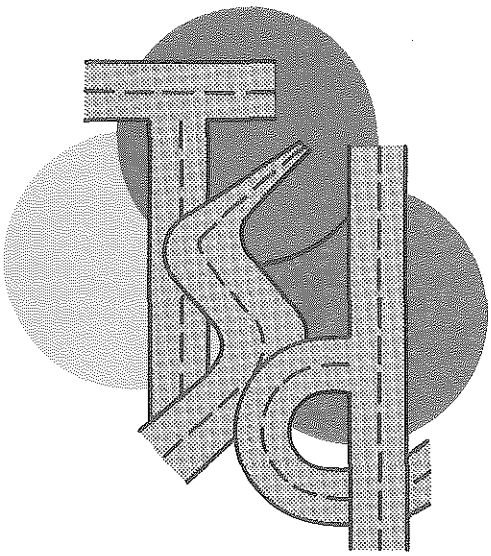
EVALUATION OF FOUR SAFETY PROJECTS

WIDENING A FOUR-LANE ROADWAY TO FIVE LANES AND PROVIDING A CENTER LANE FOR LEFT TURNS

TSD-G-207-72



TRAFFIC and SAFETY DIVISION

DEPARTMENT OF STATE HIGHWAYS
STATE OF MICHIGAN

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EVALUATION OF FOUR SAFETY PROJECTS

WIDENING A FOUR-LANE ROADWAY TO FIVE LANES AND PROVIDING A CENTER LANE FOR LEFT TURNS

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1. M-43 from Bogue Street to Hagadorn Road, Ingham County
2. M-43 from Hagadorn Road to Park Lake Road, Ingham County
3. US-27 from Douglas Street to Northcrest Road, Ingham and Clinton Counties
4. M-44 Connector (Plainfield) from I-96 to Airway Street, Kent County

Study Engineers

Bruce A. Conradson, Nasrat Al-Ashari

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

Henrik E. Stafseth. . . . . State Highway Director
John P. Woodford. . . . . Deputy Director - Chief Engineer
Gerald J. McCarthy . . . . . Assistant Deputy Director
John G. Hautala . . . . . Chief, Bureau of Operations
Harold H. Cooper. . . . . Engineer of Traffic and Safety
Max R. Hoffman. . . . . Traffic Geometrics Engineer
John R. Hoyt. . . . . Supervising Engineer, Surveillance Unit

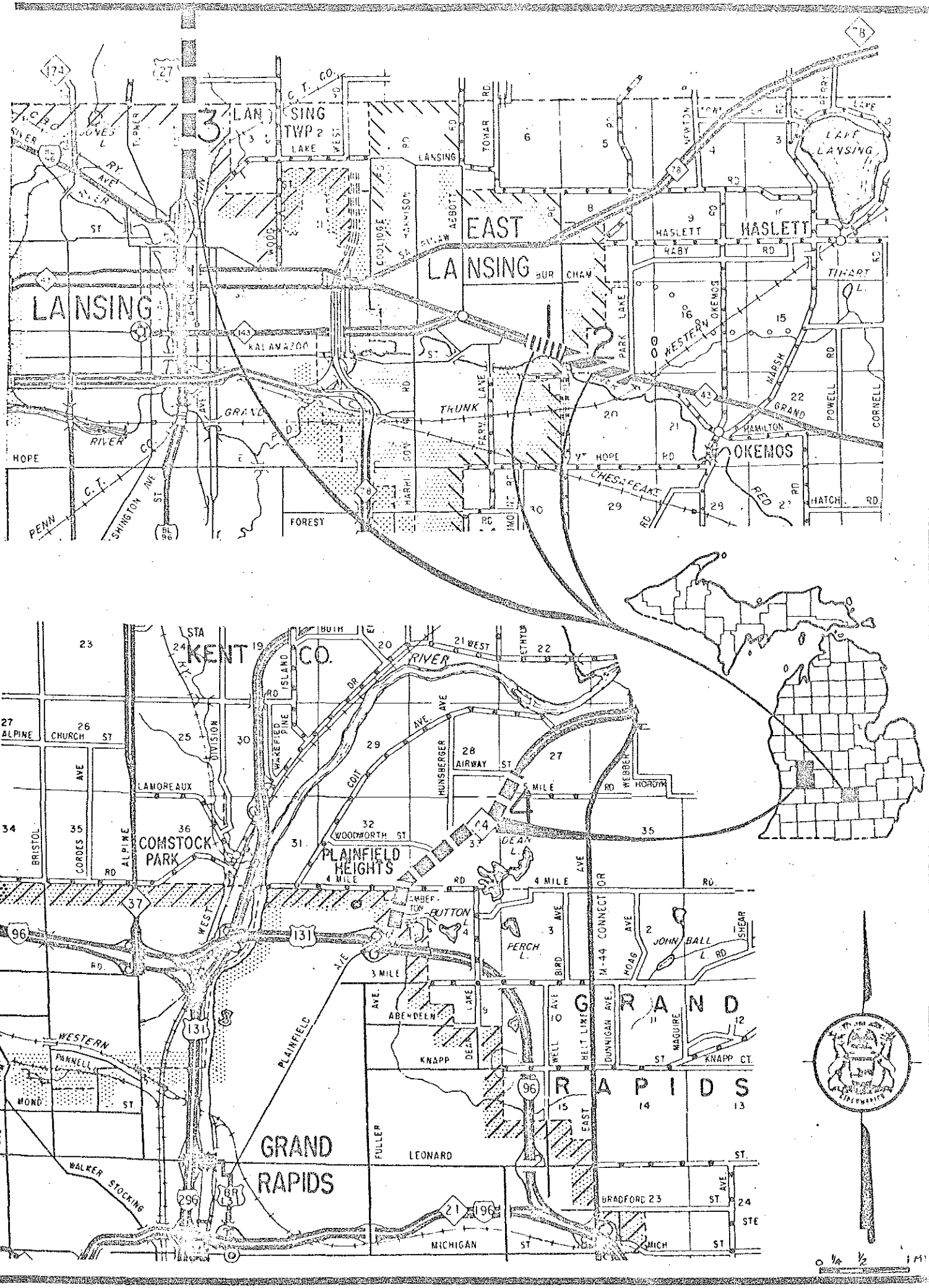
Department of State Highways
State Highways Building - P.O. Drawer K
Lansing, Michigan 48904

