.	9116375.	1.05	1.63
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345483.	9461857.	1.05	1.60
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	2681952.	12143809.	1.02	1.42
28	CLEAR GORE AREA LIST OF FIVE	1	134000.	135376.	12279185.	1.01	1.41
29	DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC	1	987000.	972145.	13251330.	0.98	1.37
30	DESLICKING MTN PKWY 3LOC DB PKWY 1LOC	1	206000.	185857.	13437187.	0.90	1.36
31	CULVERT/HEADWALL IMPROVEMENTS	1	1283000.	1010065.	14447251.	0.79	1.29
32	UPGRADE GAP BETWEEN BRIDGES-SHRUBS	1	784000.	382094.	14829346.	0.49	1.24
33	SHIELD ROCK CUTS (73.1 MILES)	1	4000000.	1621456.	16450802.	0.41	1.03
34	REMOVE ROCK OUTCROPPINGS	1	346000.	84357.	16535159.	0.24	1.01
35	RETROFIT SAFETY CURBS WITH NJ BARRIER	1	5190000.	1063476.	17598635.	0.20	0.82
37	GRADE-SEPARATED INTERCHANGE DBP-KY472	1	5000000.	917989.	18516624.	0.18	0.70
39	INTERCHANGE LIGHTING MP I64	1	100000.	3601.	18520225.	0.04	0.70
	********** TOTALS **********		26589900.	18520225.	18520225.		0.70

Figure H-10. List of recommended improvements given a $27,000,000 budget.

LISTING OF SELECTED PROJECTS BY B/C RATIO
BUDGET = 30000000.

LOCATION	LOCATION NAME	ALT-NUM	COST	RETURN	ACCUM RETURN	B/C	ACCUM B/C
1	CURVE WARNING SIGN DBP MP 14.9	1	500.	92476.	92476.	184.95	184.95
2	CURVE WARNING SIGN MTN PKWY MP 38.1	1	500.	34508.	1269984.	69.02	126.98
3	CURVE WARNING SIGN MTN PKWY MP 72.3	1	500.	16789.	1443773.	33.58	95.85
4	SEATBELT SIGNS AT ENT RAMPS AND INTERS	1	36800.	319920.	1463693.	8.69	12.11
5	DEER CROSSING SIGNS	1	5000.	29258.	1492951.	5.85	11.38
6	ADD. DIRECTIONAL SIGNING 3 LOCATIONS	1	7500.	37529.	1530480.	5.00	10.44
7	ADD. SIGNING FOR EXIT RAMP GRP TO WKP	1	1000.	3637.	1534117.	3.64	10.31
8	REPLACE RIGID LIGHTPOLES	1	220000.	681328.	1215444.	3.10	4.47
9	VEHICLE-ACTUATED WARNING DEVICES 3 LOC	1	45000.	135368.	1350812.	3.01	4.26
10	REPLACE RIGID SIGNS	1	440000.	1253799.	2604611.	2.85	3.44
11	MEDIAN CROSSOVER IMPROVEMENTS 3 TYPES	1	610000.	1555751.	4160362.	2.55	3.04
12	ACTUATED WARNING SIGN MTN PKWY MP 32.9	1	5000.	11225.	4171588.	2.25	3.04
13	TRANSVERSE STRIPES SIX LOCATIONS	1	24000.	51902.	4223490.	2.16	3.03
14	ADD. DELINEATORS JJAP-US60 MTP-I64	1	1000.	1743.	4225233.	1.74	3.02
15	GUARDRAIL TRANSITION TO BRIDGE END	1	392000.	647423.	4872656.	1.65	2.72
16	UPGRADE GAP BET. BRIDGES G-RAIL/SHRUBS	1	400000.	621842.	5494497.	1.55	2.51
17	CONCRETE BARRIER WALL PP MP 7.1 500 FT	1	19000.	29394.	5523892.	1.55	2.50
18	FLASHING BEACONS SEVEN LOCATIONS	1	7000.	10205.	5534096.	1.46	2.50
19	SCREEN ON BRIDGE OVER PPKWY 2 LOC.	1	4000.	5744.	5539840.	1.44	2.50
20	DELINEATION FOR WRONG-WAY ACCIDENTS	1	23000.	31261.	5571102.	1.36	2.49
21	REPLACE AND UPGRADE DELINEATOR POSTS	1	71400.	90229.	5661331.	1.26	2.45
22	ICE ON SENSOR AND BRIDGE SIGN 8 LOC.	1	96000.	118715.	5780046.	1.24	2.40
23	DELINEATION FOR SHOULDERS APPR.BRIDGES	1	38700.	44164.	5824210.	1.14	2.38
24	TOLL BOOTH IMPROVEMENTS THREE KINDS	1	105000.	110125.	5934336.	1.05	2.32
25	CHANGE GUARDRAIL END-TREATMENT TO BCT	1	3036000.	3182039.	9116375.	1.05	1.63
26	PAVING SHOULDER P PKWY MP 30.0-45.0	1	330000.	345483.	9461857.	1.05	1.60
27	MEDIAN AND SHOULDER PIER PROTECTION 3	1	2641000.	2681952.	12143809.	1.02	1.42
28	CLEAR GORE AREA LIST OF FIVE	1	134000.	135376.	12279185.	1.01	1.41
29	DEER FENCE WKP 3LOC. PP 3LOC. GRP 6LOC	1	987000.	972145.	13251330.	0.98	1.37
30	DESLICKING MTN PKWY 3LOC DB PKWY 1LOC	1	206000.	185857.	13437187.	0.90	1.36
31	CULVERT/HEADWALL IMPROVEMENTS	1	1283000.	1010065.	14447251.	0.79	1.29
32	UPGRADE GAP BETWEEN BRIDGES-SHRUBS	1	784000.	382094.	14829346.	0.49	1.24
33	SHIELD ROCK CUTS (73.1 MILES)	1	4000000.	1621456.	16450802.	0.41	1.03
34	REMOVE ROCK OUTCROPPINGS	1	346000.	84357.	16535159.	0.24	1.01
35	RETROFIT SAFETY CURBS WITH NJ BARRIER	1	5190000.	1063476.	17598635.	0.20	0.82
36	PAVING SHOULDER DB PKWY (MP 0-59.1)	1	1300000.	246773.	17845408.	0.19	0.78
37	GRADE-SEPARATED INTERCHANGE DBP-KY472	1	5000000.	917989.	18763397.	0.18	0.68
38	BRIDGE DECK REPAIR	1	1725000.	193143.	19956540.	0.11	0.64
39	INTERCHANGE LIGHTING MP I64	1	100000.	3601.	19960141.	0.04	0.64
	********** TOTALS **********		29614900.	18960141.	18960141.		0.64

Figure H-11. List of recommended improvements given a $30,000,000 budget.