TRAFFIC SAFETY STUDY

Muscatine, Iowa

Prepared For

THE OFFICE OF THE CITY ENGINEER

GEORGE L. CRAWFORD & ASSOCIATES, INC.
Maryland Heights, Missouri 63043

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA
#25-80

Final Report
January, 1981

Prepared for the Office of the City Engineer
Ray Childs, P.E.

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INTRODUCTION

The City of Muscatine, Iowa, with a population of approximately 25,000, is located on the east side of the state on the Mississippi River. The city has for years kept pace with the pressing need for adequate traffic control devices to handle the increasing volume of traffic.

Traffic characteristics within Muscatine differ somewhat from other cities of comparable size. Due to the geography of the city, there are several jogs in the state route (U.S. 61). Also, this state route has several separate and distinct characteristics. For example, the southern portion is primarily rural; the mid-section passes through the outer limits of the Central Business District; and the northern portion is primarily affected by residential and commercial activity.

The following report, prepared by George L. Crawford & Associates, Inc. (GLC) contains the methodology used to conduct the study, the analysis, and the proposed changes to improve safety and reduce accidents.

Specifically, this report deals with the following major topics:

- School Signing
- Traffic Signal Progression
- High Accident Locations
- Special Study Locations

This study was made possible through the coordination of the efforts of GLC and the Office of the City Engineer. Mr. Ray Childs, P.E., devoted many hours to this project from the onset by providing necessary data, manpower and valuable review comments.

CHAPTER 1
SCHOOLS

The purpose of this chapter is to discuss our field observations for the various schools within Muscatine. Our analysis of the selected locations was based on a "windshield appraisal." The need for additional signing, markings, and sidewalks were based on this appraisal. For purpose of presentation, each school is discussed separately. The school crossing signs (S1-1) and (S2-1) which have been recommended throughout this chapter are illustrated on Exhibit 1. The location of the individual schools, signs, and crosswalks recommended are attached to this report in the Appendix.

GARFIELD SCHOOL -- #1

The main routes feeding Garfield School are Wisconsin and Indiana Streets (north-south) and Schley, Miles, and to some extent, Demorest Avenues (east-west). There are four-way stops on Wisconsin at Schley and Demorest. There are no intersection controls at Miles and Wisconsin which is a direct route to the main entrance of the school. We recommend that the following school crossing signs be used at Wisconsin:

- Southbound in advance of Schley; placement of an Advance School Sign (S1-1).
- Northbound in advance of Demorest; placement of the S1-1 Sign.
- Intersection of Miles and Wisconsin; placement of School Crossing (S2-1) signs on the Wisconsin Street approach and make this a crosswalk.
- Placement of S1-1 Signs on Schley for eastbound traffic just east of Ohio and for westbound traffic just west of Kansas to replace the existing non-standard signs.
- Establish another school crossing on Schley at Indiana Street by placement of School Crossing Signs (S2-1).
- Establish a No Parking Zone approximately 50 feet on each side of Miles Avenue on Wisconsin Street.
- Construct sidewalks on the south side of Schley Avenue from Indiana east to Nebraska.

FRANKLIN SCHOOL -- #2

Primary access to Franklin School is provided along Hershey, Taylor, and Busch. There is a marked crosswalk on Hershey Avenue at Taylor and it has the proper School Advance (S1-1) and School Crossing (S2-1) signs. For southbound traffic on Taylor, the Advance School sign is non-standard. This sign should be removed and replaced with the standard School Advance (S1-1) sign. Children from Franklin School cross Taylor Avenue at two locations. Both these locations should have marked crosswalks. The first crosswalk should be located across the south leg of Taylor at New Hampshire. S2-1 signs should be erected on Taylor. The second crosswalk should be marked across the north leg of Franklin (Taylor) at Evans. S2-1 signing will not be necessary at this location because of Stop signs facing Franklin (Taylor). For northbound traffic on Taylor, there is also a non-standard Advance School sign located north of Evans which should be replaced with the School Advance (S1-1) sign.

Field observations indicate that children cross Evans at the intersection of Franklin and Evans. Therefore, we recommend that a School Crosswalk be established on the east leg of this intersection across Evans. This would require the School Advance (S1-1) signs for both directions of travel along with the School Crossing (S2-1) signs. The advance signs should be located, for westbound traffic, just west of the Pearl Street intersection. Parking on Evans at Taylor should be restricted approximately 30 feet from the east leg in order to provide the necessary sight distance for the crosswalk. There does not appear to be a need for additional sidewalks.

WASHINGTON SCHOOL -- #3

Washington School is located between Rosco Avenue and Broadway north of 8th Street. There are existing traffic signals on 8th Street at Broadway and Rosco which are vehicle-actuated and are utilized by school children crossing at these intersections. There is a fenceway from the school southwardly which intersects 8th Street at about Locust Street and provides access directly to the school. The existing signals have marked school crossings. The current signing along 8th Street is as follows:

- Eastbound; the S1-1 and S2-1 signs are posted in advance of the Broadway intersection.
- Continuing eastbound; there are no signs for westbound traffic in advance of the Broadway crossing.
- There are no signs at the Locust Street crossing or the Rosco Street crossing.
- There are S1-1 and S2-1 signs for westbound traffic at Rosco.

The following recommendations on 8th Street are made:

- Establish a new crosswalk at Locust Street and install the S2-1 signs. The crosswalk should be painted on the west side of this intersection.
- Add an S2-1 sign for eastbound traffic at Rosco and an S2-1 sign for the westbound traffic at Broadway.

The crosswalk at Locust Street is recommended because of the paved walk that leads directly to the school from 8th Street. The two existing traffic signals should provide enough gaps on 8th Street to allow children to cross.

Recommendations for the improvement of the traffic signals will be made under the topic of Special Study Locations.

Maiden Lane, which also serves as access to the school along the north side, should be posted with a School Advance (S1-1) sign for eastbound traffic just east of Newell Avenue and for westbound traffic 150' west of Rosco Avenue. An additional S1-1 sign should also be added approximately 100 feet north of 8th Street on Broadway. There appears to be no need for additional sidewalks to serve this school.

An S2-1 sign for northbound traffic on Broadway should be placed approximately 300' south of 8th Street. Another one should be placed for southbound traffic on Rosco approximately 300' north of 8th Street.

MCKINLEY SCHOOL AND WEST JUNIOR HIGH SCHOOL -- #4 & #5

The first intersection which has a crosswalk for students is at the intersection of Fulliam Avenue and Logan Street. Since there are no sidewalks along the north side of Fulliam, this crossing provides access to one on the south side of Fulliam. In addition, a roll-out Stop Sign for Fulliam is used at this location. Full-time Stop signs for Logan are in place.

There are standard S1-1 and S2-1 signs in place on Fulliam at Logan Street for both directions of travel.

On DeVitte Avenue, there is an established school crossing approximately 300' north of Americana. The only signing for this crossing is a School Crossing (S2-1) sign for southbound traffic located approximately 300' north of the crossing. It is recommended that this S2-1 sign be relocated south to a point next to the crosswalk and that an additional S2-1 sign be posted at the crosswalk for northbound traffic. In addition to this, the S1-1 signs should be posted in advance of the crosswalk. On Fulliam Avenue, we note that there are painted crosswalks at Hammann Avenue and Kindler Avenue. There is no signing at the Hammann Avenue crossing. There are the required S1-1 and S2-1 signs in advance of the crosswalk of Kindler. We recommend the following:

- That the crosswalk and signs at Kindler be eliminated.
- That the crosswalk at Hammann be continued and that S1-1 and S2-1 signs be placed in both directions on Fulliam.
- We recommend that a sidewalk be constructed along the south side of Fulliam from Kindler west to Meadow Lane. At the time that this crosswalk is established, an additional crossing should be established on Fulliam at Meadow Lane. This will require S1-1 and S2-1 signs be posted in advance of this new crosswalk.

The existing S1-1 sign for eastbound traffic can remain in its present location. The S1-1 sign for the westbound traffic which is presently east of Hammann should be moved further to the east to approximately Pearl View Court. The S2-1 signs that are presently at Kindler should be relocated to Hammann Avenue.

On Kindler Avenue, there is a 25 MPH speed limit. Sidewalks are located on the east side of this street. An S1-1 sign for southbound traffic is located almost directly in front of the school and should be relocated to the north approximately 300'.

There is a "Do Not Enter" sign facing southbound traffic for the Junior High School drive and this sign should be removed and replaced with R6-1L and R6-1R signs (One-Way Arrows).

Proceeding southbound on Kindler, at the intersection between the Junior High School and the McKinley School, there is a signalized mid-block school crossing. This signal has two pedestals and four signal heads. The pedestals are located on the far side of the crosswalk so the far left signal is located on the near side of the crosswalk. This does not meet the standards set forth in the Iowa MUTCD for mid-block locations. Because of the excellent sight distances at this location, we recommend the elimination of these signals. Should the city desire to leave this location signalized it will be necessary to improve the existing signals to meet the Iowa MUTCD. Under either condition the skewed crossing should be eliminated and the crosswalk placed east and west from the east point of the skewed crossing (Exhibit 1). Also, the S2-1 sign facing northbound traffic is obstructed by a "No Parking Sign." The "No Parking Sign" should be relocated. Continuing south on Kindler, past the Junior High School, there is an S1-1 sign facing northbound traffic at the south school boundary. This sign should be relocated approximately 300' south to give more advance warning to northbound motorists.

Additional crosswalks located within the vicinity of the schools are: across Lucas Street at Fletcher Avenue; and across Newell at Kindler. For eastbound traffic on Lucas Street, the S1-1 sign and S2-1 signs are posted prior to the crossing at Fletcher Avenue. However, for westbound traffic, only the S2-1 sign is posted and the S1-1 sign should be added approximately 300-400' in advance of the Fletcher Avenue crosswalk. At the intersection of Kindler and Newell for eastbound traffic on Newell, an S2-1 sign is required and should be located as far west on the island as possible. For westbound traffic on Newell, there are the required S1-1 and S2-1 signs in advance of this crossing.

The old crosswalk approximately 50' east of the point where Newell Avenue and Lucas Street intersect should be eliminated.

Houser Street also serves the Junior High School area and it should be noted that there are no sidewalks on either side of Houser Street. There is an S1-1 sign located just south of Broadlawn for northbound traffic and a school crosswalk is at Allen Street. This crossing is properly marked with the required S2-1 signs in each direction. The pavement is not marked

EXHIBIT 1

SCHOOL CROSSING FOR MCKINLEY SCHOOL AND WEST JUNIOR HIGH SCHOOL ON KINDLER

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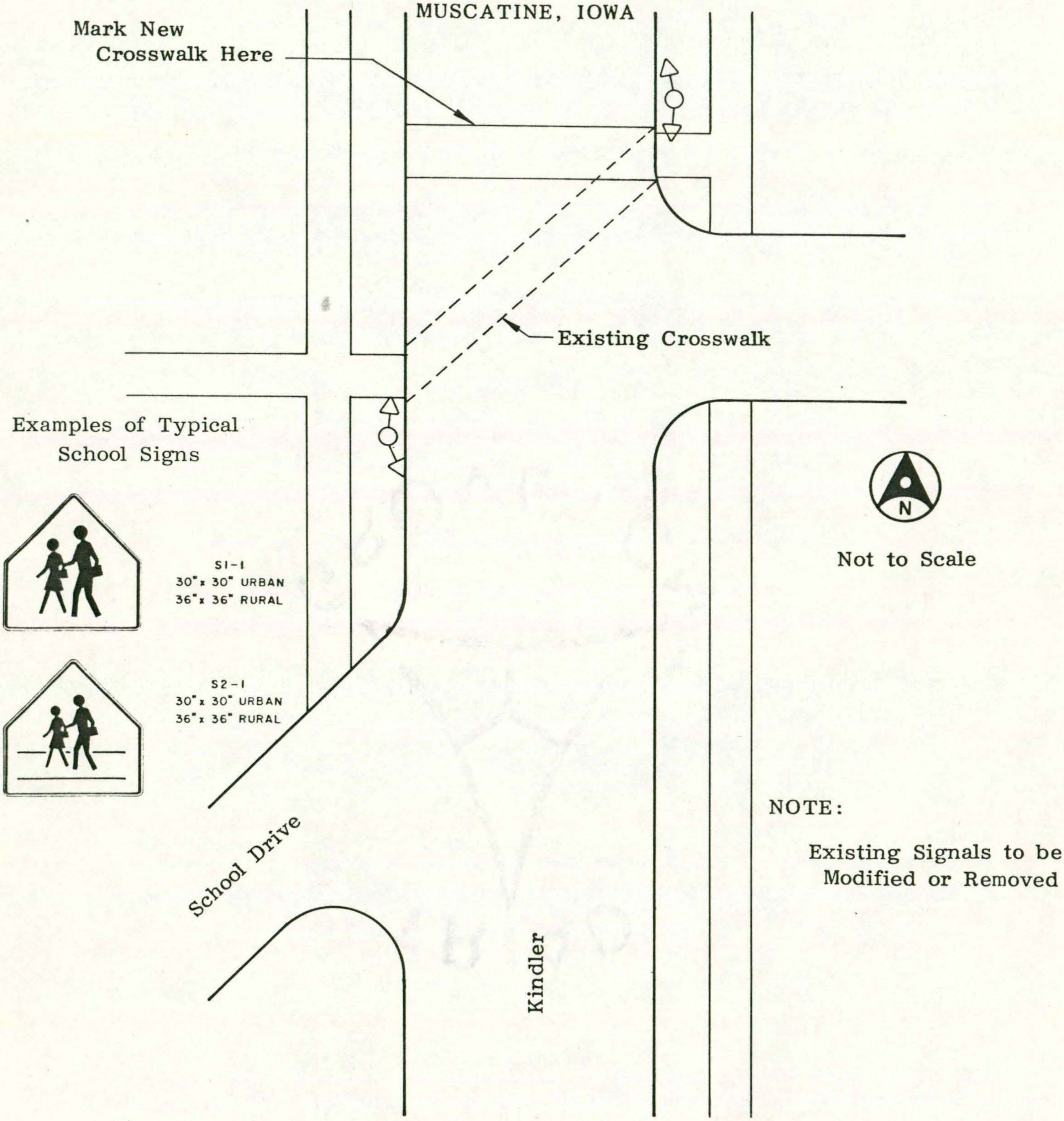


George L. Crawford and Associates Inc.
Traffic Engineers
Maryland Heights, Missouri

due to the type of surface. There is a roll-out stop which is used during school hours at Houser. For southbound traffic, the S1-1 sign is posted approximately 200' north of Dawson Street.

Further examination of this area would indicate that the direct route to the Junior High School is actually on Dawson Street. There are two possibilities for the improvement of this intersection which would allow the safe crossing of school children:

1. Alternate 1 would be to signalize the intersection of Houser Street and Dawson Street.
2. Alternate 2 would be to place a signal mid-block approximately 100' south of Dawson Street.

Based on the volume counts, Alternative I is not recommended. However, as traffic volumes and vehicular speeds increase with the construction of the four-lane facility, Alternative 2 may be considered by the city. At that time, a gap analysis should be made to determine the feasibility of the signal. Exhibit 22 illustrates Alternative 2.

Additional sidewalks should be provided on both sides of Houser from the L.L. Pickett School south of Lucas Street. This should be undertaken after the improvement of Houser. Sidewalks should also be provided on the south side of Dawson Street from Houser to the school grounds.

HAYES ELEMENTARY SCHOOL -- #6

The main street which serves the Hayes Elementary School is Cedar Street (Highway 22). The Hayes Elementary School drive with Cedar Street does not have stop controls and it is recommended that a Stop sign be posted at this location.

The speed limit along Cedar Street is normally 45 MPH. A variable message sign converts the speed limit to 25 MPH during school zone. This sign is posted for both eastbound and westbound traffic. There are no additional traffic controls needed for this school.

JEFFERSON SCHOOL AND CENTRAL JUNIOR HIGH SCHOOL -- #7 & #8

Jefferson School is located along Cedar Street and Mulberry Avenue between 9th and 10th Streets. On Cedar Street, there are two marked crosswalks; one at 9th Street and one at 10th Street. Both crosswalks should remain because of the location of the entrances to the schools. For southbound traffic there exists the S1-1 and S2-1 signs in advance of the 10th Street crossing. For northbound traffic, there is an S1-1 and S2-1 sign in advance of the 9th Street crossing. Roll-out stops are used at both the 9th and 10th Street crossings during school hours. Additional S2-1 signs should be added at the two crossings.

Parking is prohibited along the east side of Cedar adjacent to the school. Although it would be desirable to prohibit additional parking in advance of these crosswalks in order to provide greater sight distance the closeness of the residences on Cedar prohibits this. Therefore, the S2-1 signs should all be installed with at least 7' clearance to the bottom of the sign.

At the intersection of 9th and Mulberry Avenue, there are four marked crosswalks. The one located on the south leg across Mulberry should be eliminated. Ninth Street is required to stop at Mulberry Avenue. Additional S2-1 signs should be added on Mulberry Avenue at the 9th Street crossing.

There is a roll-out stop on Mulberry at 10th Street. S2-1 signs should be erected on Mulberry in advance of this crossing. It should also be noted that parking is presently allowed on both sides of Mulberry Avenue. It is recommended that parking be restricted on Mulberry 50' in each direction from 10th Street. In addition, school buses should not be allowed to park on the west side of Mulberry north of 10th. A S1-1 sign should be erected on 9th Street west of Orange.

There are four crosswalks located at the intersection of 8th Street and Mulberry. S1-1 signs should be erected on 8th Street in both directions from Mulberry. On Mulberry an S1-1 sign should be erected for northbound traffic south of 8th Street. The one facing northbound traffic north of 8th Street should be removed. S2-1 signs should be erected on both 8th Street and Mulberry.

There does not appear to be a need for any additional crossings marked for this school. Neither does there appear to be a need for additional sidewalks to serve this school.

GRANT SCHOOL -- #9

The main streets serving Grant School are Barry Avenue and LeRoy Street. Presently, there is a marked crossing on Barry Avenue at Amherst Avenue (Amherst is plotted but not constructed). This crosswalk is signed properly with S2-1 and the S1-1 sign for eastbound traffic. However, the S1-1 sign for westbound traffic should be moved to a point west of Circle Drive. A roll-out stop is used at this location during school hours. West of Grant School, there are sidewalks on both sides of Barry Avenue. However, east of the school the sidewalks are on the north side only.

There are three additional locations where marked crosswalks serve the school. The first is located at the intersection of Barry Avenue and Mulberry Avenue. The north and south legs of Mulberry are marked with the required S2-1 and S1-1 signs. There is also a roll-out stop used during school hours at this location. There are sidewalks on both sides of Mulberry.

The second location is on Sunset Drive at Center Drive. This crosswalk appears to be properly located and has the required S2-1 and S1-1 signs. The sidewalks in this area will be installed during the completion of the subdivison.

The third location is on LeRoy Street at Amherst Avenue. The crosswalks are located on the east leg of LeRoy and the south leg of Amherst Avenue. LeRoy Street is marked with the standard school crossing signs and a roll-out stop is used during school hours. Permanent stop signs should be erected on Amhurst for LeRoy. There are sidewalks on both sides of LeRoy. We do not recommend any traffic control changes.

MULBERRY SCHOOL -- #10

The main street that serves Mulberry School is Mulberry Avenue. At this time there is one marked crosswalk directly in front of the school and it is signed with the S2-1 and S1-1 signs. This crossing is approximately 500' east of Bonnie Drive. There is no roll-out stop at this location and the speed limit is posted at 35 MPH. There are no sidewalks on either side of Mulberry which would provide access for students walking to the school. Since the students are bused to this school (or arrive by private means), sidewalks are not needed at this time.

MADISON SCHOOL -- #11

The primary route serving Madison School is 1st Avenue. Sidewalks begin approximately 75' south of McArthur Street on 1st Avenue. There is a crosswalk directly in front of the school and a roll-out stop sign is used during school hours. For northbound and southbound traffic on 1st Avenue, there are non-standard school signs. These two signs should be removed and replaced with the standard S1-1 signs. The standard S2-1 signs should be placed at the main crossing in front of the Madison School.

Oak Street, which also accesses the south boundaries of the school does not have sidewalks on either side and it does not appear that school children travel this route heavily.

Another major crossing serving this school is the intersection of Clay Street and 1st Avenue. At this location, there is a traffic signal with "Walk" and "Don't Walk" lights. Also, there are marked crosswalks. There are sidewalks on both sides of 1st Avenue with the standard S1-1 and S2-1 signs posted.

The pedestrian walk clearance is three seconds and this should be extended to approximately seven seconds. The only additional sidewalks for this school should be constructed on each side of 1st Avenue approximately 75' south from McArthur Street to meet existing sidewalks serving the remainder of the block.

COLORADO SCHOOL -- #12

According to the school boundaries, all of the students which attend Colorado School emanate east of Park Avenue and south of Grant Street. There are no sidewalks on either side of Colorado Street. There are sidewalks on both sides of Park Avenue south of Colorado and a sidewalk on the west side of Park north of Colorado. It is recommended that sidewalks be constructed along the north side of Colorado from the School to Park Avenue. An easement should be obtained over the old Colorado right-of-way so that this sidewalk would continue in a straight line to Park rather than following the present curves on Colorado. A sidewalk should be constructed on the east side of Park north of Colorado to intersect with the sidewalk over the old right-of-way. The Park Avenue crossing at Colorado should be marked with appropriate S1-1 and S2-1 signs. Furthermore, Colorado Street should be posted with a 25 MPH speed limit due to the geometric conditions and the Colorado School. Students south of Grant Street can cross at the existing signal at Washington Street or at the signal at 5th Street. Because of the high volume of traffic on Park Avenue, no further crosswalks (which would be unprotected) are recommended.

CHAPTER 2

TRAFFIC SIGNAL SYNCHRONIZATION

The purpose of this chapter is to provide an analysis of the existing CBD signal interconnection and the feasibility of creating a system of synchronized signals along two traffic corridors. Our analysis has been focused on the following locations:

- Central Business District
- Mississippi Drive
- Park Avenue

The analysis has been based on average daily traffic flows, speed delay runs, and field observations of the existing systems.

The Central Business District (CBD), which includes Mississippi Drive, presently operates on a 60-second cycle from a one-dial pretimed Monotrol master controller. The master is located in the basement of the fire house. Fire runs are preempted at the fire house and control only the signals within the CBD. The traffic signals within the CBD are generally timed on a 50-50 split (30 seconds for each approach).

Based on our analysis, the following deficiencies have been noted for the CBD system.