SYNOPSIS

This report was prepared in order to evaluate the effectiveness of four separate but similar improvements. Each project consists of widening an existing four lane undivided roadway to five lanes, with the center lane being reserved for left turns. Each roadway must serve high volumes of thru traffic as well as provide service to abutting strip commercial development.

A comparison of accident experience for twelve month periods before and after completion of the improvements reveals that total accidents were reduced by 33 per cent, 532 to 356. Even more dramatic was the 45 per cent reduction in left-turn type accidents, 94 before to 52 after, and the 62 per cent reduction in rear-end type accidents, 238 before to 90 after.

The accident reductions were found to be statistically significant and produced a monetary benefit of $455,000 in one year. In a period of seven years, the accrued benefits will surpass total project costs of $3,246,000.


LANSING
EAST LANSING
HASLETT
OKEMOS
HOPE
FOREST
LAKE LANSING
KENT CO.
COMSTOCK PARK
PLAINFIELD HEIGHTS
GRAND RAPIDS
WEST GRAND RAPIDS
EAST GRAND RAPIDS
RIVER
KALAMAZOO
GRAND
TRUNK
WESTERN
PLAINFIELD
MICHIGAN
LEONARD
FULLER
WALKER
STOCKING
0 1/4 1/2 1 MI

Background

These four sections of recently improved trunkline were selected for evaluation because of their similarity in original cross section and roadside development. All sections carry relatively high average daily traffic volumes. Together they provide an opportunity for gauging the effectiveness of 6.58 miles of continuous center left-turn lane.

The sections as originally constructed were four-lane undivided roadways with curb and gutter, and, at the time, provided an acceptable level of service. However, through the years, commercial development spread out from the incorporated portions of the cities of Lansing, East Lansing, and Grand Rapids, forming a continuous strip of small businesses, such as service stations, drive-in restaurants, and supermarkets which are largely dependent on commuter traffic. Turning desire increased as numerous driveways were constructed to serve these businesses in what had been primarily rural areas. Coincident with roadside development, through traffic volumes continued to increase as residential development spread out into the surrounding suburban areas.

This often repeated pattern of development is common to many metropolitan areas, and, without fail, leads to a marked reduction in level of service and an increase in accident rates. The inside lanes soon lose almost all effectiveness as carriers of through traffic, becoming little more than storage lanes for motorists awaiting an opportunity to complete left turns. This, in turn, causes through traffic to overload the remaining lanes, thus further reducing the availability of gaps in which left turns can be completed.

Accident patterns common to such an operation include rear-ends and sideswipes as motorists continually face the need to brake to a halt or change lanes to avoid entrapment behind a left-turning vehicle. Head-on, left-turn accidents are also common as left turns are attempted in the infrequent gaps available. Left-turning motorists feel some pressure from other vehicles approaching from the rear, and consequently attempt to use gaps of less than desirable length.