- Traffic volumes within the CBD are quite different from those on Mississippi Drive although they are controlled by the same master controller. The 60-second cycle, while being adequate for the downtown signals, does not provide the necessary flexibility for traffic flows on Mississippi Drive.
- Traffic on Mississippi Drive is often delayed due to the phasing and signal equipment. Because the controllers are pretimed, the side streets adjacent to Mississippe Avenue receive the green indication every cycle whether or not there are vehicles present.
- The 50-50 cycle split within the CBD does not allow for the heavier traffic movements.

The Park Avenue Corridor presently consists of four signalized intersections. Three of these intersections are fully actuated with

Colorado-Clay being semi-actuated. Due to the irregular traffic movements from the shopping areas and developments along Park Avenue, there is a great deal of inefficiency in terms of traffic progressions. With a queue of traffic on any particular side street, the actuated controller responds to this movement on an equal basis with the main traffic movements. This severely limits the available green time for Park Avenue and thereby creates congestion and undue backups.

Ideally, Park Avenue should be progressed in such a manner that traffic on the side streets could only enter at pre-determined intervals. Other than possibly Clay-Colorado, there are no major east-west corridors that warrant an equal priority with Park Avenue traffic.

Based on this analysis, the following recommendations are presented.

RECOMMENDATIONS

Install a new one-dial pretimed master controller expansible to three dials. A reset interrupter should be included with this controller. This equipment could be installed at its present location or to replace one of the local on-street controllers, preferable at 5th and Cedar Streets. The pre-emption of the signals as they exist today would remain.

Separate Mississippi Avenue, Pine to Cedar Avenue, from the existing CBD system to provide a more responsive system for the traffic flows on Mississippi Avenue. The side streets of Pine, Chestnut, Iowa, Sycamore, and Cedar should be semi-actuated along with all separate left turn lanes on Mississippi Avenue. These signals should then be interconnected via hardwire overhead cable. A two-dial background cycle timer would also be required at each intersection to coordinate the progression and the intervals when the actuated movements occur. Install opti-com at the five locations to provide the necessary flexibility for emergency vehicles.

Interconnect the four existing traffic signals along Park Avenue. The progression has been established such that, with the installation of a traffic signal at Cleveland, the progression will not be affected. In order to accomplish this, a background cycle timer will be required at each intersection and the interconnect cable should be placed in trench. Again, the use of opticom is recommended to accommodate emergency vehicles.

SYNCHRONIZATION OF TRAFFIC SIGNALS-TIME SPACE DIAGRAMS

Although the traffic signals within the CBD are presently synchronized and do progress traffic, the travel time studies indicate that the progression can be improved. This is accomplished by reducing delays at intersections with the major flow of traffic.

As noted earlier, a 60-second cycle with a 50-50 split is utilized within the CBD. The split can be changed at locations where traffic volumes are heavier on one approach. However, the Walk-Don't Walk interval is the governing factor in regards to the minimum timing for any approach.

The travel time studies indicate that vehicle operating speeds vary from 5 MPH to 20 MPH. These operating speeds include signal delay time which will be reduced as the progression is optimized, thereby increasing operating speeds. With the delay times eliminated from the analysis, operating speeds between 15 and 25 MPH will be realized. With a system of synchronized signals, travel speeds are not greatly increased. What is noticed is that the start-stop effect and speeding up between signals is greatly reduced. This will create a more even flow of traffic and greatly enhance vehicle efficiency and save energy.

Exhibits 2 thru 14 illustrate the progressions which have been established for the following:

- CBD - 1 Dial System
- Mississippi Avenue - 2 Dial System
- Park Avenue - 2 Dial System

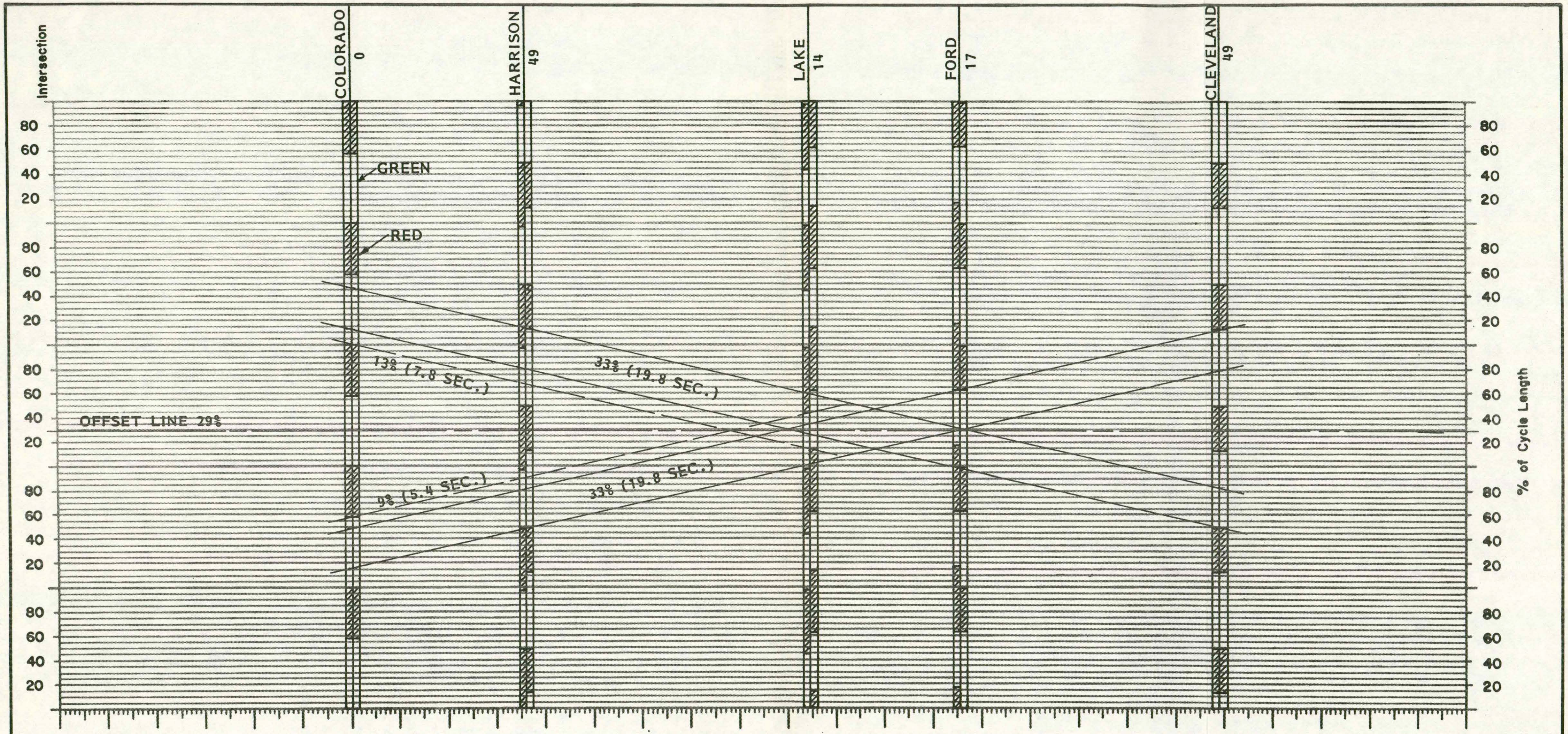
These time-space diagrams illustrate the progressions which can be realized along the two corridors (Park and Mississippi Avenues) and on the various streets within the CBD. Sycamore, Iowa, and Mulberry Streets will have improved progressions. This will attract more vehicles to these corridors. Fourth, Fifth, Cedar, and Walnut will not experience good progressions due to their interaction with those streets where the progression is desired.

Table 1 illustrates various corridors where a time-space diagram has been developed and the band width for each direction of travel.

As a general comment, it is recommended that a four-second amber be incorporated into the CBD signal system. For Park and Mississippi Avenues, a one-second all red clearance interval is recommended due to the higher operating speeds.

TABLE 1
PROGRESSION ANALYSIS
MUSCATINE, IOWA

Corridor	Band Width Percent	Green Time (Seconds)
• Mississippi Avenue		
Northbound		
Normal	30	18.0
Peak	32	24.8
Southbound		
Normal	30	18.0
Peak	31	25.6
• Park Avenue		
Northbound		
Normal	32	19.8
Peak	32	19.2
Southbound		
Normal	33	19.8
Peak	33	19.8
• 2nd Street		
Northbound	26	15.6
Southbound	--	--
• 3rd Street		
Northbound	--	--
Southbound	25	15.0
• 4th Street		
Northbound	14	8.4
Southbound	N/A	N/A
• 5th Street		
Northbound	10	6.0
Southbound	18	10.8
• Mulberry Avenue		
Eastbound	36	21.6
Westbound	36	21.6
• Sycamore Avenue		
Eastbound	32	19.2
Westbound	22	13.2



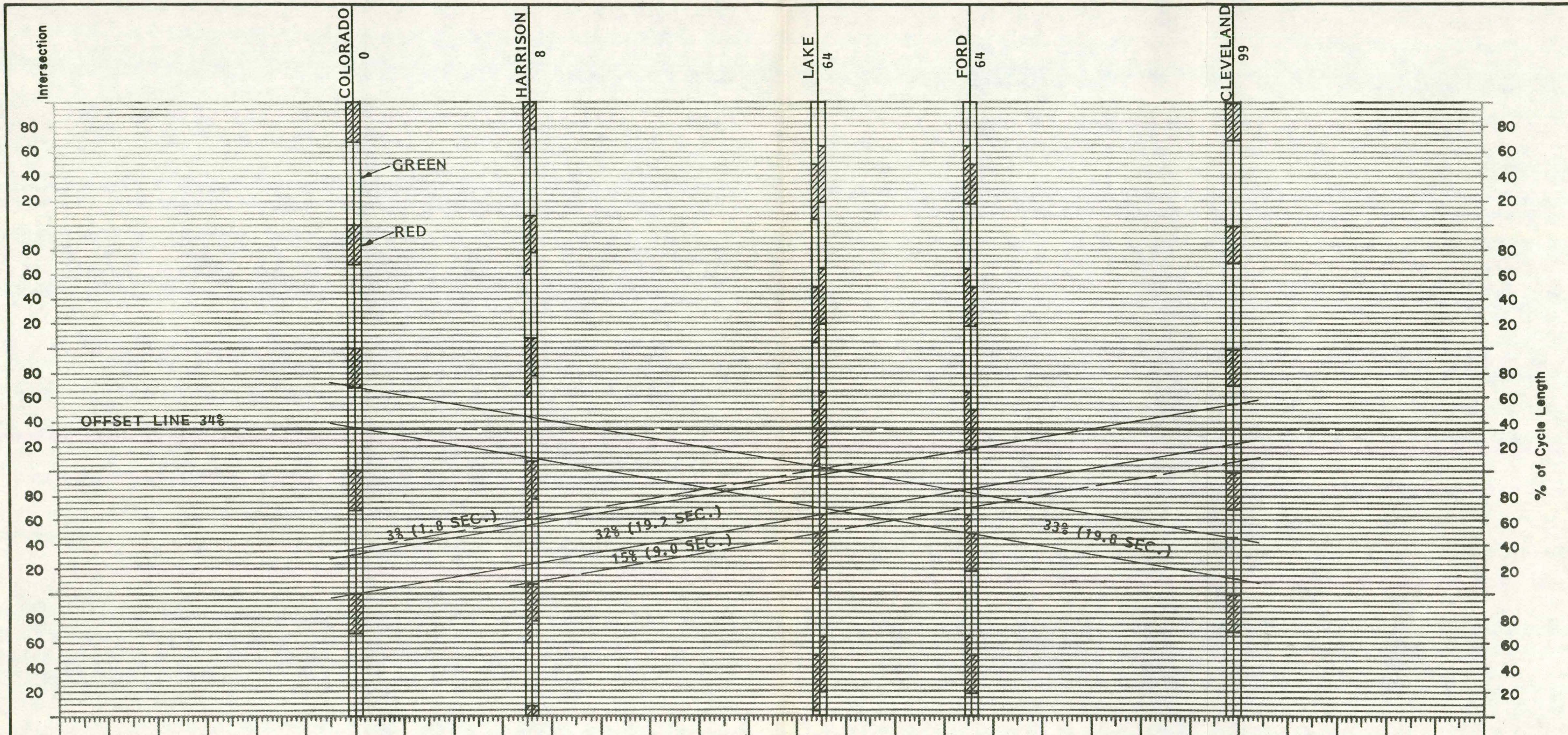
TIME SPACE GRAPH

Scale: 1" = 400'
Cycle Length 60 sec.
Progression Speed 25 MPH
Dial NORMAL
Date 4-7-80

OFFSET	29	80	15	12	80														
Intersection	COLORADO	HARRISON	LAKE	FORD	CLEVELAND														

EXHIBIT 2

PARK AVENUE
ARTERIAL



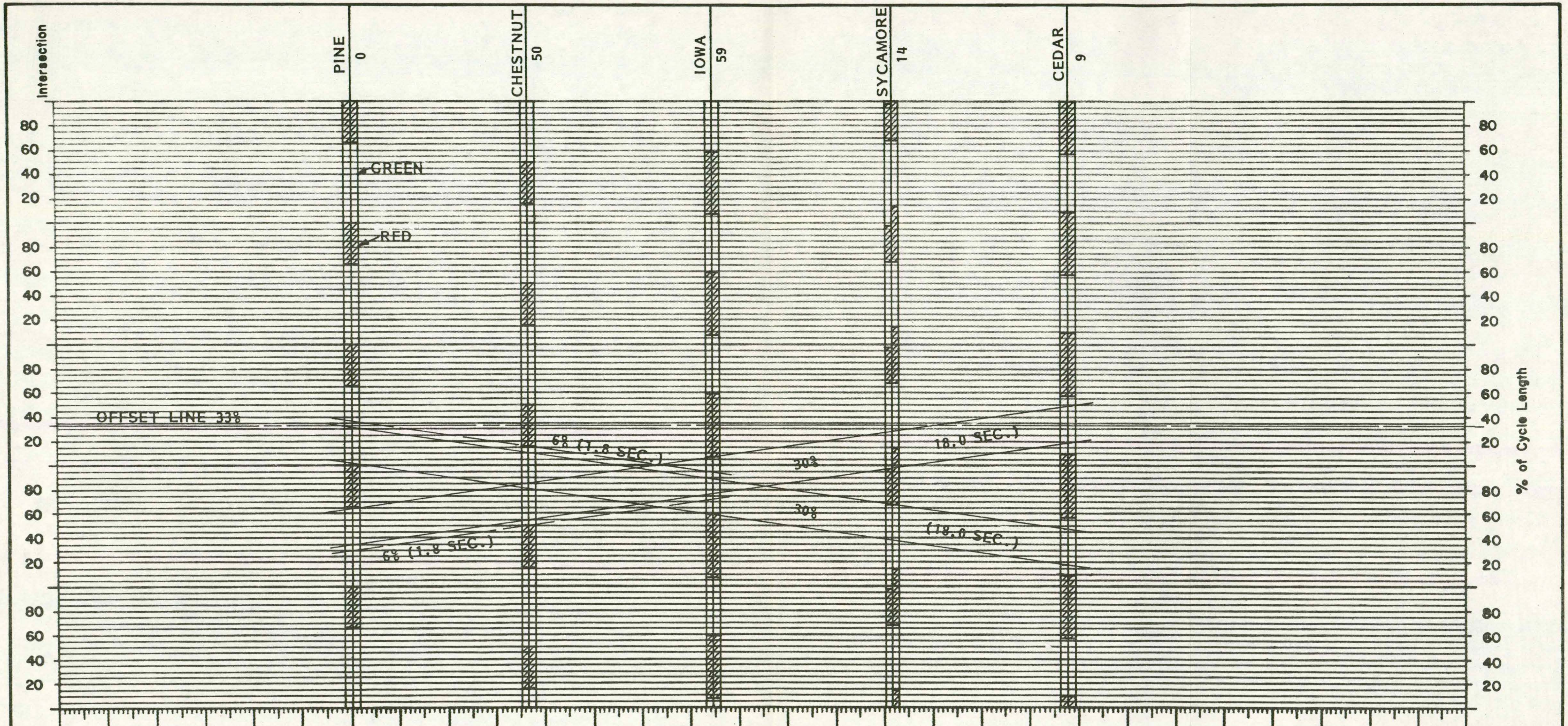
TIME SPACE GRAPH

Scale: 1" = 400'
Cycle Length 80 sec.
Progression Speed 25 MPH
Dial PEAK
Date 4-7-80

OFFSET	34	26	70	70	35														
Intersection	COLORADO	HARRISON	LAKE	FORD	CLEVELAND														

EXHIBIT 3

PARK AVENUE
ARTERIAL



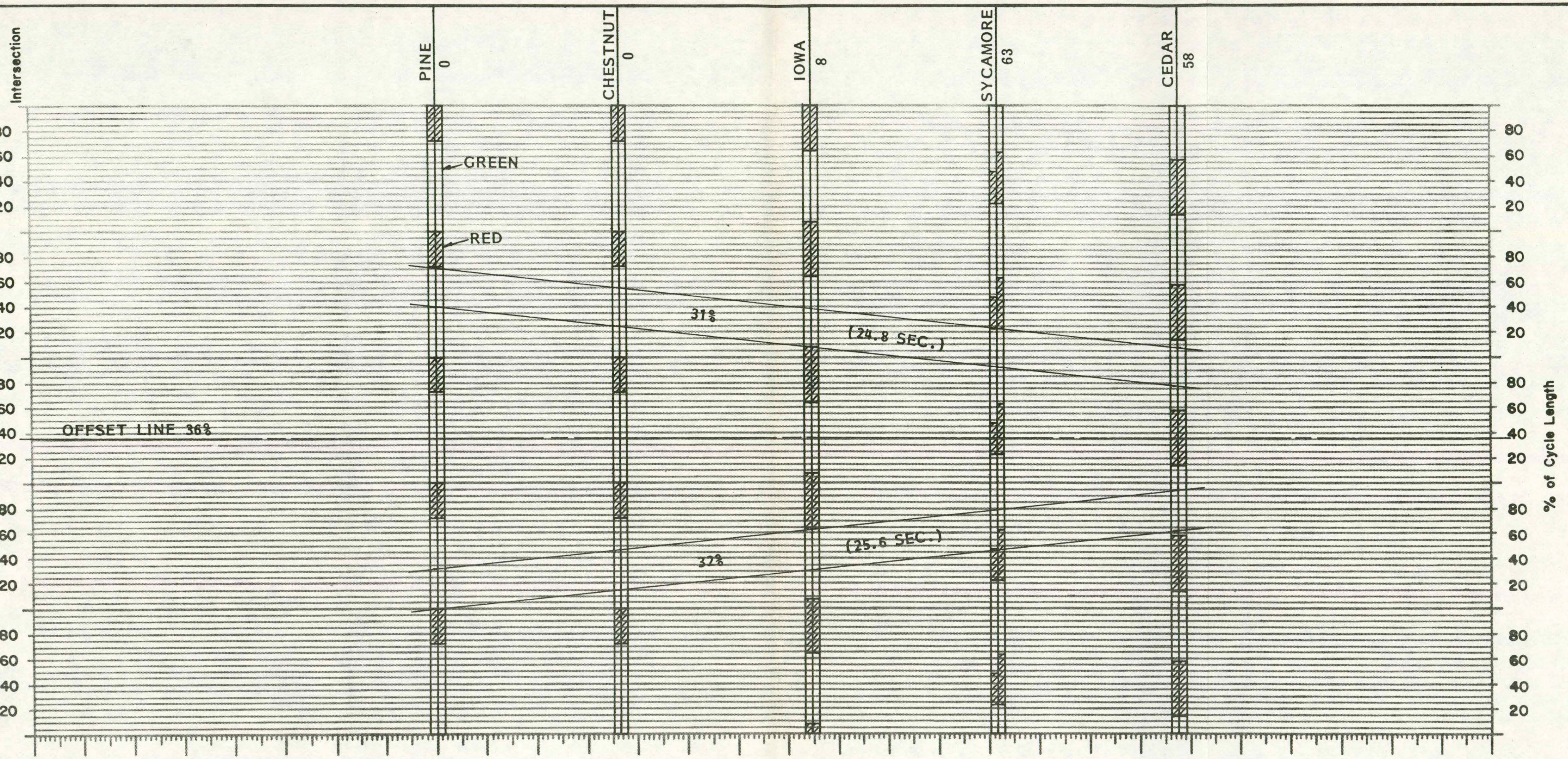
TIME SPACE GRAPH

Scale: 1" = 200'
Cycle Length 60 sec.
Progression Speed 20 MPH
Dial Normal
Date 4-4-80

OFFSET	33	83	74	19	24
Intersection	PINE	CHESTNUT	IOWA	SYCAMORE	CEDAR

EXHIBIT 4

MISSISSIPPI DRIVE
ARTERIAL



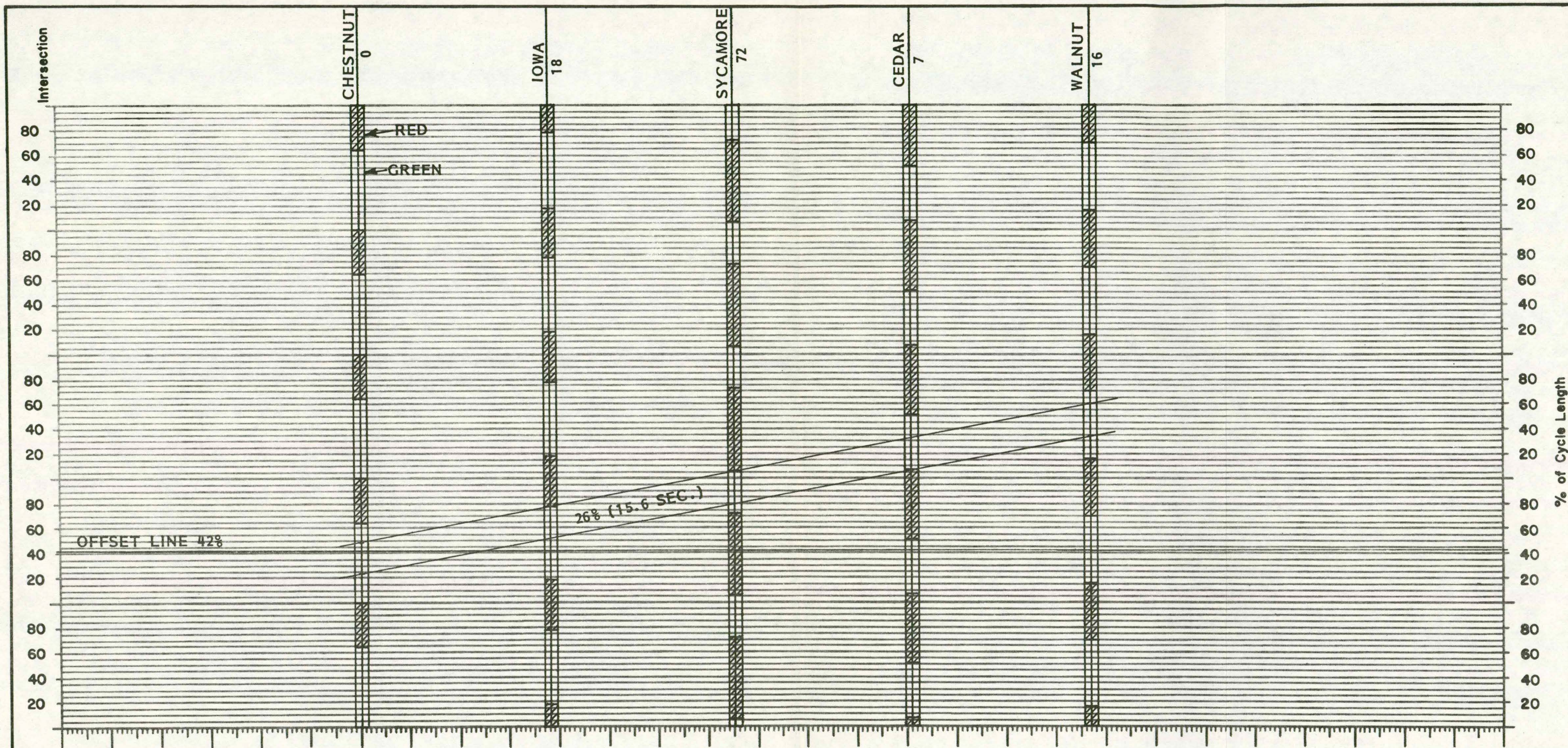
TIME SPACE GRAPH

Scale: 1" = 200'
Cycle Length 80 sec.
Progression Speed 20 MPH
Dial Peak
Date 4-4-80

OFFSET	36	36	28	73	78													
Intersection	PINE	CHESTNUT	IOWA	SYCAMORE	CEDAR													

EXHIBIT 5

MISSISSIPPI DRIVE
ARTERIAL



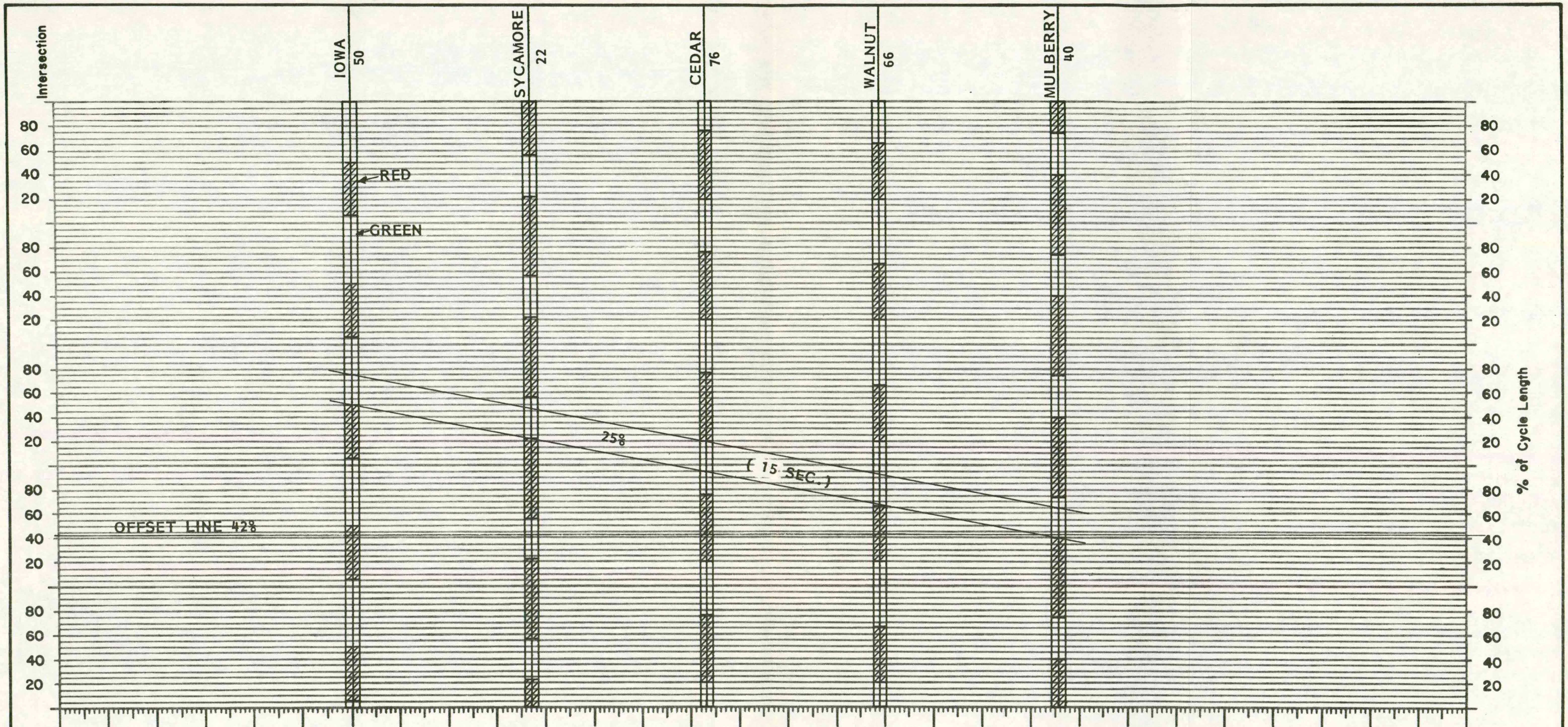
TIME SPACE GRAPH

OFFSET	42	24	70	35	26														
Intersection	CHESTNUT	IOWA	SYCAMORE	CEDAR	WALNUT														

Scale: I" = 200'
Cycle Length 60 **sec.**
Progression Speed 15 **MPH**
Dial ____
Date 4-3-80

EXHIBIT 6

2ND STREET
ARTERIAL



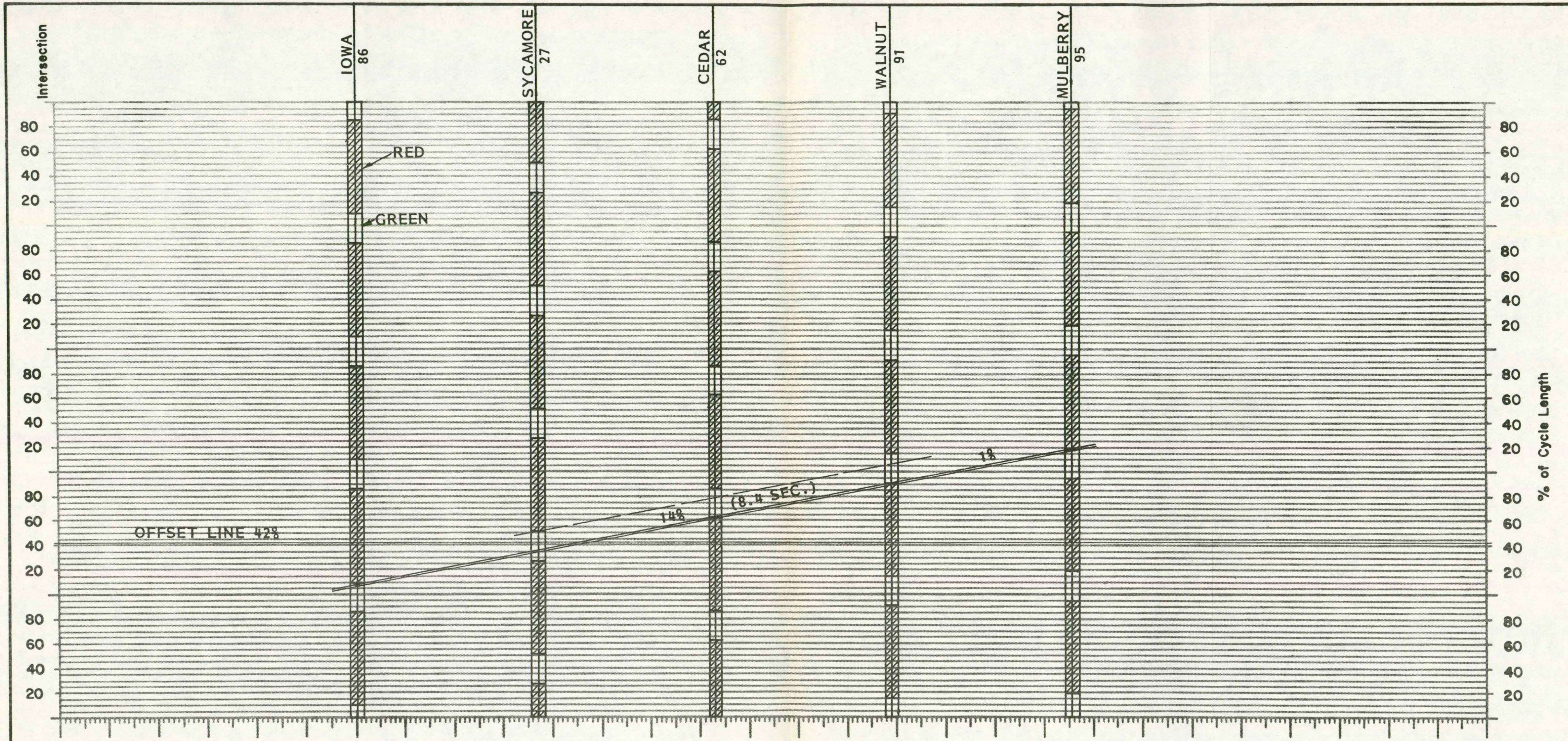
TIME SPACE GRAPH

Scale: 1" = 200'
Cycle Length 60 sec.
Progression Speed 15 MPH
Dial ____
Date 4-3-80

OFFSET	92	20	66	76	2														
Intersection	IOWA	SYCAMORE	CEDAR	WALNUT	MULBERRY														

EXHIBIT 7

3RD STREET
ARTERIAL



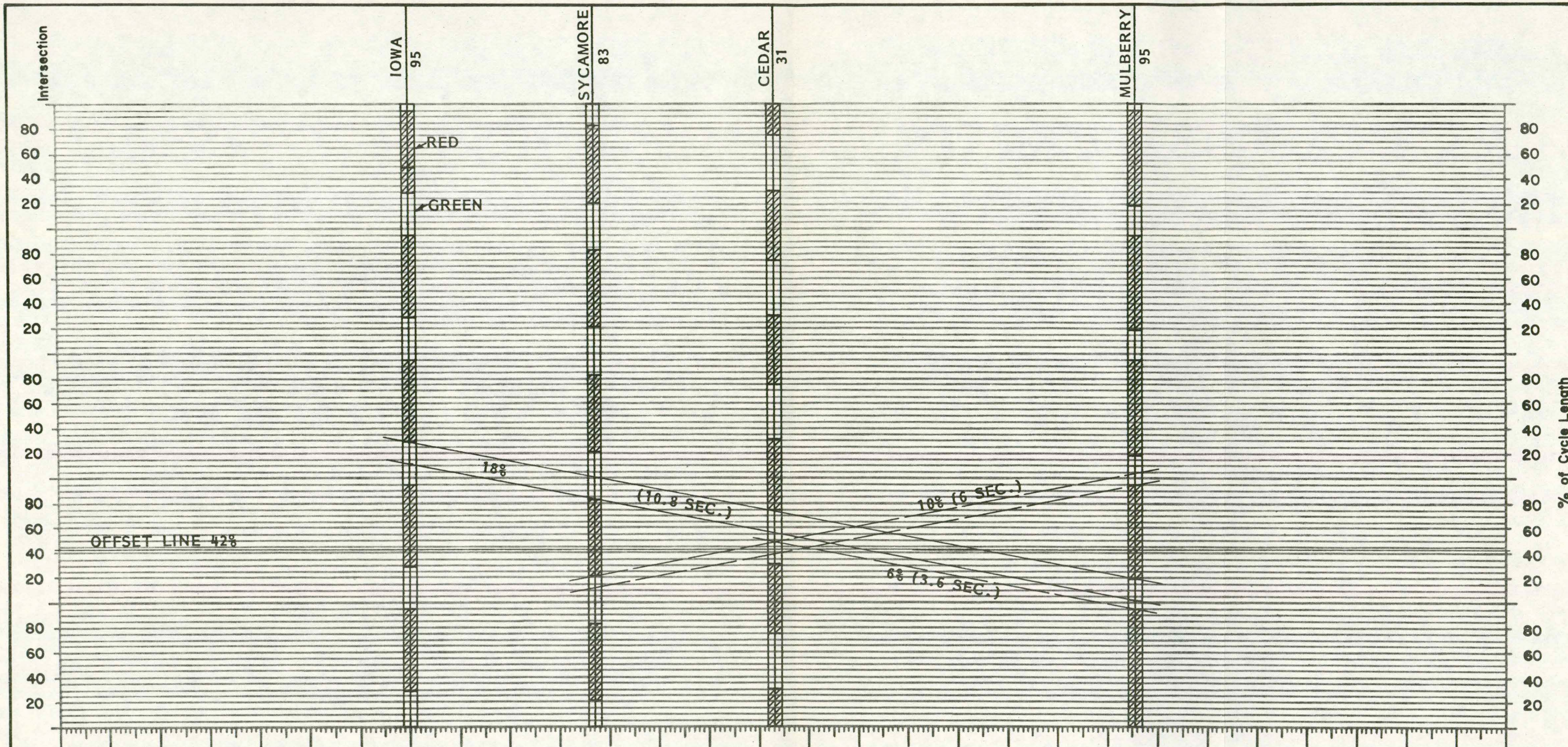
TIME SPACE GRAPH

OFFSET	56	15	80	51	47														
Intersection	IOWA	SYCAMORE	CEDAR	WALNUT	MULBERRY														

Scale: 1" = 200'
Cycle Length 60 **sec.**
Progression Speed 15 **MPH**
Dial ____
Date 4-3-80