Improvement

The decision to construct the fifth lane (center lane for left turns) was based on both economic and traffic operational considerations. The addition of a single lane was, in itself, economical because of minimized costs, but further savings are realized because of the reduced need for acquiring additional right-of-way. Operationally, a continuous refuge area for left-turning traffic is created and produces the added benefit of separating opposing through traffic. Reservation of the center lane for left-turn storage frees the remaining four lanes for through traffic, essentially doubling available capacity. Five-lane roadways thus provide an increased level of service, both for through traffic and for motorists desiring access to roadside businesses. Additionally, opposing left-turning vehicles are "headed-up" and drivers are afforded a better view of opposing through traffic as their vision is not obstructed by an opposing left-turning vehicle.

While the improvements in driving quality were obvious immediately upon completion of the projects, an evaluation of the accident experience was completed in order to determine the actual ratio of benefits to cost. There had also been some concern that the proposed design might tend to increase head-on collisions between opposing vehicles making simultaneous use of the center left-turn lane. Special attention was given in both the before and after periods to this accident pattern.

Typical 4-Lane Roadway in the Before Period

Typical 5-Lane Roadway in the After Period

Conclusions

Accident experience was gathered for 12 months "before" and 12 months "after" completion of the projects and reduced into four basic patterns for analysis and comparison. The study confirmed both a marked reduction in total accidents (33%), and that the projects were successful in favorably reducing the accident patterns at which they were most directed, namely, left-turns (45%) and rear-ends (62%). It should be noted that these accident reductions were produced despite increases in average daily traffic on all four sections of roadway.

With regard to the head-on type of collision, the "before" period produced a total of 14 accidents with 18 persons injured, and the "after" period produced 8 of this type with 1 person injured. This would indicate that earlier concern over potential head-on accidents was not warranted.

A statistical analysis of the significance of the accident reduction and a cost-benefit analysis were performed, the computations appearing in the appendix of this report. It was confirmed that the accident reductions were statistically significant and produced a monetary benefit of $455,000 in one year. As the total cost of the improvements was $3,246,000, accrued benefits will surpass project costs in seven years.

It is apparent that the use of a continuous center lane for left turns is both an economical and effective treatment for maintaining an acceptable level of service and safety on high-volume roadways serving areas of strip commercial development.

ACCIDENT RECORD TABLE

ACCIDENT ANALYSIS	BEFORE					AFTER				
	LOC. 1	LOC. 2	LOC. 3	LOC. 4	TOTAL	LOC. 1	LOC. 2	LOC. 3	LOC. 4	TOTAL
ACCIDENT SEVERITY	2060	2036	781	656		1213	1682	482	363	
TOTAL ACCIDENTS	84	91	176	181	532	53	84	117	102	356
PROPERTY DAMAGE	55	60	115	112	342	40	54	78	65	237
INJURY (INJURED)	29 (63)	31 (56)	61 (111)	68 (119)	189 (349)	12 (24)	29 (60)	39 (61)	37 (54)	117 (199)
FATAL (KILLED) (INJURED)	—	—	—	1 (1) (2)	1 (1)(2)	1 (1) (4)	1 (1) (3)	—	—	2 (2)(7)
ACCIDENT TYPE										
LEFT TURN	17	21	41	15	94	11	19	16	6	52
REAR-END	35	33	76	94	238	15 42% 57	21 45% 36	30 39% 60	24 74	90 62%
RIGHT ANGLE	13	18	28	33	92	12	25	26	42	105
SIDESWIPE	6	4	13	19	42	4	7	13	15	39
OTHERS	13	15	18	20	66	11	12	32	15	70
PAVEMENT & LIGHT CONDITION										
WET SURFACE	28 (33%)	36 (40%)	56 (32%)	61 (34%)	181 (34%)	15 (28%)	19 (23%)	24 (21%)	30 (29%)	88 (25%)
DARK	38 (45%)	48 (53%)	56 (32%)	57 (32%)	199 (37%)	31 (58%)	44 (52%)	52 (44%)	40 (39%)	167 (47%)

LOCATION 1

M-43 FROM BOGUE TO HAGADORN
INGHAM CO. 0.57 MILES $119,000

BEFORE PERIOD 9-10-63 TO 9-9-64 ADT 19,600

AFTER PERIOD 7-15-65 TO 7-14-66 ADT 21,000

LOCATION 2

M-43 FROM HAGADORN TO PARK LAKE RD.
INGHAM CO. 0.80 MILES $391,000

BEFORE PERIOD 2-26-67 TO 2-25-68 ADT 15,300

AFTER PERIOD 10-10-68 TO 10-9-69 ADT 17,100

LOCATION 3

US-27 FROM DOUGLAS NORTHERLY TO NORTHCREST
INGHAM CO. CLINTON CO. 2.73 MILES $1,536,000

BEFORE PERIOD 11-28-66 TO 11-27-67 ADT 22,600

AFTER PERIOD 11-1-68 TO 10-31-69 ADT 24,350

LOCATION 4

M-44 CONNECTOR FROM I-96 NORTHERLY TO AIRWAY ST.
KENT CO. 2.48 MILES $1,200,000

BEFORE PERIOD 3-25-68 TO 3-24-69 ADT 30,500

AFTER PERIOD 9-25-69 TO 9-24-70 ADT 31,000

TOTAL COST 3,246,000

TABLE 1

APPENDIX A

The Significance of Accident Reduction

To test the aggregate accident reduction for statistical "significance" reference is made to the "Null Hypothesis" (H_0)* stating that there is no change in "before" and "after" accident numbers.