EXHIBIT 8

4TH STREET
ARTERIAL



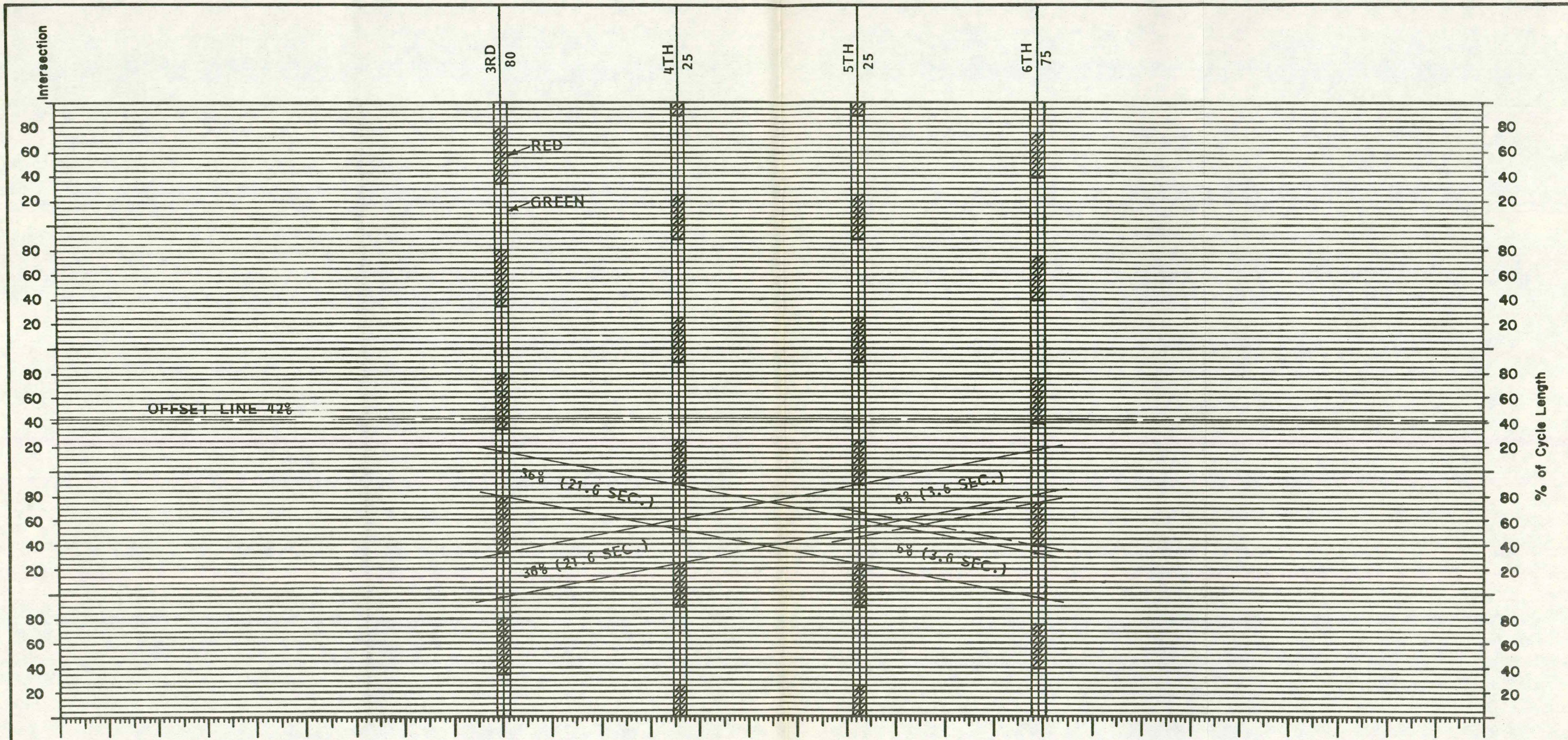
TIME SPACE GRAPH

Scale: 1" = 200'
Cycle Length 60 sec.
Progression Speed 15 MPH
Dial
Date 4-3-80

OFFSET	47	59	11	47															
Intersection	IOWA	SYCAMORE	CEDAR	MULBERRY															

EXHIBIT 9

5TH STREET
ARTERIAL



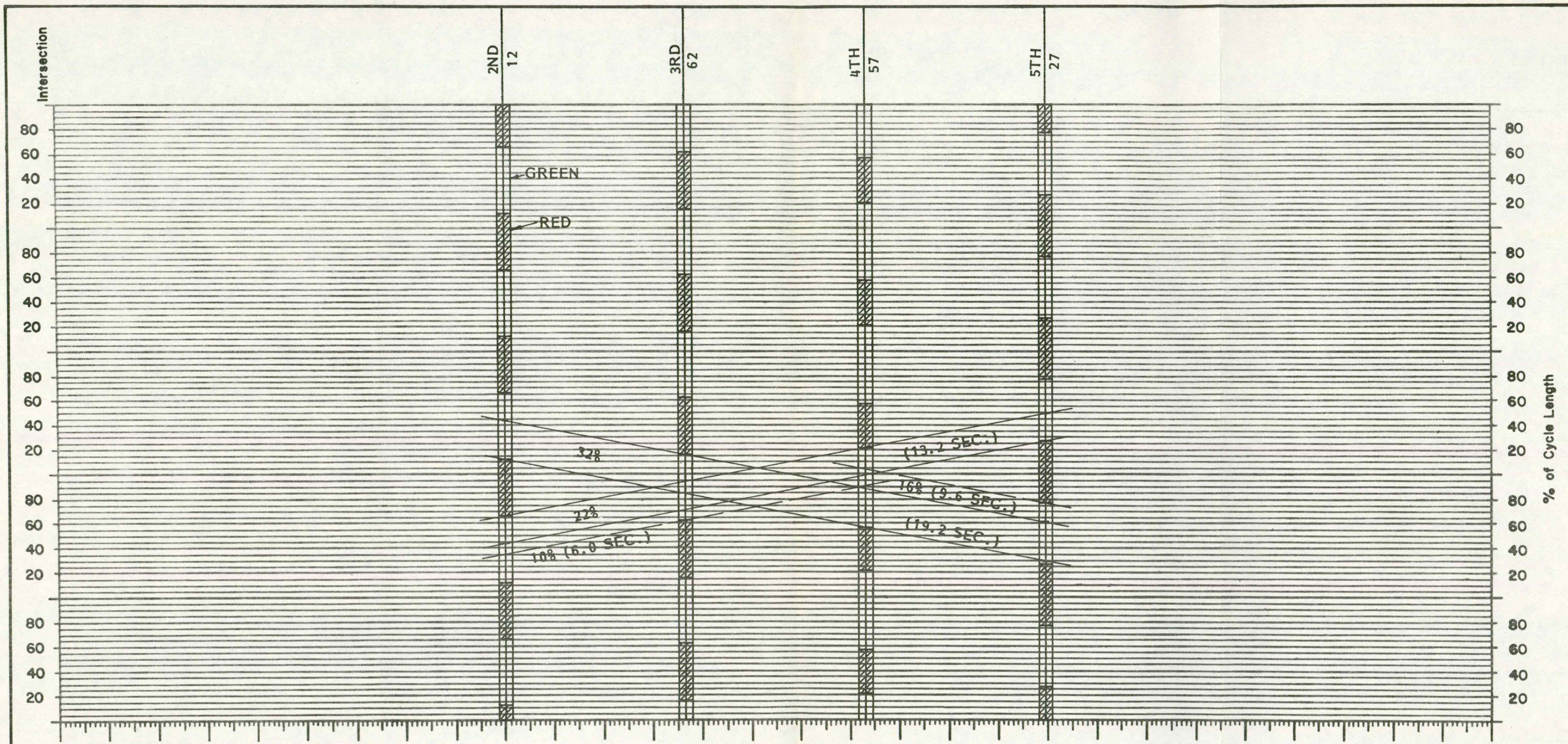
TIME SPACE GRAPH

OFFSET				67															
Intersection				6TH															

Scale: 1" = 200'
Cycle Length 60 sec.
Progression Speed 15 MPH
Dial
Date 4-3-80

EXHIBIT 10

MULBERRY AVENUE
ARTERIAL



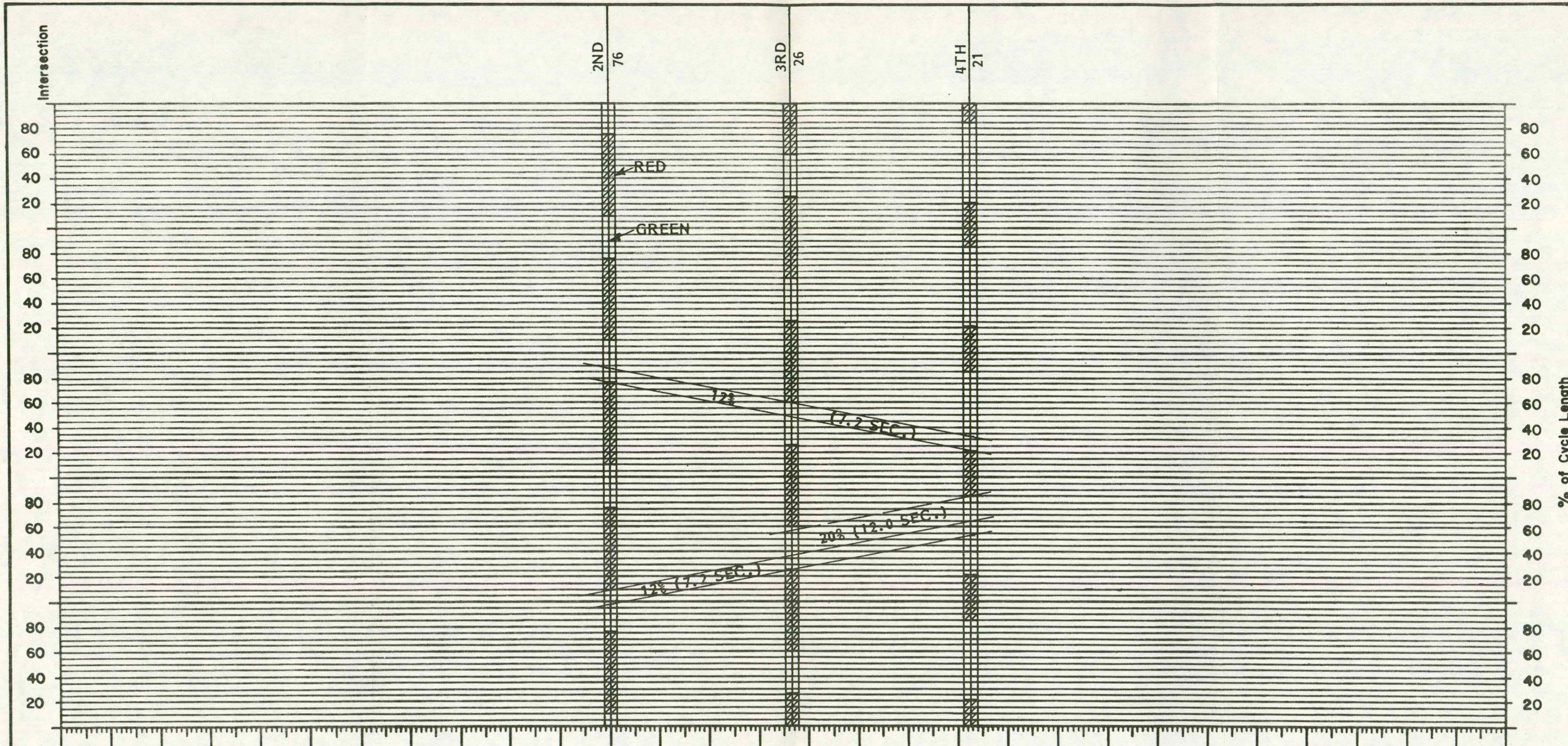
TIME SPACE GRAPH

Scale: 1" = 200'
Cycle Length 60 sec.
Progression Speed 15 MPH
Dial
Date 4-3-80

OFFSET																			
Intersection																			

EXHIBIT 11

SYCAMORE STREET
ARTERIAL



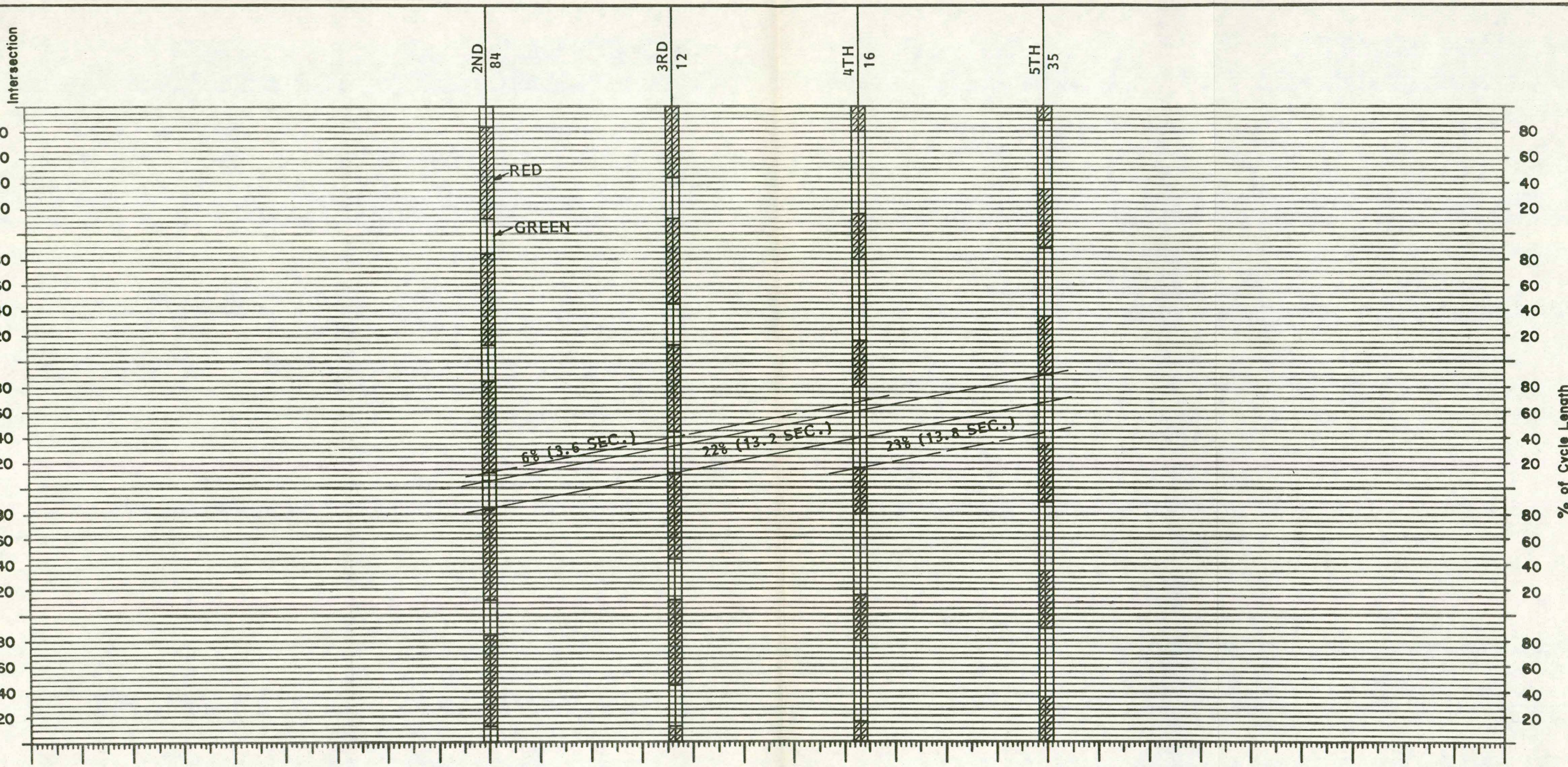
TIME SPACE GRAPH

Scale: 1" = 200'
Cycle Length 60 sec.
Progression Speed 15 MPH
Dial ____
Date 4-3-80

OFFSET																			
Intersection																			

EXHIBIT 12

WALNUT STREET
ARTERIAL



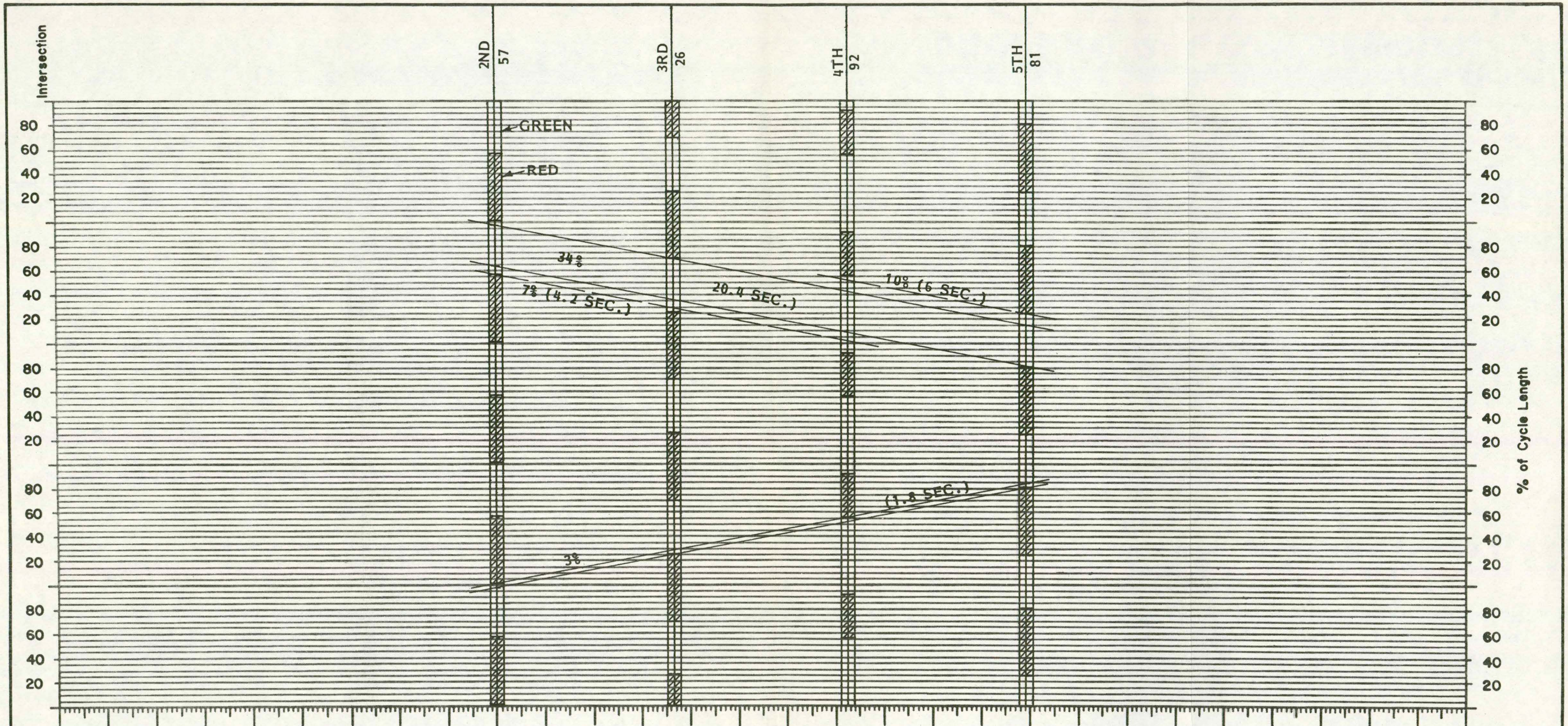
TIME SPACE GRAPH

Scale: 1" = 200'
Cycle Length 60 **sec.**
Progression Speed 15 **MPH**
Dial ____
Date 4-3-80

OFFSET																			
Intersection																			

EXHIBIT 13

IOWA AVENUE
ARTERIAL



TIME SPACE GRAPH

Scale: 1" = 200'
Cycle Length 60 sec.
Progression Speed 15 MPH
Dial ____
Date 4-3-80

OFFSET																			
Intersection																			

EXHIBIT 14

CEDAR STREET
ARTERIAL

CHAPTER 3

HIGH ACCIDENT LOCATIONS

This chapter has been prepared to provide a detailed analysis and recommendations for various high accident locations and segments within the City of Muscatine. Basically, the selection of the high accident locations and links was provided by a review of the ALAS computer printout which summarized each location and link by the number of accidents which occurred during a two-year period. Each location was field reviewed with special items noted that may be contributing to the high accident rate. Based on the field review, the data obtained by the consultant, the data provided by the city, and the detailed analysis, each location is presented separately with the explanation of the data utilized for analysis and the recommendations set forth.

U.S 61 (GRANDVIEW) AT WARREN

The intersection of Grandview and Warren is signalized and operates with a semi-actuated traffic controller. The traffic movements on Grandview from the north and Warren (both sides) are actuated. The existing phasing is as follows:

Phase A - Northbound and southbound movements on Grandview

Phase B - Southbound movements continuing on Grandview with a lagging left

Phase C - The east and west movements on Warren

Based on the computer printout provided by the Iowa Department of Transportation, this intersection had a total of 10 accidents between January, 1977 and March, 1979 (27 months). The intersection was ranked as the seventh highest accident location within the city. The accident data indicates that seven accidents were listed as "unknown" by type. The remaining three accidents do not indicate any particular collision pattern. Field observations were made along with the review of the accident data and traffic volumes. Rather than utilizing the accident data for analysis, the traffic volume counts and field observations became the basis for recommendations at this intersection. Based on the volume counts and field observations, the following deficiencies were noted at this location:

- Traffic southbound on U.S. 61 approaching the Warren intersection has two traffic lanes. At the intersection, the traffic using the inside lane is required to turn left while thru traffic is required to use the right or outside lane. As noted earlier, the signal operates under three traffic phases. The second phase being a lagging left for the southbound left turns. A review of the a.m. peak hour indicates that approximately 403 cars during the a.m. peak hour make this left turn while at the same time 333 vehicles proceed straight through this intersection. The moving of thru traffic to the right lane appears to be confusing the motorists and may be a contributing accident factor. At the same time, traffic from the east leg to the north is extremely heavy. This would account for the right turn overlap on the existing phasing.

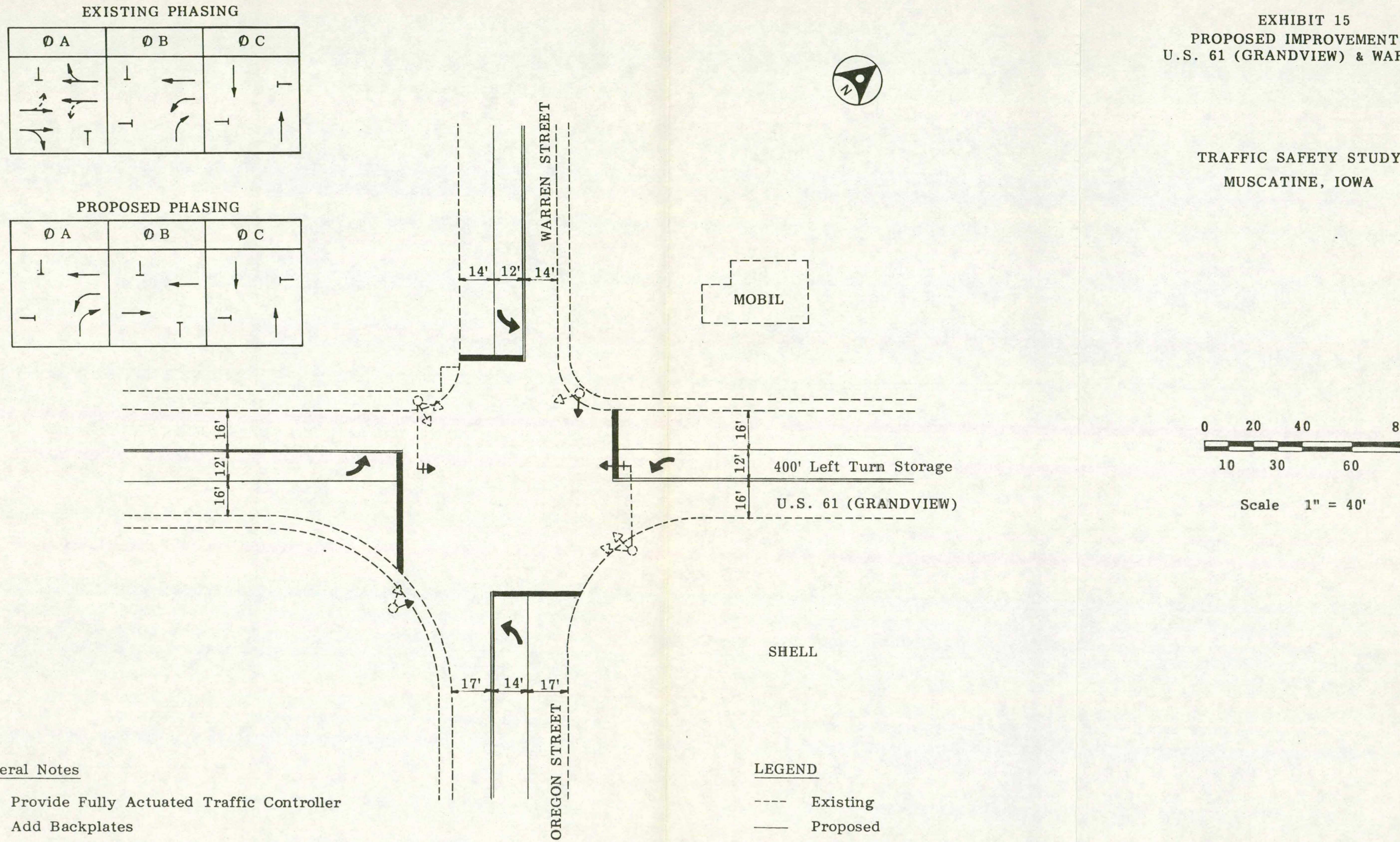
This intersection should be redesigned in order to provide fully actuated traffic movements. This is based on the analysis of the traffic counts which shows that there are approximately 12 hours during the day when the approach volumes on U.S. 61 range between 700 and 1100 vehicles per hour. The remaining hours range between 72 and 400 vehicles per hour. It should be noted that approximately 55% of the daily traffic occurs within an eight hour time period at this location (9:00 a.m. to 5:00 p.m.).

In order to reduce the number of accidents at this location and at the same time improve the safety of this intersection, the following recommendations are presented and illustrated in Exhibit 15.

- Revise the traffic signal phasing at this location to allow for a leading left indication for southbound traffic. The north leg should be striped to provide a three lane cross section with 400 feet of left turn storage for southbound traffic. From this point north

EXHIBIT 15
PROPOSED IMPROVEMENTS
U.S. 61 (GRANDVIEW) & WARREN

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA



General Notes

1. Provide Fully Actuated Traffic Controller
2. Add Backplates

LEGEND

---- Existing
—— Proposed
Existing Mast Arm
Existing Traffic Signal Head
Replace Existing Traffic Signal Heads

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to the intersection of Grandview and Hershey three lanes should be marked with the center lane used for left turns in either direction. (This is discussed later in the report).

- The south leg should be striped in a manner that northbound traffic would remain in the right lane and only those vehicles that would be turning left would use the left turn lane. It should be noted that the left turn from the south is minimal during the a.m. peak hour but is estimated between 25-30 during the p.m. peak hour. The cross section of the north leg should be as follows:
  - 16-foot southbound lane
  - 12-foot left turn lane
  - 16-foot northbound lane

  The 16-foot northbound lane will allow the heavy right turn movement from the east to enter the northbound flow of traffic without encroaching on the left turn lane. The south leg of the intersection should be striped in a similar manner as the north leg. The east leg should be striped for a two-lane approach as follows:
  - 17-foot thru lane
  - 14-foot left turn lane

  The approach for the west leg should be striped as follows:
  - 15-foot thru lane
  - 11-foot wide left turn lane

  The volume data indicates that very few left turns are made from the west leg and, therefore, by providing the wider thru lanes, this would eliminate the need for costly reconstruction of the corner radius points to allow for the required truck turning movements.

Minor recommendations at this intersection include the following:

- Add backplates to the mast arms on U.S. 61. Background lighting in this area indicates that the signals may blend in with other lighting and, therefore, distract the motorist.

- For southbound traffic, replace the four section head on the mast arm with a four section head which would include a dual mode signal indication. For southbound traffic, replace a three section signal head on the southeast corner with a four section signal head which would include the dual mode for the left turn traffic.
- Change the signal head for westbound traffic in the northwest quadrant to a four section head which would include one section for a dual mode indication for the right turn overlap.
- Change the northbound three section signal head on the mast arm to a three section signal head with all 12" lenses.
- Install a fully actuated controller at this location.

Finally, the signal heads at this location should be reaimed to provide the maximum visibility.

U.S. 61 (GRANDVIEW) BETWEEN WARREN AND HERSHEY-MISSISSIPPI AVENUE

This section of road is marked as a four-lane highway. As discussed previously, southbound traffic on U.S. 61 approaching Warren is forced into one lane at the intersection. This same condition exists for northbound traffic approaching Hershey-Mississippi where traffic following U.S. 61 makes a right hand turn onto Mississippi. Between these two intersection, the highway is marked as a four lane facility with approximately 11-foot traffic lanes. Nine accidents have occurred on this section within the last two years. Field observations along this link indicate two deficiencies:

- Between the two intersections there are a number of commercial developments and/or residential drives. Vehicles making left turns into these drives force thru traffic into the right lane. This condition creates a potential for rear end accidents.
- Field observations indicate that traffic does not utilize the four lanes due to the lane widths and the geometric conditions, particularly the curve near Mill Street.

The Iowa Department of Transportation had proposed prior to funding cutbacks this section of highway for resurfacing. In order to improve the traffic flow on the corridor, we recommend that a three lane cross section be marked with a center lane for left turns in either direction. This would separate the left turning vehicles from any thru movements and avoid the rear end accident potential. Also, an analysis indicates that the capacity of this section would be increased by providing the three lane section.

The city may desire to strip this section of roadway with a three lane cross section prior to the application of the overlay as a "test" to determine if the three lane concept is acceptable to the motorist and desireable to the city.

Exhibit 16 illustrates a typical three lane section.

FIFTH AND MULBERRY (not primary)

The intersection of Fifth and Mulberry is signalized and interconnected with the CBD signal system. During the years 1977-1978, this location was the second highest accident intersection in the city. During that time period, 18 accidents occurred. Of the 18 accidents, nine were listed on the computer printout as "unknown" by type. Six of the remaining accidents were right angle; two rear end collisions; and one head on collision. Field observations at this intersection indicated that the approach width along Mulberry is 30'.

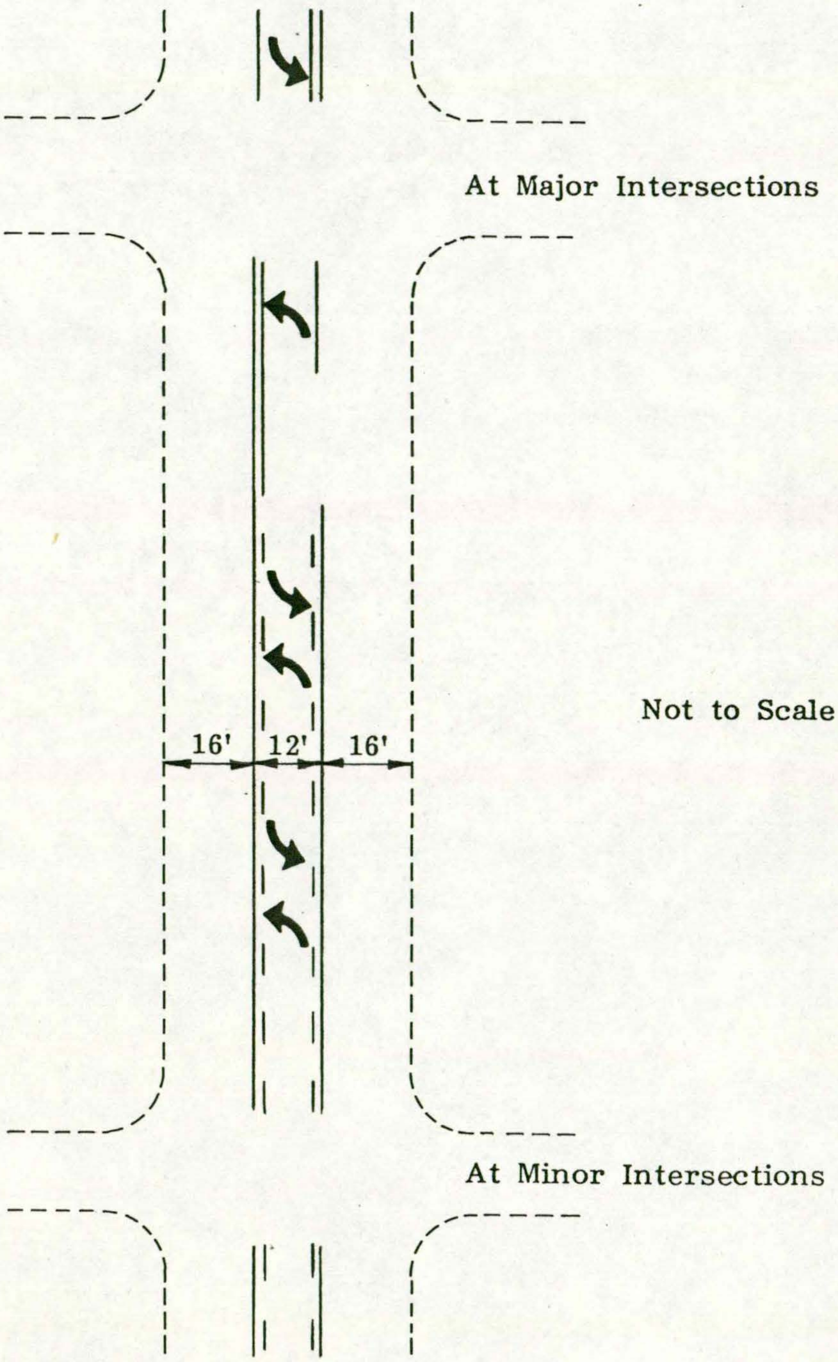
Also, it should be noted that the traffic volume data indicates that fewer than 20 cars an hour make a left turn from Mulberry onto Fifth Street in either direction. The pattern of accidents noted earlier may partially be attributed by the backups which occur in the presence of left turning vehicles. In order to reduce the number of accidents at this location and increase the overall safety and operation of this intersection, the following recommendations are made:

- Install mast arms on all four light posts at this location. These mast arms should be constructed of aluminum and with a length of approximately 15' long.

EXHIBIT 16
U.S. 61 (GRANDVIEW) BETWEEN WARREN
AND HERSHEY-MISSISSIPPI AVENUE
TYPICAL THREE LANE SECTION

TRAFFIC SAFETY STUDY

MUSCATINE, IOWA



LEGEND

---- Existing

—— Proposed

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- Replace the 8" red signal heads with 12" adaptors. Add backplates to the new mast arm signals.
- A one second all red clearance interval should be incorporated into the phasing at this location.

With the use of relatively short ambers (three second) and physical restrictions (buildings), the one second all red will provide an additional margin of safety.

OAK AND SECOND STREET

The intersection of Oak and Second Street is signalized and is controlled by a pretimed traffic signal which operates on a 75-second cycle. Fifteen seconds of the time is allocated to Oak Street. Between January, 1977, and March, 1979, this intersection ranked as the fifth highest accident location in the city with 13 accidents. Of the 13 accidents which occurred during this time period, eight are listed as "unknown" by type. Of the remaining five, two were rear end collisions; one a sideswipe; one a right angle collision; and one collision with a left turning vehicle. It should be noted that many of these accidents occurred prior to the installation of the mast arms at this location.

Field observations indicate that the sight distance at this location is limited due to buildings close to the corners. Parking is restricted on U.S. 61 at this location. A review of the traffic data indicates that the highest two-way traffic on the Oak Street approaches occurs between 12:00 and 1:00 p.m. The industrial area apparently has a quiting time between 3:00 and 4:00 p.m. as the volume on the Oak Street approaches 55 vehicles during that hour. During the remaining hours of the day, from 6:00 p.m. to approximately 7:00 a.m., the number of vehicles on this street is negligible. The west leg, however, which serves more of the industrial park, in a similar manner has very few vehicles between the hours of 6:00 p.m. and 5:00 a.m. During the hours between 7:00 a.m. and 4:00 p.m., approximately 80 vehicles per hour use this approach leg. The two-way ADT on the north leg (U.S. 61) averages between 700 and 1,000 vehicles per hour between the same period of time. The hourly traffic on U.S. 61 decreases between 8:00 p.m. and 6:00 a.m.

As previously noted, many of the accidents occurred before the installation of the mast arms at this location. However, even with the installation of the mast arms, several deficiencies still exist. These deficiencies are as follows:

- Backplates should be added to the traffic signal heads on the mast arms in order to provide more visibility to motorists.
- A one second all red clearance interval should be provided between the two traffic phases because of the limited sight distance for motorists.
- The controller should be changed to an actuated type with only the side street being actuated. Thus, in the absence of vehicles on the side street the signal will remain green for traffic on the state highway.

HIGHWAY 22 (CEDAR STREET) AND HOUSER STREET

The intersection of Houser and Cedar Street is located on the northwest side of Muscatine. Cedar Street serves traffic to the Central Business District while Houser primarily serves the residential area near and along that street. It also serves as a bypass for much of the traffic south of the Central Business District.

During 1977 and 1978 the computer printout indicated that eight accidents occurred at this intersection. Based on the summary of this data, four accidents were listed as "unknown" by type; one a right angle collision; one a rear end collision; one a rear end collision with a backing vehicle; and one accident with a vehicle leaving the highway and striking a fixed object. It is difficult to establish an accident pattern based on this data.

It should be noted that the vehicular speeds at this intersection are in excess of 40 MPH along Cedar. These speeds were obtained using the "floating car" technique to determine the average speeds at which motorists traverse this intersection. Using Warrant 1, an analysis was made to determine if signals are warranted. Based on this analysis, five of the required eight hours meet the warrants with two hours being 50-60 vehicles per hour short on the major street. Using a 70% factor, as allowed by the

Iowa Manual on Uniform Traffic Control Devices, 350 vehicles per hour are required on the major street, whereas 105 vehicles are required on the minor street. The traffic volumes on the east-west route (Cedar Street) or the minor route, are easily met. However, thru volumes on Houser only meet warrants for five hours of the day. The primary deficiency appears to be the speed at which motorists are traveling on Cedar. Based on our field observations and the volume counts, it is recommended that this intersection be counted again on an annual basis and when the eight hours of warrants are met, a semi-actuated traffic signal should be installed at this location. Consideration for the addition of the left turn lanes on Cedar should be made at that time. Table 2 illustrates the volumes used for this analysis.

The signs which now read "Iowa 22 Traffic Does Not Stop" should be replaced with signs reading "Cross Traffic Does Not Stop."

GRANT STREET AND PARK AVENUE (U.S. 61)

The intersection of Grant and Park (U.S. 61) is located one block south of Washington. During a two-year period, eight accidents occurred at this location. Of these, three were of the "unknown" type; and five involved a rear end collision due to a vehicle turning left. Only one accident involved a right angle collision.

It would appear that the major deficiency is created by vehicles turning left from Park Avenue onto Grant rather than vehicles attempting to enter the flow of traffic from Grant onto Park Avenue. This creates a rear end accident potential. This accident potential will be reduced if our recommendation to provide a three lane cross section on Park Avenue is followed. (Discussed elsewhere in the report.) This will separate the left turning vehicles from the flow of traffic and reduce the number of rear end collisions.

PARK AVENUE AND WASHINGTON STREET

The intersection of Park Avenue and Washington Street experiences heavy turning movements particularly those from the east approach. The east leg has two approach lanes. These lanes are narrow and create difficulty for right turning vehicles to the north.

TABLE 2

TRAFFIC DATA

HOUSER & CEDAR

MUSCATINE, IOWA

Time Period	Approach Volume							
		NB*		SB		EB		WB
8 AM		225		138		108		246
9		206		147		137		221
10		120		101		86		112
11	109	103	88	84	123	104	120	160
12	96	141	89	101	108	109	128	135
1 PM		160		130		117		147
2		125		119		124		167
3		162		89		125		180
4		230		165		147		268
5		211		152		156		220
6		184		152		157		190
7		102		83		79		139
8		71		63		61		88
9								
10								
11								
12								
1 AM								
2								
3								
4								
5								
6								
7								
30th		146		160		135		235

NB, SB, EB, WB; i.e. NB = Traffic Northbound

During a two year period, this intersection experienced 16 accidents. Of these, nine were of the "unknown" type. Examining the remaining seven accidents plus our field observations, it was determined that many of these accidents are rear end collisions involving left turning vehicles. Also, right angle collisions are occurring because vehicles are running the amber or red light due to inadequate visibility of the signal heads.

The intersection is pretimed and operates on a 75-second cycle. Using the Park Avenue corridor progression, an analysis was made to determine if this signal would fit into that progression. Based on this analysis, this signal can be interconnected with the others on Park Avenue. However, because of the distance from this intersection to others in the progression, the cost of interconnection when compared to the benefits is not justified.

The major deficiencies noted during our field observations and review of the data are as follows:

- The visibility of the signal heads for east and westbound traffic is not adequate.
- The northeast corner radius is inadequate for the heavy truck turning movements.
- The required "Flash Don't Walk" interval is not provided.

Based on these deficiencies, along with the traffic and accident data, the following recommendations are made:

- Provide mast arms to improve the visibility of the traffic signals for all of the approaches.
- Reconstruct the northeast radius to a 40-foot radius.
- Add backplates to all the mast arm signal heads and use 12" signal indications for signal heads on the mast arms.
- The traffic signal timing should be revised such that the majority of time would be allocated to Park Avenue. This can be accomplished with the present controller by providing minimum timing for Washington Street. The capacity analysis for the existing and proposed conditions are attached to the appendix.

- Provide a "Flash Don't Walk" pedestrian interval.
- Restripe the east approach on Washington Street.

Since the traffic volumes at this intersection range between 300 and 500 vehicles per hour in each direction on Park Avenue, the three lane cross section recommended for this facility will adequately handle this volume.

Exhibit 17 illustrates these recommendations.

PARK AVENUE WITH CLAY-COLORADO STREETS

This intersection is signalized using a two phase pretimed, semi-actuated controller. There are vehicle detection loops on the side street approaches. Traffic volumes were examined and updated to 1980. The updated volumes were utilized as a basis for analysis and recommendations.

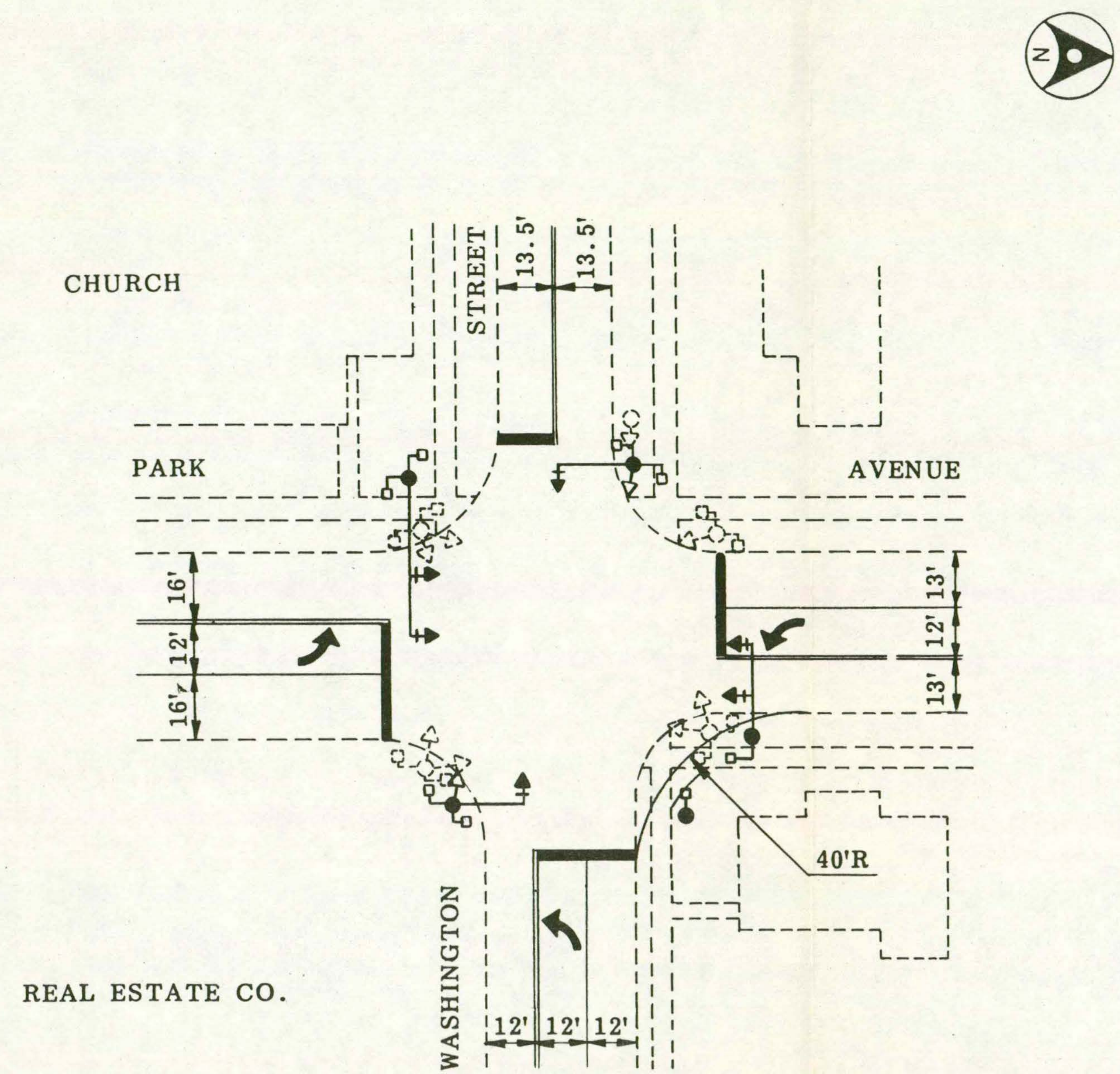
During the two year period between 1977 and 1978, this intersection experienced the highest accident rate within the city. Of the 30 reported accidents, 15 were listed as "unknown" on the computer printout. Of the remaining 15, six were right angle collisions; six involved thru movements with left turning vehicles; and the remaining three were rear end collisions.

Field observations and review of the volume data indicate that there may be several reasons why this intersection is the highest accident location within Muscatine. The south leg has two approach lanes and many times right turning vehicles delay thru traffic in the outside lane. In a like manner, left turning vehicles often delay thru movements in the inside lane. These two conditions probably cause most of the rear end collisions. In addition, the present two phase signal is not responsive to the existing heavy traffic movements. Therefore, in order to reduce accidents and improve safety at this intersection, as well as increase capacity, the following recommendations are made:

- Move the southbound vehicles into the outside lane approximately 500 feet north of this intersection so that the cross section for the north leg would be a three lane approach similar to that which has been recommended for the south leg.

EXHIBIT 17
PROPOSED IMPROVEMENTS
PARK AVENUE & WASHINGTON STREET

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA



0 20 40 80
10 30 60

Scale 1" = 40'

LEGEND

----	Existing
——	Proposed
---▷	Existing Traffic Signal Head
—▷	Relocated Traffic Signal Head
—▶	New Traffic Signal Head (12" Lens)
---▫	Existing Pedestrian Signal Head
—▫	Relocated Pedestrian Signal Head
—●	Mast Arm

General Notes

1. Add Backplates
2. Provide Flash Don't Walk Interval
3. Add Mast Arms

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- The south leg should be striped to accommodate the three lane cross section.
- Enlarge the corner radii on all four corners to 35 feet.
- Backplates should be added to the mast arm signals and the signal heads on those mast arms should be changed to 12" lenses.
- The intersection should be interconnected into the Park Avenue progression which will be discussed later under Park Avenue improvements.
- Replace the existing controller with a standard semi-actuated traffic controller. The master coordinating unit for the Park Avenue interconnect system should be located at this intersection.
- The cross section of Clay should be as follows:
  - 16-foot exit lane
  - 12-foot left turn lane
  - 12-foot approach lane
- To improve the signal visibility, mast arms should be installed along Clay Street and add a one second all red clearance between opposing phases to reduce the possibility of right angle collisions.

By channelizing the thru movements into a lane and the left turns into a separate lane, the accident potential will be reduced. The improvement of the signal head visibility and a one second all red should help to reduce the potential for right angle collisions.

A capacity analysis was made for this location based on the existing and proposed geometrics. The existing geometrics, with the two lane approaches, operates at a green/cycle ratio (g/c) of 0.89. The proposed lane usage will increase this g/c ratio to 0.94. Although the capacity of the intersection decreases slightly, this is offset by the decreased accident potential.

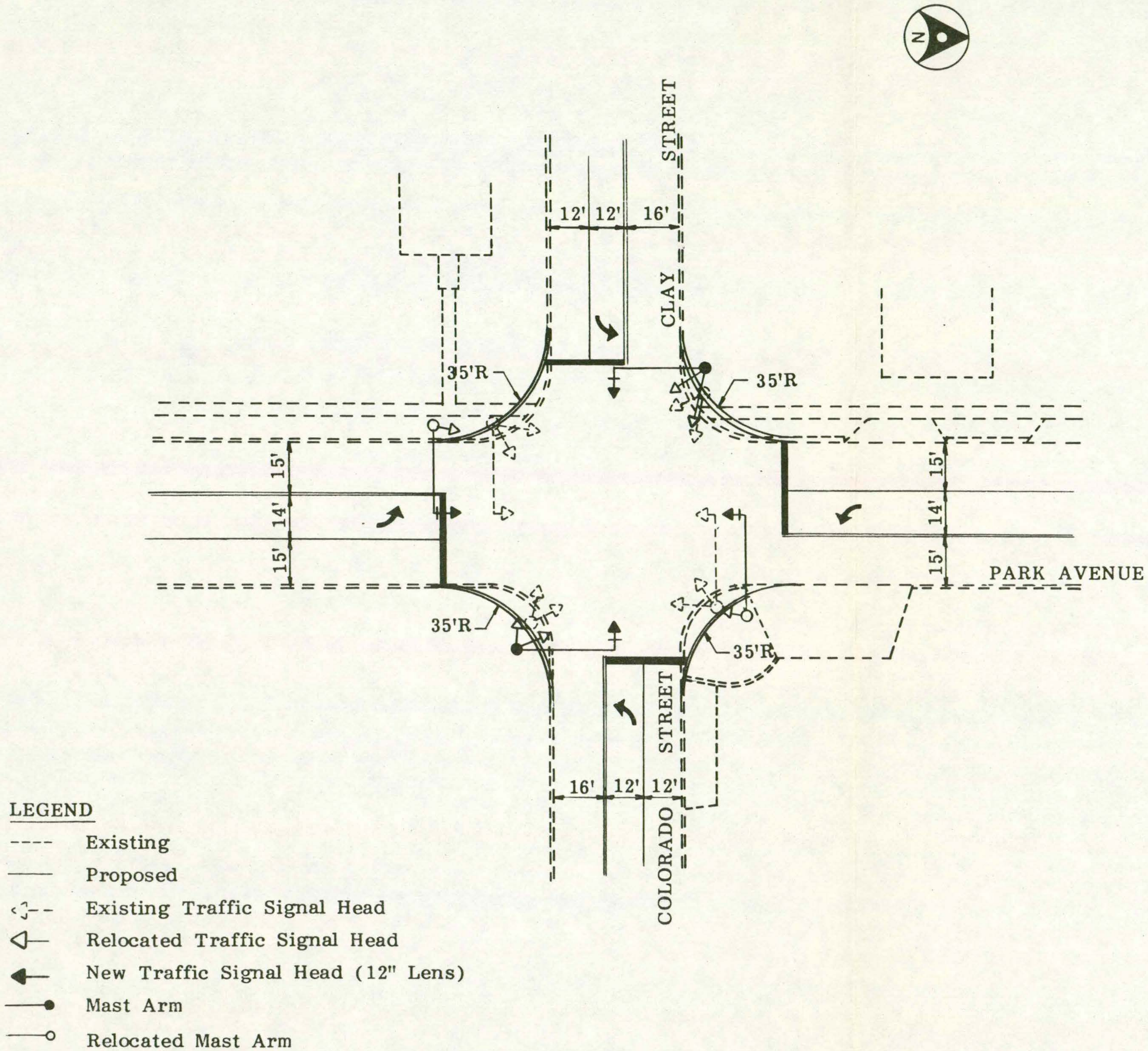
Exhibit 18 illustrates these improvements.