Where

	"Before"	"After"
Number of vehicles not involved in accidents	A	B
Number of vehicles involved in accidents	C	D

Assume: $A/B = C/D \quad (H_0)$

Using Chi-square statistics

$$\chi^2 = \frac{(AD - BC)^2 N}{(A + B)(C + D)(A + C)(B + D)}$$

Where $N = A + B + C + D = 66,229,250$

From Chi-square "2 x 2" Table

$\chi^2_{.99,1}$ (read Chi-square at the 99 confidence level with 1 degree of freedom) = 6.63

and using

$A = 88,000 \times 365 - 1,059 = 32,118,941$

$B = 93,450 \times 365 - 696 = 34,108,554$

$C = 1059$

$D = 696$

then

$\chi^2 = 98.56 > 6.63$

*Reference is made to "Statistical Inference" by Helen M Walker, page 100.

Therefore, the original hypothesis, H_0, (stating that the number of accidents during the "after" period could have been equal to the number of accidents in the "before" period) is rejected within a 99 percent level of confidence and the reduction is therefore shown to be statistically significant.

APPENDIX B

Computed Benefits Derived Through Accident Reductions
Cost Analysis

The method of evaluating accident costs, used below, is given on Page 67 of Roy Jorgensen's Report of "Highway Safety Improvement Criteria," 1966 Edition. This same method is given in the Federal Highway Administration PPM21-16 (March 7, 1969).

In the following analysis the costs provided by the National Safety Council are:

	Year	
	1966	1969
Death -	$36,000	$41,700
Non-fatal Injury -	2,000	2,500
Property Damage Accident -	340	380

$$B = \frac{ADTa}{ADTb} \times (Q\ R_1{}^* + 340^{**}\ R_2{}^*)$$

where

B = annual benefit in dollars

ADTa = average daily traffic volume after the improvement from Table 1
Location 1 (21,000) Location 2 (17,100) Location 3 (24,350) Location 4 (31,000)

ADTb = average daily traffic volume before the improvement from Table 1
Location 1 (19,600) Location 2 (15,300) Location 3 (22,600) Location 4 (30,500)

R_1 = reduction in fatalities and injuries combined from Table 1 Location 1 (63-29=34) Location 2 (56-64=-8) Location 3 (111-61=50) Location 4 (122-54=68)

R_2 = reduction in property damage accidents from Table 1 Location 1 (55-40=15) Location 2 (60-54=6) Location 3 (115-78=37) Location 4 (112-65=47)

$$Q_{66} = \frac{36,000^{**} + (I/F \times 2,000^{**})}{1 + I/F}$$

*In the above noted reference, R_1 is listed as $A_{fi} \times P_{fi}$. Therefore, upon inspection, $P_{fi} = \frac{R_1}{A_{fi}}$ so that $A_{fi} \times P_{fi} = A_{fi} \times \frac{R_1}{A_{fi}} = R_1$. Similarly R_2 replaces $A_{pd} \times P_{pd}$.

**See above figures for 1969

where

I/F = ratio of injuries to fatalities that occurred on all Michigan streets and highways

1966	1969
$\frac{156,694}{2296} = 68.24$	$\frac{175,400}{2487} = 70.53$

therefore

$$Q_{66} = \frac{36,000 + (68.24 \times 2,000)}{1 + 68.24} = 2491$$

$$Q_{69} = \frac{41,700 + (70.53 \times 2,500)}{1 + 70.53} = 3048$$

The computed benefits to the motoring public accrued during the year "after" period is then:

$$B = \frac{21,000}{19,600} \times \left[(2491 \times 34) + (340 \times 15) \right] + \frac{17,100}{15,300} \times \left[(3048) (-8) + (380 \times 6) \right] + \frac{24,350}{22,600} \times \left[(3048 \times 50) + (380 \times 37) \right] +$$

$$\frac{31,000}{30,500} \times \left[3048 \times 68) + (380 \times 45) \right] = 96,200 - 24,700 +$$

$$155,500 + 228,000 = \$455,000$$

Annual Benefit (B) = $455,000