PARK AVENUE AND HARRISON STREET

This intersection is signalized using a semi-actuated controller. This intersection primarily serves the shopping center. As

EXHIBIT 18
PROPOSED IMPROVEMENTS
PARK AVENUE AND CLAY-COLORADO

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA



0 20 40 80
10 30 60

Scale 1" = 40'

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illustrated by the geometrics, there are two northbound lanes with no separate left turn storage. There is left turn storage for southbound traffic.

A review of the accident data indicates that 10 collisions have occurred at this location during a two year period of which four are of the "unknown" type. Of the remaining accidents, two involved rear end collisions on the south leg; two left turning accidents; and two right angle collisions. Based on the above data, the following recommendations are made and illustrated in Exhibit 19.

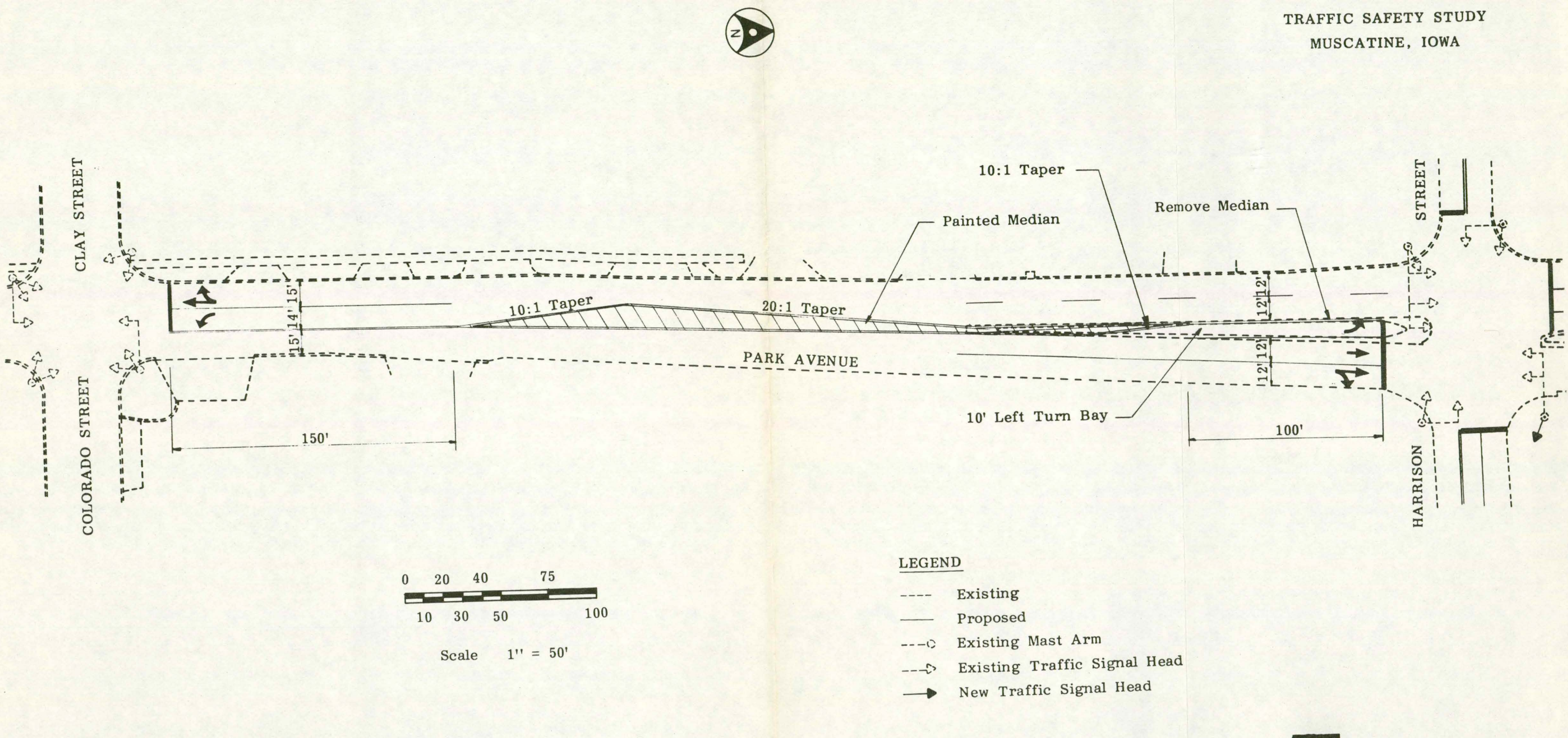
- With the recommendation of the three lane section through the Clay-Colorado intersection, it is proposed that the concrete median on the south leg of Park and Harrison be removed so that a left turn storage lane can be provided for northbound left turning vehicles.
- The two thru green arrows located on the mast arms for the north and southbound traffic on the outside lanes should be removed.
- The signal timing should be adjusted so that the green time is maximized on Park Avenue. Backplates should be added to the mast arm signals at this location.
- A one second all red clearance interval should be provided at this location to reduce the possibility of right angle collisions.
- A near side signal, for westbound traffic exiting the shopping center, should be added. This will assist those motorists in viewing the signal indications. Field observations indicate that the visibility of these signal heads are not optimized.

PARK AVENUE-JACKSON STREET TO HARRISON STREET

The computer printout indicates 17 accidents have occurred on this section of Park Avenue. Improvements to the intersections along this segment of Park have previously been discussed. These recommended improvements should decrease the present accident experience.

FIGURE 19
PROPOSED IMPROVEMENTS
PARK AVENUE-HARRISON STREET

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA



General Notes

For Park Avenue and Colorado, Clay Streets Improvements See Figure 18.

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Maryland Heights, Missouri

Northbound traffic would have one exit lane and widen into two lanes past the intersection of Clay. The concrete median should also be removed at Harrison so that left turns could be separated from the through movements.

In addition, by providing an interconnected traffic signal system along this corridor, traffic will move more orderly thereby decreasing the frequency of collisions.

PARK AVENUE AND LAKE PARK BOULEVARD

The intersection of Park Avenue with Lake Park Boulevard experienced 14 accidents during a two year period according to the computer printout. Six of these accidents were of the "unknown" type. Of the remaining accidents, six involved right angle collisions; the two other collisions did not fit into a pattern.

Traffic counts indicate that approximately 1,000 cars per hour travel Park Avenue with about 275 vehicles on the east-west legs of the intersection. Traffic movements on the east leg are heavier than the west one. However, there are no reported accidents involving vehicles from this approach. Therefore, it would seem that the right angle accidents may be caused by improper signal visibility for vehicles on the west approach. In order to reduce accidents at this location, the following recommendations are made:

- The intersection should be retimed to maximize the green time on Park Avenue based on the progressions established in Chapter 2. For east and westbound traffic, a dual mode arrow indication should be added for the right turn overlap phases.
- Backplates should be added on all the mast arm signals. The left turn arrow signal heads for Park Avenue should be replaced due to their poor condition.
- The controller should be tied into the proposed Park Avenue interconnect system.
- A near side signal should be added for the west approach to help eliminate right angle collisions.

- A one second all red clearance interval should be provided between the north-south and east-west traffic movements.

PARK AVENUE AND FORD AVENUE

The intersection of Ford and Park is presently controlled by an actuated signal with actuation occurring on the side street and the southbound left turn lane. During a two year period, 10 accidents were reported at this location. Of these, four were "unknown" by type. Of the six remaining, four involved rear end collisions and two were of the right angle type. These rear end collisions may indicate that motorists are not seeing the termination of the green signal in time and are making hurried stops. Motorists following those making a hurried stop may not be perceiving this problem, thereby creating a potential for rear end collisions. Both of the right angle collisions are from the west leg which may indicate difficulty in seeing the signal heads on that approach.

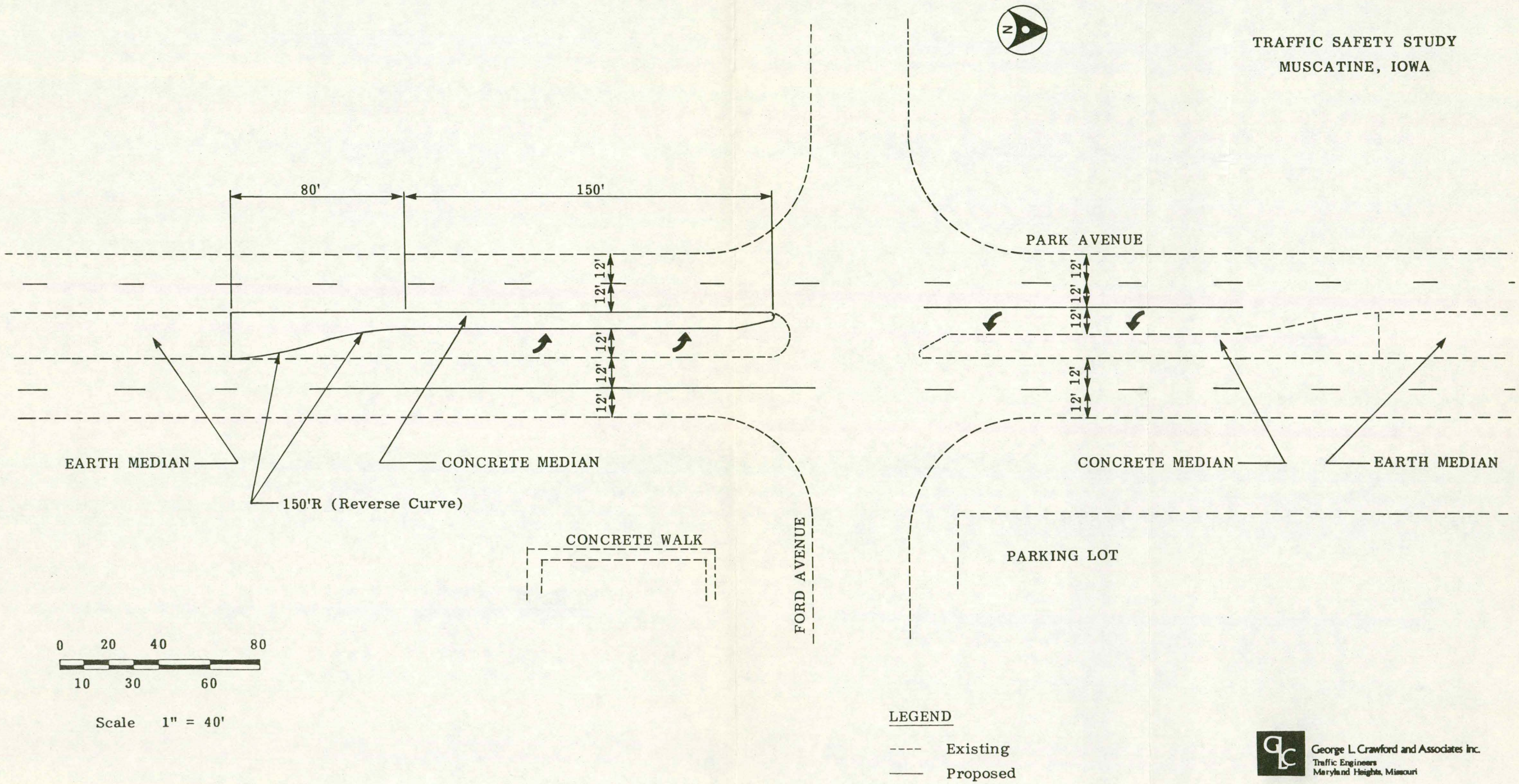
In addition, field observations indicate that commercial growth has occurred on the west leg which has generated a number of left turning vehicles on Park Avenue from the south. For example, during a mid-day count between 11:00 a.m. and 1:00 p.m., between 56 and 116 vehicles per hour, respectively, made a left turn from Park Avenue. It should be noted that these lefts are currently being made from the thru lanes and severely restricts the capacity of this intersection. At this time it does not appear that these left turns are creating an accident hazard. It is recommended that the concrete median south of Ford be partially removed and a 150 foot left turn lane be constructed. The taper should be two 150 foot reverse curves, 80 foot in length. The length of this left turn lane has been maximized for future traffic growth.

The remaining recommendations for this intersection are as follows and as illustrated in Exhibit 20.

- Interconnect this signal into the proposed Park Avenue system to provide a progression.
- Add a one second all red clearance interval between the major phases.
- Add backplates to the signal heads on the mast arms.

EXHIBIT 20
PROPOSED IMPROVEMENTS
PARK AVENUE AND FORD AVENUE

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA



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FIFTH STREET FROM LOMBARD TO PARK

This street is approximately 25 feet wide with parking permitted on both sides. Accident data for a two year period indicates that five collisions occurred. The type of accidents are as follows: two with a fixed object or parked vehicle; one head on collision; one collision involving a turning vehicle; and one "unknown" by type. A major deficiency along this corridor is that parking is permitted. The geometric alignment also may be contributing to the accident occurances. Therefore, in order to reduce accidents on this segment, it is recommended that parking be eliminated on the south side in order to provide the necessary sight distance and provide two free traffic lanes. In addition, the street is crowned rather than superelevated on the curve. Also, the street is generally rough which impedes the flow of traffic. To correct these deficiencies, it is recommended that this section of roadway be reconstructed.

MISSISSIPPI DRIVE FROM HERSHEY AND GREEN TO MISSISSIPPI AND ELM

During a two year period, seven accidents occurred on this corridor. Field observations indicate that the major cause for the accidents along this segment are commercial developments and that the four lane pavement again does not provide the adequate lane widths in order to allow four lanes of traffic flow. Also, the curve at Mississippi and Elm restricts the use of the four lane cross section on this segment. Therefore, the recommendations to reduce the accident rates on this segment are as follows:

- Southbound traffic on Mississippi Drive, south of Locust Street, should be merged into one lane to begin the three lane cross section. This would be carried from Locust Street down onto Hershey-Mississippi and Green Street. At that point the left and thru traffic would utilize one lane.
- Two eastbound exit lanes would be provided at Hershey-Green in order to allow a free flow of traffic movement from U.S. 61 (Grandview) to U.S. 61 (Mississippi)

This recommendation continues the revisions recommended for the intersection of Hershey and Grandview.

CHAPTER 4

SPECIAL STUDY LOCATIONS

U.S. 61 (GRANDVIEW AVENUE) AT HOUSER-SAMPSON STREET

The intersection of Houser-Sampson Street and Grandview Avenue is the first major intersection entering the City of Muscatine from the south. Traffic volumes on Houser Street have grown steadily since its completion. The ADT in 1975 was 3,000 vehicles while in 1979 it had grown to 4,300 vehicles. Thus, volumes on Houser Street have grown by 10.8% per year. This means that the ADT for 1980 is approximately 4,800 vehicles. The computer accident data indicated that six accidents occurred at this location during a two-year period and their patterns are as follows:

- Three accidents involved rear end collisions with left or right turning vehicles at this intersection. One accident involved a right angle collision and two accidents were "unknown" by type.

Volume counts have been reviewed for the a.m., mid-day, and p.m. peak hours. This data is illustrated in the appendix of this report. The most notable data at this intersection would be the approach volumes on Houser Street between the hours of 8:00 a.m. and 10:00 a.m. when approximately 197 and 104 vehicles entered Grandview Avenue from the west leg. Between 4:00 and 5:00 p.m., 167 and 105 vehicles entered the flow of traffic from Houser to Grandview. During the same p.m. peak hour between 3:00 p.m. and 6:00 p.m., approximately 60 cars an hour made left turns onto Houser Street from the south on Grandview and approximately 60 cars made lefts onto Sampson Street from the north on Grandview.

Based on field observations, the operating speeds of motorists through this intersection appears to be in excess of 40 miles per hour. Generally, these speeds averaged 45 miles per hour. This is not surprising due to the location of this intersection and the rural conditions. In order to determine whether or not the remaining hours met the required warrants, traffic volumes from the intersection of Grandview and Warren were superimposed onto the approach at Houser-Sampson Street and Grandview. It should be noted that the south leg of the intersection of Grandview and Warren had a total hourly volume in excess of 700 vehicles per hour for a period of 12 hours a day. Field observations indicate that most of the vehicles which approach or exit on the south leg of the intersection of Grandview and Warren do reach the intersection of Houser and Grandview. Furthermore, field observations indicate that in the presence of left turning vehicles from Grandview onto Houser, severe operational and safety problems exist. These include vehicles which are often required to stop suddenly in order to prevent a rear end collision with a left turning vehicle. Since the city is improving portions of Houser Avenue, it is anticipated that traffic volumes will further increase on this corridor.

The actual traffic data indicates that six of the nine hours counted do meet the warrants for signalization. The intersection should be recounted on an annual basis to determine when traffic signals are warranted.

An analysis was also made to determine the level of service if this intersection were not signalized. This analysis indicates that a "D" level of service exists without traffic signals. This is due to the heavy thru volumes where there are insufficient gaps to allow for entering or exiting vehicles. These calculations are included in the appendix to this report.

Therefore, based on our observations and data, we are recommending that a traffic signal be installed at this location which would be semi-actuated for the left turns and the side streets when the warrants are fully met. Left turn lanes should also be provided at this location. The warrants in which we have examined for traffic signalization are Warrants 1 and 2 and utilizing 70% of the required volume due to vehicular speeds of 45 miles per hour. Exhibit 21 illustrates the recommendations for this intersection.

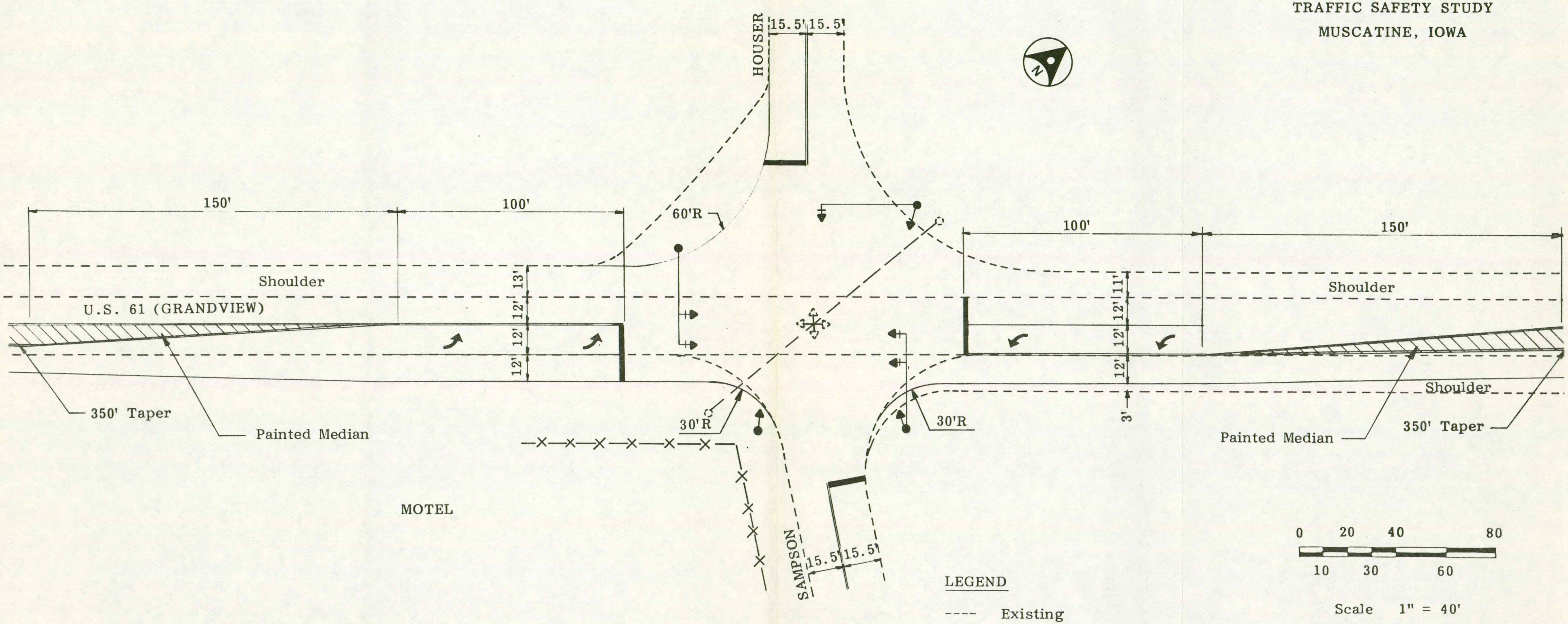
HOUSER STREET--DAWSON AND ALLEN STREETS

Not primary

The intersection of Houser with Allen and Dawson is located on the west side of town north of Lucas Street. Dawson and Allen

EXHIBIT 21
PROPOSED IMPROVEMENTS
U.S. 61 (GRANDVIEW) AT
HOUSER-SAMPSON STREETS

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA



LEGEND

---- Existing
—— Proposed
—● Mast Arm
—▶ New Traffic Signal Head
- -▷ Existing Traffic Signal Head

General Notes

1. Semi-Actuated Left Turns and Side Streets

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Streets both provide access to two community schools east of Houser Street. Continuing residential development in this area has created a demand to provide protection for school children crossing Houser. Since the city is improving Houser Street, vehicular speeds could increase and may create an unsafe condition for school children crossing Houser. It is the city's intention to install a traffic signal on Houser Street for school children. In order to determine the location of the signal, a field investigation was made. This revealed that Dawson Street was used as the direct route to the two schools. It should be noted that there are no sidewalks along Houser Street at this time. However, it is planned by the city to provide sidewalks along Houser when it is reconstructed. A 7:00 a.m. to 9:00 a.m. traffic count was made to determine if traffic signals would be warranted at either Allen or Dawson Streets. During the two hour period, seven cars exited from Dawson while at the same time 26 vehicles exited Allen. At this time during the peak hour, there are 200 vehicles on Houser Street. Based on these volumes, a traffic signal at either Allen or Dawson Streets cannot be justified. Therefore, we recommend the placement of the school crossing signal between the south edge of the pavement on Dawson Street and the north edge of the pavement on Allen Street or approximately 77 feet south of Dawson. Exhibit 22 illustrates this recommendation.

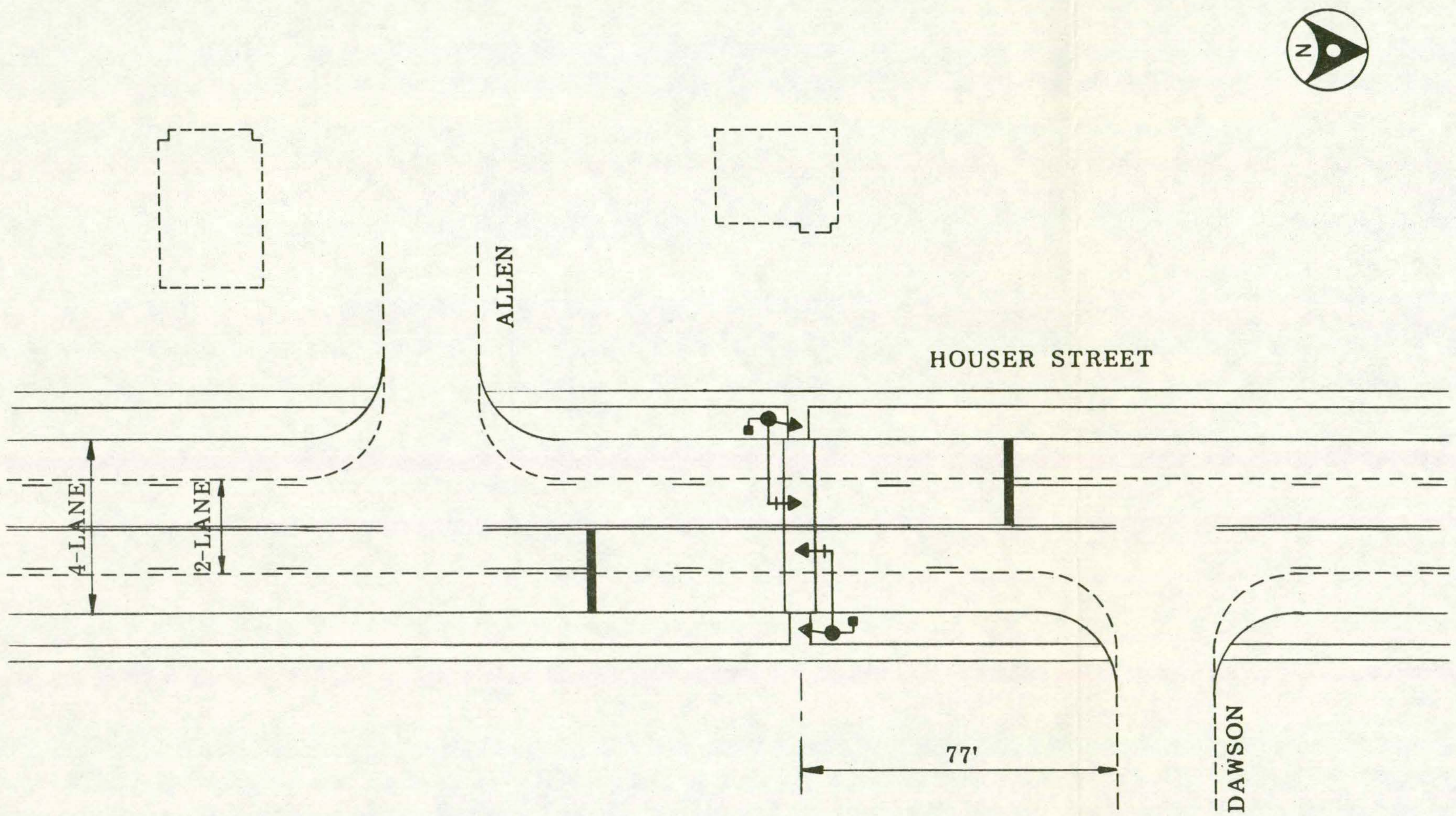
It is also planned to provide parking on both sides of the street when it is widened. At that time, it is recommended that parking be restricted between Allen and Dawson on both sides of Houser in order to provide the necessary sight distance for both school children and motorists. Exhibit 22 illustrates these recommendations.

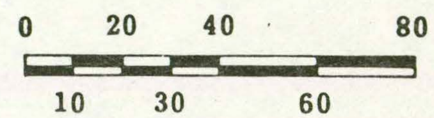
MISSISSIPPI AVENUE--GREEN, GRANDVIEW AND HERSHEY

The intersection of Hershey, Grandview, Mississippi and Green is actually two signalized intersections. The north leg, Green Street, carries approximately 300 to 400 vehicles a day while the south and east legs carry approximately 10,000 vehicles a day. The west leg, Hershey, has an ADT of approximately 3,500. The

EXHIBIT 22
PROPOSED IMPROVEMENTS
HOUSER STREET-DAWSON & ALLEN STREETS
SCHOOL TRAFFIC SIGNAL LOCATION

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA





Scale 1" = 40'

LEGEND

---- Existing
—— Proposed
New Mast Arm
New Traffic Signal Head
Crosswalk

General Notes

1. Houser Street To Be Widened to Four-Lane With Sidewalks

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intersection is semi-actuated such that traffic on Green, Hershey, and left turns from Grandview onto Hershey are actuated. The southbound traffic on Mississippi and the northbound traffic on Grandview are treated as thru movements.

Field observations along with the counts indicate that a heavy thru turning movement from south to north and north to south occurs at this intersection.

Because of the geometrics, vehicles turning left from Mississippi onto Grandview experience difficulty getting by a vehicle making a left turn onto Hershey from Grandview. Field observations which were made during both the a.m. and p.m. peak hours indicate that very few left turns are made at this intersection. Basically, most left turns are made at the intersection of Grandview Avenue and Main Street. Therefore, as part of the overall recommendations for this intersection, we will include the intersection of Grandview and Main.

During our field observations, the possibility of closing Green Street or allowing only right turns was studied.

The accident data indicates that five accidents occurred at Grandview and Hershey. Of the five which occurred at Grandview and Hershey, three accidents were "unknown" by type and the remaining two were rear end collisions involving vehicles making the right turn onto Mississippi or the left turn onto Grandview from Mississippi. The intersection of Green and Mississippi experienced eight accidents during the same time period of which four were "unknown" by type. One of the accidents involved a rear end collision. Two of the four do not have any distinctive pattern and the fourth one involved a vehicle turning left onto Green Street.

There are several signal deficiencies at this intersection which include the lack of two far side indications for traffic on Green Street. The traffic signal pedestal in the northeast quadrant of Green also appears to create confusion in regards to the right turn overlap with the different phases. Based on this data and field observations, the following recommendations are presented:

- Provide a left turn lane for northbound traffic on Grandview at Main Street. This left turn lane should be approximately 150 feet long.
- Eliminate left turns from Grandview into Hershey by reconstructing the island and making minor signal revisions and from Mississippi into Green.
- Change the semi-actuated controller to full actuation. This will allow the thru traffic to be actuated which will provide additional green time for this heavy movement in the absence of heavy traffic on the side streets.
- Traffic southbound on Green should be required to turn right. This can be accomplished by the construction of an island which would require this movement.
- Provide a three lane cross section on the east leg (Mississippi). One lane would be utilized for southbound traffic on U.S. 61, one lane for traffic on Grandview wishing to go north on Mississippi and one lane for northbound traffic on U.S. 61.

Exhibit 23 illustrates these recommendations.

SECOND-PARK WITH FOURTH STREET

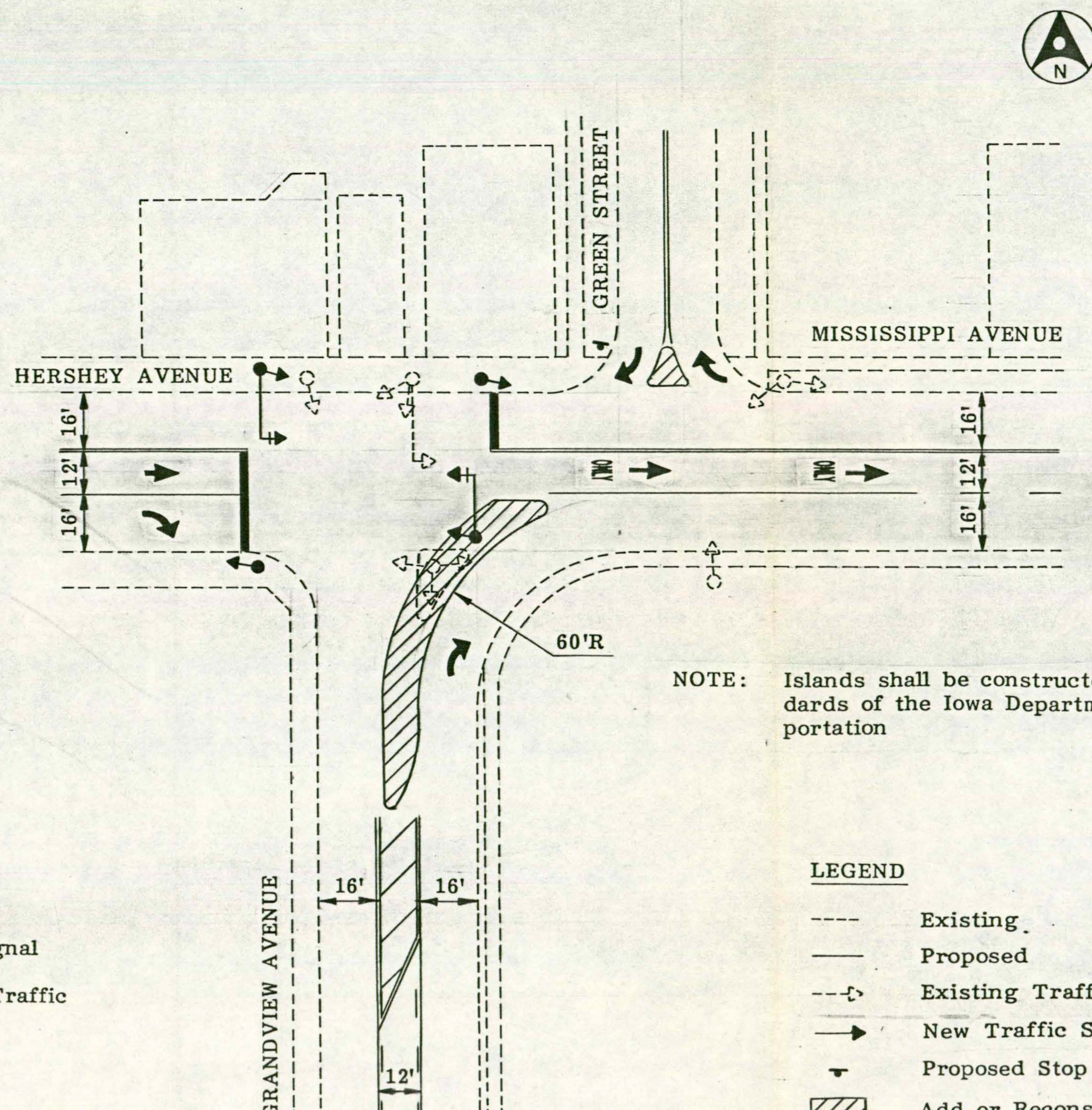
This intersection is presently signed as a four-way stop. This intersection carries approximately 1,200 vehicles per hour during the peak hour (two-way). The cross street traffic is minimal. The location is not a high accident intersection.

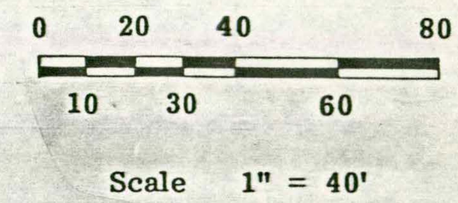
Based on our observations, it is recommended that the geometrics of this intersection be improved by providing approximately a 16 degree curve through this location and closing Park Avenue south of the intersection and 4th Street west of the intersection. This new alignment would affect two buildings at this intersection. However, this would expedite the flow of traffic. Table 3 illustrates the range of calculations based on degree of curve and super elevation rates. The actual design speed and super elevations should be determined after a calculation of drainage requirements. After this improvement is made, the stops should be removed from U.S. 61.

Exhibit 24 illustrates these recommendations.

EXHIBIT 23
PROPOSED IMPROVEMENTS
MISSISSIPPI AVENUE-GREEN,
GRANDVIEW & HERSHEY

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA





NOTE: Islands shall be constructed to the standards of the Iowa Department of Transportation

General Notes

1. Fully Actuated Signal
2. Remove Existing Traffic Signal Equipment

LEGEND

- ---- Existing
- —— Proposed
- ---▷ Existing Traffic Signal Head
- ——▶ New Traffic Signal Head (12" Lens)
- Proposed Stop Sign
- Add or Reconstruct Islands
- ---○ Existing Mast Arm
- ——● New Mast Arm

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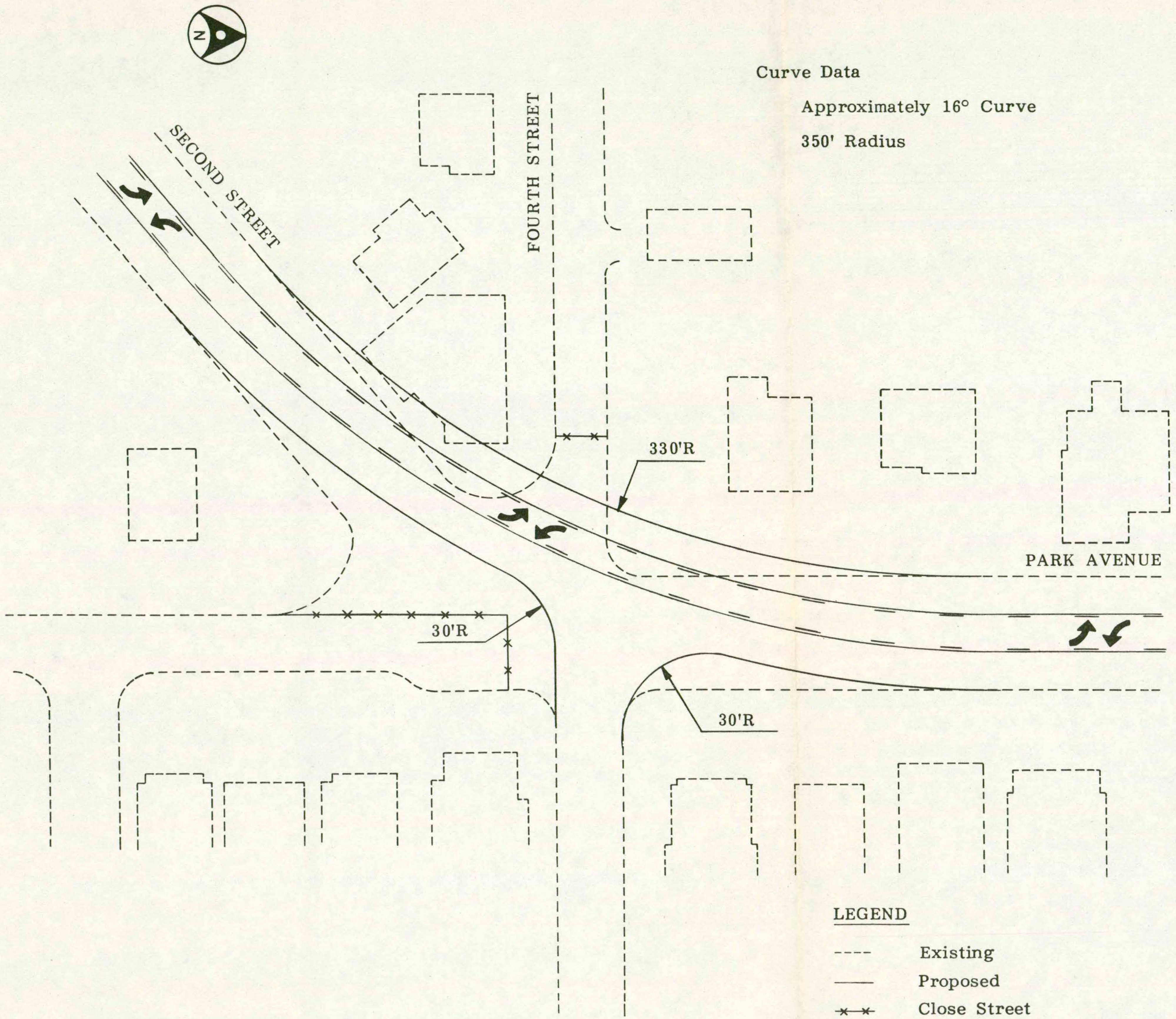
Maryland Heights, Missouri

EXHIBIT 24
PROPOSED IMPROVEMENTS
SECOND, PARK WITH FOURTH STREET

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA



0 20 40 80
10 30 60

Scale 1" = 40'

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TABLE 3

CURVE CALCULATIONS

PARK-MISSISSIPPI AT 4TH

Formula =

$$R = \frac{V^2}{15\,(e + f)}$$

V = 35	R
e = .02	440
.04	398
.06	362

Degree of Curve

$$D = \frac{5729.6}{R} = \frac{5729.6}{362} = 15.8° \text{ for a } 362' \text{ Radius}$$

$$\frac{5729.6}{440} = 13.02° \text{ for a } 440' \text{ Radius}$$

Legend

R = Radius of Curve

D = Degree of Curve

V = Velocity

e = Super Elevation

f = Side Friction

EIGHTH AND BROADWAY Not primary

The intersection of Broadway and Eighth is controlled by a semi-actuated signal and serves as a school crossing for the Washington School. The intersection has been selected as a special study location to determine whether or not the traffic signal at this location is warranted and should be removed. A traffic count was made at this location between 3:00 and 6:00 p.m. which includes the afternoon school dismissal hour. During this time, traffic on the main route, Eighth Street, averaged 438 to 600 vehicles per hour. At the same time traffic from Broadway, the minor approach, averaged 48 to 52 cars per hour. Field observations made during this same time indicate that an eight second gap would be required for children to safely cross Eighth Street. An analysis of vehicular volumes indicate that a traffic signal is not needed. However, the gap study indicated that the removal of this signal would create an unsafe condition for school children. This unsafe condition is further compounded by a geometric alignment which places the crest of a vertical curve at the intersection. As a consequence, the signal does not have the most optimum visibility. Therefore, based on our field observations and gap timing, it is recommended that 15-foot mast arms be installed on Eighth Street.

EIGHTH AND ROSCOE Not primary

The intersection of Eighth and Roscoe is signalized with a semi-actuated traffic control which basically serves as a school crossing signal. A review of this intersection indicated that the signal heads for southbound traffic are not adequately visible. During the period of 3:00 to 6:00 p.m., a traffic count was made along with the determination of available gaps. During this three hour count it should be noted that traffic ranged between 482 to 621 vehicles per hour on Eighth Street. Side street traffic ranged between 47 and 53 vehicles per hour. These volumes do not meet the requirements for traffic signals. However, the gap analysis indicates that a gap of 10 to 12 seconds is required for children to cross Eighth Street and during the peak hour period, sufficient gaps of this length are not available.

Based on this analysis we recommend that this signal remain and continue to operate in a semi-actuated fashion. Because the intersection does serve school children, we are recommending that 15 foot mast arms be installed for both directions of Eighth Street to improve visibility.

MULBERRY AND SECOND

The intersection of Mulberry and Second is located northeast of the Central Business District. The intersection experiences high turning movements due to a turn in the state highway at this location. Second Street is one-way northbound at Mulberry. The traffic volumes indicate that approximately 70% of all vehicles on the east approach of Mulberry make right turns onto Second Street. Sixty-five percent of the traffic on the north approach of Second Street turns left onto Mulberry. Mulberry is marked as a four lane pavement between Second Street and Mississippi Avenue. This segment of street is 39 feet wide. Because southbound Route 61 traffic on Mulberry must turn right at Mississippi Avenue, a four lane facility through this area does not operate efficiently.

Accident data indicated that for a two year period, nine accidents occurred at this intersection. Of these nine accidents, six were of the "unknown" type and it is difficult to establish a pattern for the other three. However, two of them did involve striking a fixed object.

Based on our capacity analysis and traffic volumes, the following recommendations are presented for this intersection:

- Add a pedestrian signal head on the northeast quadrant.
- Add a dual mode signal indication for westbound right turning vehicles going to U.S. 61 north.
- Install a "Flash Don't Walk" unit.
- Provide a one second all red clearance.
- Mark a three lane cross section on Mississippi Avenue and on Mulberry from approximately Walnut Street to Second Street.
- Add four mast arms to this intersection to improve signal visibility.
- Reconstruct the intersection to allow for a full actuated controller.

Note that this intersection is recommended to be removed from the existing CBD system. The main reason for this which has been discussed under the CBD analysis is that the traffic flows at this point are too erratic and the movements are too heavy in different directions to allow any east-west or north-south progression through the CBD with this signal as a part of the 50-50 split used throughout the CBD.

SECOND-PARK FROM MULBERRY TO CLAY-COLORADO

Field observations indicate that the existing marked four-lane facility with lanes approximately 11 foot wide does not operate efficiently. Very seldom do vehicles utilize this highway two abreast in one direction. It was noted during the field observations that vehicles turning left into side streets, commercial driveways and residential drives further complicates this problem.

The thru volumes of traffic on this corridor were examined and it should be noted that the highest volume occurred mid-day at which time the two-way traffic exceeded 1,000 vehicles per hour. The remaining part of the day, traffic volumes are much less than this.

This facility should be marked for a three lane cross section with a center lane for left turns in either direction. The thru lanes would be 14 feet wide and the center lane 12 foot wide. This type of cross section will handle a one-way flow of approximately 900-1200 vehicles per hour. The existing cross section under forced conditions and a poor level of service will handle the same volume of traffic but with a much greater potential for accidents. Therefore, in order to decrease this accident potential, we recommend that a three lane cross section be established.

LEROY AND BIDWELL *Not primary*

The intersection of Leroy and Bidwell is located northwest of the Heinz Plant. At this time, southbound traffic on Bidwell stops for eastbound and northbound traffic. During the two-year period, eight accidents were reported at this location. Of these eight accidents, four were of the "unknown" type and three involved left turning vehicles with thru movements. One accident involved a rear end collision.

Field observations of this intersection indicated that the visibility for traffic is very poor in the northwest quadrant of the intersection. This is created by a steep bank at this corner. It is recommended that a retaining wall be placed approximately four to six feet behind the existing line of sight. This would allow motorists approaching from Leroy to have adequate sight distance in order to determine when it would be appropriate to enter this intersection. Once this sight distance is clear, it is recommended that only Leroy be required to stop.

HIGH ACCIDENT LINK BETWEEN ISETT AND BIDWELL AND BIDWELL AND WOODLAWN

This segment of highway serves a high volume of traffic on a four-lane facility. A p.m. peak hour and a.m. peak hour count indicated that 435 and 500 vehicles per hour, respectively, utilize this street.

The accident data indicated that for a two-year period, seven collisions were reported on this segment. The major contributing cause seems to be the entrance to the Heinz Plant in which both employees and slow moving vehicles cross and enter the street.

There are two recommendations which could be initiated for this high accident link:

- A three-lane cross section could be provided on Bidwell in order to separate out the left turning vehicles from the thru movements. This cross section could be easily carried through the south leg of the intersection of Bidwell and Isett.
- Install a traffic signal at the entrance to the Heinz Plant. This signal would assist in the crossing of the employees during various hours as well as the safe movement of trucks into and out of this facility. A gap analysis shows that about 13 seconds are required for a tractor trailer to safely enter the flow of traffic onto Bidwell. Based on the traffic volumes, a sufficient number of these 13 second gaps are not available during the season peak periods. This signal should be fully actuated and thereby optimizing the green time for the minor street.

ISETT AND BIDWELL

We are recommending that the Isett three lane cross section be extended thru the south leg of this intersection. Exhibit 16 illustrates a typical three lane section. Although the signals are visible, a one second all red clearance should be added to this location. This is recommended to further add to the safety of the intersection.

WASHINGTON AND DIAGONAL

The intersection of Washington and Diagonal has been selected as a special study location. Going eastbound, Washington makes a left onto Diagonal. Diagonal at this point begins a downgrade slope. Washington Street, eastbound at Diagonal, becomes a narrow rock road which is also downgrade. Residences along Washington Street can easily gain access to Diagonal by using the River Road at the bottom of the hill where there is an overhead flasher. Motorists attempting to use the intersection of Washington and Diagonal have limited sight distance from the east leg of Washington and should be discouraged from using this location. The speed limit along this route is 45 miles per hour which contributes to limited sight distance.

Based on our field observations, the following recommendations* are made:

- A thermoplastic centerline and edge line should be placed from a point approximately 1,000 feet west of the intersection of Diagonal and Washington to the intersection of Diagonal and River Road.
- Raised pavement markings should be used for the center line and edge line in conjunction with the thermoplastic from the River Road to Oak Drive on Washington and Diagonal.
- Guardrail should be installed on the south side of Diagonal and River Road to Washington. The flasher over the intersection of River Road and Diagonal should be replaced due to its age. For motorists driving this location at night, this intersection is dangerous in regards to the combination of vertical and horizontal curves. These are the main reasons we have recommended this special treatment by providing pavement markings for this section of roadway.

* The Iowa Department of Transportation requires approval of these items on their route and must be installed to their standards.

SECOND--CYPRESS-TOLL BRIDGE

The intersection of Cypress with Second, which leads to the Muscatine Bridge, is presently signalized. The intersection operates with actuated traffic control from the bridge approach. The present phasing has a leading and/or a lagging green arrow for southbound traffic to make a left onto the bridge.

Our field observations indicated several deficiencies. Those deficiencies and recommendations are listed below:

- The traffic signal phasing should be changed so that the phasing provides a leading left instead of the lead and a lagging left.
- Due to the background lighting, backplates should be added to the mast arm signals.
- The signal heads on the mast arms appear to have a low intensity and, therefore, the lamps and lenses should be replaced in order to improve the intensity of the signal heads.
- A yellow clearance arrow should be added at the termination of the leading left phase along with a one second all red clearance between the opposing phases.

PARK AND CLEVELAND

The intersection of Park and Cleveland is actually the first major intersection on the Park Avenue corridor for traffic from the north. At present, Park Avenue is divided into four lanes with a grass median. Commercial development has been increasing on both sides of Park. This includes a McDonald's; approximately 150 apartment units (ultimate); a Wendy's; a storage area; and a trailer court. These developments have increased traffic at this intersection.

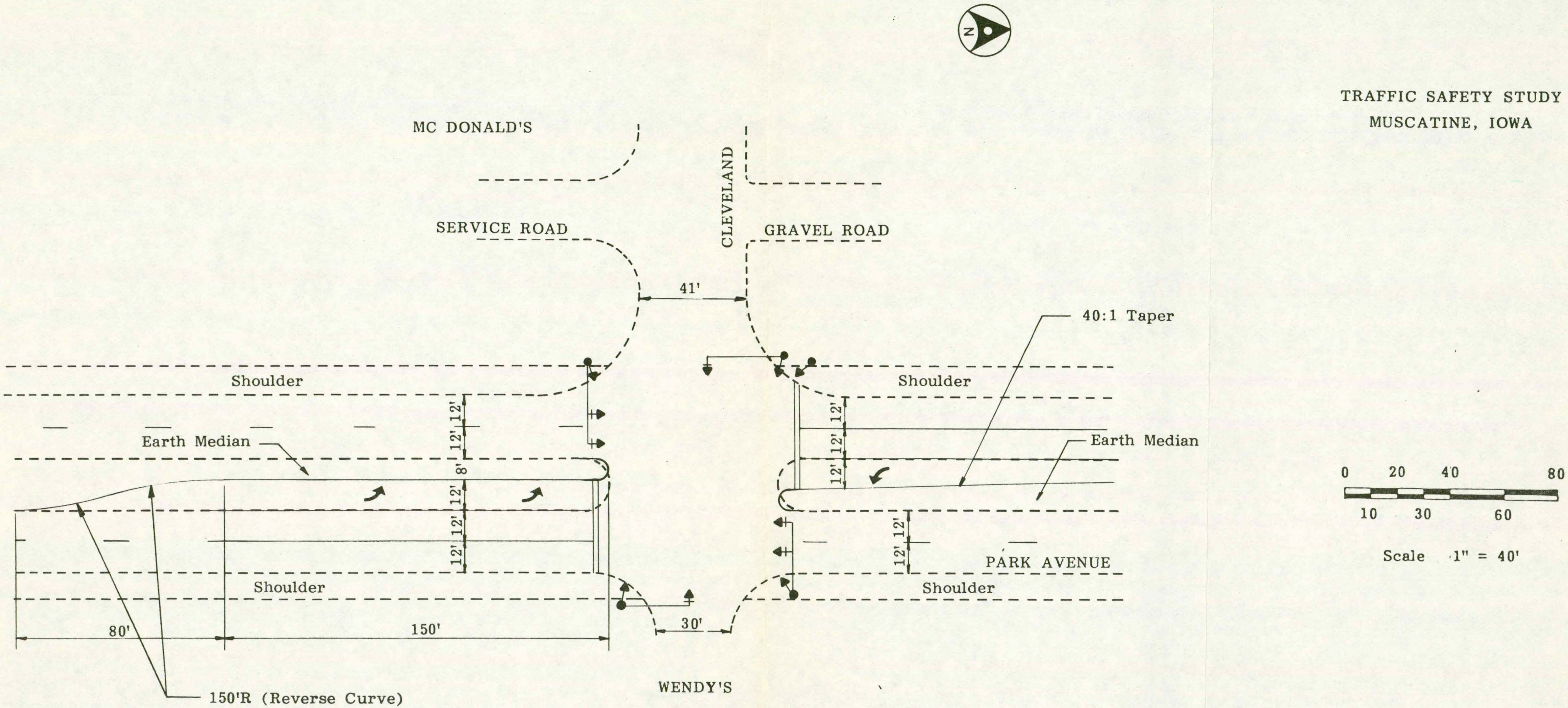
Traffic volume data was obtained for this location which included a mid-day peak hour count. Existing traffic was added to projected traffic and a capacity analysis was conducted at this intersection both signalized and unsignalized. Field observations at this intersection indicate that a high number of left turns are being made from the south approach on Park. During this two-hour period, between 90 and 116 left turns were made at this intersection. At the same time, approximately 400 vehicles are northbound. Based on combining existing with generated traffic, this intersection will meet the warrants for traffic signal installation by 1981-1982. However, at this time we would recommend that this traffic signal be installed under the Systems Warrant which is defined as follows:

> The System Warrant is applicable when the common intersection of two or more major routes has a total existing or immediately projected entering volume of at least 800 vehicles during the peak hour of a typical weekday. A major route as used in the above warrant has one or more of the following characteristics:
>
> 1. It is part of the street or highway system that serves as a principal network for through traffic.
> 2. It connects areas of principal traffic generation.
> 3. It includes rural or suburban highway outside entering or transversing a highway.
> 4. It has a surface street or expressway ramp terminal.
> 5. It appears to be a major route or official plan such as a major street plan and urban traffic and transportation study.

Based on this, it would appear that this intersection would meet the Systems Warrant. The analysis of the traffic signal progression along Park Avenue included this intersection. This intersection does fit into the Park Avenue progression, and, therefore, would not create any adverse delay for traffic. In addition to the installation of signals at this location, it is recommended that a minimum of 150 feet of left turn lane be installed on the south leg and a 75 foot turn lane be constructed on the north leg. Exhibit 25 illustrates these recommendations.

EXHIBIT 25
PROPOSED IMPROVEMENTS
PARK AVENUE & CLEVELAND

TRAFFIC SAFETY STUDY
MUSCATINE, IOWA



General Notes

1. Install Traffic Signals
2. Construct Northbound Left-Turn Lanes
3. Construct Southbound Left-Turn Storage

LEGEND

---- Existing
—— Proposed
—● New Mast Arm
—▶ New Traffic Signal Head

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Traffic Engineers
Maryland Heights, Missouri

CHAPTER 5

GENERAL COMMENTS

CBD

As a general field observation, it was noted that in the Central Business District, many of the traffic signals had poor visibility. This is due to the placement of signal heads on the street lighting posts and restricted sight distances as a result of buildings close to the curb lines. At several locations mast arms have been added to the light standards similar to the intersection of Oak and Second Streets. Therefore, as a general recommendation, mast arms should be added to the signalized intersections within the CBD. These mast arms should be approximately 15 feet in length and constructed of light weight aluminum. Field observations indicate that vehicles are running the amber interval. To minimized right angle collision potential, it is recommended that a one second all red clearance interval be added between signal phases.

MISSISSIPPI DRIVE CORRIDOR

This corridor was analyzed and presented in Chapter 2. Presently, it is interconnected with the CBD system and operates on a 60 second cycle. Our speed and delay studies indicate that a better progression can be achieved by separating Mississippi Drive from the CBD system and interconnecting it independently. Field observations made during the peak hours substantiate this recommendation. It was observed that many times when traffic was stopped on Mississippi Drive there was no traffic on the side streets. This is primarily because streets such as Iowa, Sycamore, and Cedar are used for CBD circulation.

PARK AVENUE CORRIDOR

Park Avenue has been analyzed from Second Street to Cleveland. Commercial growth along with increasing traffic volumes has made this a high traffic activity corridor. The lack of an interconnect system for the existing signals creates ineficiencies in the movement of traffic. The signals at Washington and 5th could be interconnected into the system. However, the cost to accomplish this is considerably higher than the resulting benefits. Due to the adverse distance, there are too many variables that may actually create a delay for motorists at these two locations. For example, if a progression has been established for 35 miles per hour and a vehicle traveled at 37 miles per hour over the distance, the green band opening could be missed and, therefore, be forced to stop. In a similar manner, if a motorist traveled at 33 miles per hour, again a delay would result. Therefore, our recommendations for this corridor are briefly summarized as follows:

- A three lane section where previously recommended.
- Interconnect the signals between Clay-Colorado and Cleveland.
- Install a traffic signal at Cleveland.
- Make intersection modifications at Washington, Harrison, and Ford.
- Provide a one second all red clearance interval between major opposing phases.

CHAPTER 6

ACCIDENT EVALUATION

In order to determine if a highway safety project has been effective in reducing accidents after implementation, an evaluation must be performed. This evaluation is critical if a city is to decide what countermeasure will be continued, deleted, or put in effect in order to improve safety and reduce accidents.

The projects which should be evaluated after corrective measures have been implemented are the 14 intersections/corridors as described in Chapter 3 entitled "High Accident Locations." For these locations, the purpose for an improvement is to reduce accidents. For simplicity, the city may wish to aggregate similar projects into groups for evaluation.

In order to evaluate the project in terms of accident reductions, the following data is necessary:

- Accident history for three years prior to and upon implementation. This data can be easily obtained from the ALAS computer printouts.
- Vehicle exposure data (vehicle counts or vehicle miles)
- Project cost.

This data should be collected using proper engineering procedures and the "Manual of Traffic Engineering Studies" should be referenced. The U.S. Department of Transportation, Federal Highway Administration uses two forms to analyze this data:

1. Accident Summary Table
2. Exposure Worksheet

A copy of these forms has been attached to the Appendix of this report.

After the data has been obtained for the "after" evaluation, a form entitled "MOE Data Comparison Worksheet" should be utilized. This form is also attached to the Appendix.

Finally, the ratio of Benefits/Costs (B/C) should be calculated. One method has been described in the October, 1978 Federal Highway Administration Manual entitled "Evaluation of Highway Safety Projects" and is printed on the following page.

BENEFIT/COST RATIO ANALYSIS*

The benefit/cost method may be performed for either individual projects or for the project groups established in Function A. The B/C technique may be performed in two ways; using equivalent uniform annual costs and benefits or using present worth of costs and benefits. Either method is capable of valid results. However, for projects consisting of countermeasures with unequal service lives, the use of present worth of costs and benefits is not appropriate. Equal or unequal service life of countermeasures may be used in conjunction with equivalent uniform annual costs and benefits.

The B/C technique consists of the following steps:

- Determine initial implementation costs.
- Determine net annual operating and maintenance costs.
- Determine the annual safety benefits in terms of the number of fatal, injury and property damage accidents prevented.
- Assign a dollar value to each benefit category. Recent NHTSA accident cost figures are $287,175, $3,185 and $520 per fatality, injury and property damage involvement, respectively. NSC accident cost figures are $125,000, $4,700 and $670 for fatal, injury and property damage accidents, respectively. Any other set of costs may be used.
- Estimate the service life. Table 4 illustrates typical service life of improvements.
- Estimate the salvage value.
- Determine an interest rate.
- Calculate the components of the B/C ratio.

The B/C Worksheet should be used to perform the analysis. These are attached to the Appendix of this report.

* Evaluation of Highway Safety Project, October, 1978, U.S. Department of Transportation, Federal Highway Administration.

TABLE 4

ESTIMATES OF IMPROVEMENT SERVICE LIFE

Improvement	Service Life
Signals	15 Years
Safety Lighting	15 Years
Median Barriers	15 Years
Flashing Beacons	10 Years
Guardrail	10 Years
Pavement Grooving	10 Years
Signing (Major)	10 Years
Signing (Minor)	5 Years
Raised Pavement Markers	5 Years
Guide Markers	5 Years
Painted Stripes	2 Years

CHAPTER 7
COST ESTIMATES

This chapter has been presented to list the recommendations outlined in the first four chapters and their estimated costs.

CHAPTER 1 -- SCHOOLS

School	Item	Estimated Cost
• Garfield	Signing Sidewalk	$ 300.00 15,000.00
• Franklin	Signing	200.00
• Washington	Signing	200.00
• McKinley-West Junior High	Signing Sidewalk	200.00 9,000.00
• Hayes	---	---
• Jefferson-Central Jr. High	---	---
• Grant	---	---
• Mulberry	---	---
• Madison	Sidewalks	2,200.00
• Colorado	Sidewalks	18,000.00
	Total	$45,100.00

CHAPTER 2 -- TRAFFIC SIGNAL SYNCHRONIZATION

Area		
• CBD	Controller Update Mast Arms Misc. Total	$20,000.00 80,000.00 15,000.00 $115,000.00
• Mississippi Avenue Corridor Mississippi Avenue @		
• Cedar	Provide Semi-Actuated Controller for Side Street & Left Turns Install Opticom	$12,000.00 5,000.00
• Sycamore	Provide Semi-Actuated Controller for Side Street & Left Turns Install Opticom	$10,000.00 5,000.00

Area	Item	Estimated Cost
Mississippi Avenue @		
• Iowa	Provide Semi-Actuated Controller for Side Street & Left Turns	$10,000.00
	Install Opticom	5,000.00
• Chestnut	Provide Semi-Actuated Controller for Side Street & Left Turns	$10,000.00
	Install Opticom	5,000.00
• Pine	Signal Modifications	$ 1,000.00
	Semi-Actuated Controller	10,000.00
	Install Opticom	5,000.00
Interconnect Corridor (Overhead)		$12,000.00
	Total	$90,000.00
• Park Avenue Corridor Park Avenue @		
• Cleveland	Install Semi-Actuated Traffic Signal	$50,000.00
• Ford	Signal Head Modifications	$ 1,000.00
	Add Left Turn Lane (northbound)	15,000.00
	Modify Controller	5,000.00
• Lake Park	Signal Head Modifications	$ 1,000.00
	Modify Controller	5,000.00
• Harrison	Signal Head Modifications	$ 1,000.00
	Modify Controller	5,000.00
• Clay-Colorado	Signal Head Modifications	$ 1,000.00
	Controller Change	12,000.00
	Improve Southeast & Southwest Corner Radii	10,000.00
• Washington	Add Mast Arm in Southwest Quadrant	$ 2,500.00
	Redesign Northeast Corner Radii	5,000.00
	Signal Head Modifications	1,000.00
	Interconnect (if feasible)	*
• 5th	Improve Radii in Northwest Corner	$ 5,000.00
	Interconnect (if feasible)	*
Interconnect Corridor		30-75,000.00 ?

* Report indicated interconnect is not feasible

CHAPTER 3 -- HIGH ACCIDENT LOCATIONS

Location	Improvement	Estimated Cost
U.S. 61 (Grandview) @		
• Warren	Signal Head Modifications	$ 2,500.00
	Revise Phasing	500.00
	Provide A Three-Lane Cross Section	-0-
Grandview @		
• Main	Provide Three Lane Cross-Section with a Left Turn Lane at Main	-0-
• Fifth & Mulberry	Mast Arms	5,000.00
	Signal Heads	500.00
• Oak and Second	Controller-Actuated	10,000.00
• Highway 22 (Cedar) & Houser	Signing	50.00
• Grant & Park (U.S. 61)	Three-Lane Cross Section	-0-
• Park & Washington	Signal Revisions	20,000.00
	Radii Improvements	6,000.00
• Park & Clay-Colorado	Radii Improvement	12,000.00
	Signals	(See Costs in Chapter 2)
• Park & Harrison	Overlay	100,000.00
	Median Removal & Replacement	20,000.00
	Signals	(See Costs in Chapter 2)
• Park & Lake Park	Signals	(See Costs in Chapter 2)
• Park & Ford	Left Turn Lane	25,000.00
	Signals	(See Costs in Chapter 2)
• Fifth-Lombard to Park	Signing	350.00
• Mississippi Drive-From Hershey & Green to Mississippi & Pine	Overlay	150,000.00

CHAPTER 4 -- SPECIAL STUDY LOCATIONS

Location	Improvement	Estimated Cost
U.S. 61 (Grandview) @		
• Houser-Sampson	Signals	70,000.00
	Widening	175,000.00

Location	Improvement	Estimated Cost
• Houser & Allen-Dawsen	Signals	$22,000.00
• Mississippi Avenue-Green, Grandview & Hershey	Signals	15,000.00
	Geometric Revisions	15,000.00
	Controller	5,000.00
• Second-Park & Fourth St.	Realign Street	100,000.00
	Buildings	75,000.00
• Eighth & Broadway	Mast Arms	5,000.00
• Eighth & Roscoe	Mast Arms	5,000.00
• Mulberry & Second	Traffic Signals	30,000.00
	Controller	10,000.00
• Second-Park from Mulberry to Clay-Colorado	Overlay	300,000.00
• Leroy & Bidwell	Earthwork & Retaining Walls	5,000.00
• High Accident Link - between Isett & Bidwell & Bidwell & Woodlawn	Signals at Heinz	50,000.00
• Isett & Bidwell	3-Lanes	-0-
• Washington & Diagonal	Pavement Markings	5,000.00
	Raised Pavement Markings	2,500.00
	Guardrail	5,000.00
• Second-Cypress-Toll Bridge	Signal Modifications	12,000.00
• Park & Cleveland	Left Turn Lanes	50,000.00
	Signals	(See Costs in Chapter 2)

CHAPTER 8

PRIORITIES & IMPLEMENTATION

Based on the cost estimates as outlined in Chapter 7 for each recommendation, the following implementation schedule has been prepared. This schedule has grouped the projects into five fiscal years to match anticipated funds.

The total improvement program has been estimated at $1,708,000. It is anticipated that Federal Aid Urban System (FAUS), Urban-State-Traffic Engineering (USTEP), and local funds will be available to implement these projects.

Based on the priorities and funds available, Table 5 has been prepared.

TABLE 5
IMPLEMENTATION SCHEDULE BY FISCAL YEAR
MUSCATINE, IOWA

FY 1980 (Current Year)

School Signal on Houser Street between Allen and Dawson	$ 22,000	
Sign Installations on Fifth Street between Lombard and Park Avenue	350	
Sign Replacement at Houser and Cedar	50	(Stake on Cedar)
1980 TOTAL	$ 22,400	

FY 1981

Schools: Sidewalks and Signs (Chapter 1)	$ 45,100	
CBD Traffic Synchronization	115,000	FAUS (?)
Mississippi Drive Interconnects	90,000	U-STEP
Second and Oak Signal Modifications	10,000	U-STEP
Eighth and Broadway Signal Modifications	5,000	FAUS
Eighth and Roscoe Signal Modifications	5,000	FAUS
Second and Cypress Signal Modifications	12,000	U-STEP
1981 TOTAL	$282,100	

FY 1982

Park Avenue and Washington Signal Modifications and Radius Changes	$ 26,000	U-STEP
Park Avenue and Clay-Colorado Radius Changes	12,000	"
Park and Harrison Left-Turn Bay	120,000	"
Park and Ford Left-Turn Bay	25,000	"
Park and Cleveland Left Turn Bays	50,000	"
Park Avenue Corridor Signal and Controller Changes (Includes New Signals at Cleveland)	119,500	"
Park Avenue Interconnect - Clay to Cleveland	30,000	"
Grandview and Warren Signal Modifications	3,000	"
Hershey and Grandview Signals and Island	35,000	"
Isett Avenue Signals at Heinz Entrance	50,000	
1982 TOTAL	$470,500	

FY 1983

Fifth and Mulberry Signal Modification	$ 5,500	FAUS
Houser-Sampson and Grandview Intersection	245,000	U-STEP
Second and Mulberry Signal Modification	40,000	"
Washington and Diagonal Markings & Guardrail	12,500	"
Mississippi Drive Overlay - Green to Pine	150,000	"
1983 TOTAL	$453,000	

FY 1984

Second and Fourth Curve Reconstruction	$175,000	U-STEP
Second-Park Corridor Overlay-Mulberry to Colorado	300,000	"
Leroy-Bidwell Retaining Wall	5,000	FAUS (?)
1984 TOTAL	$480,000	

TABLE 5 (Continued)

TOTALS

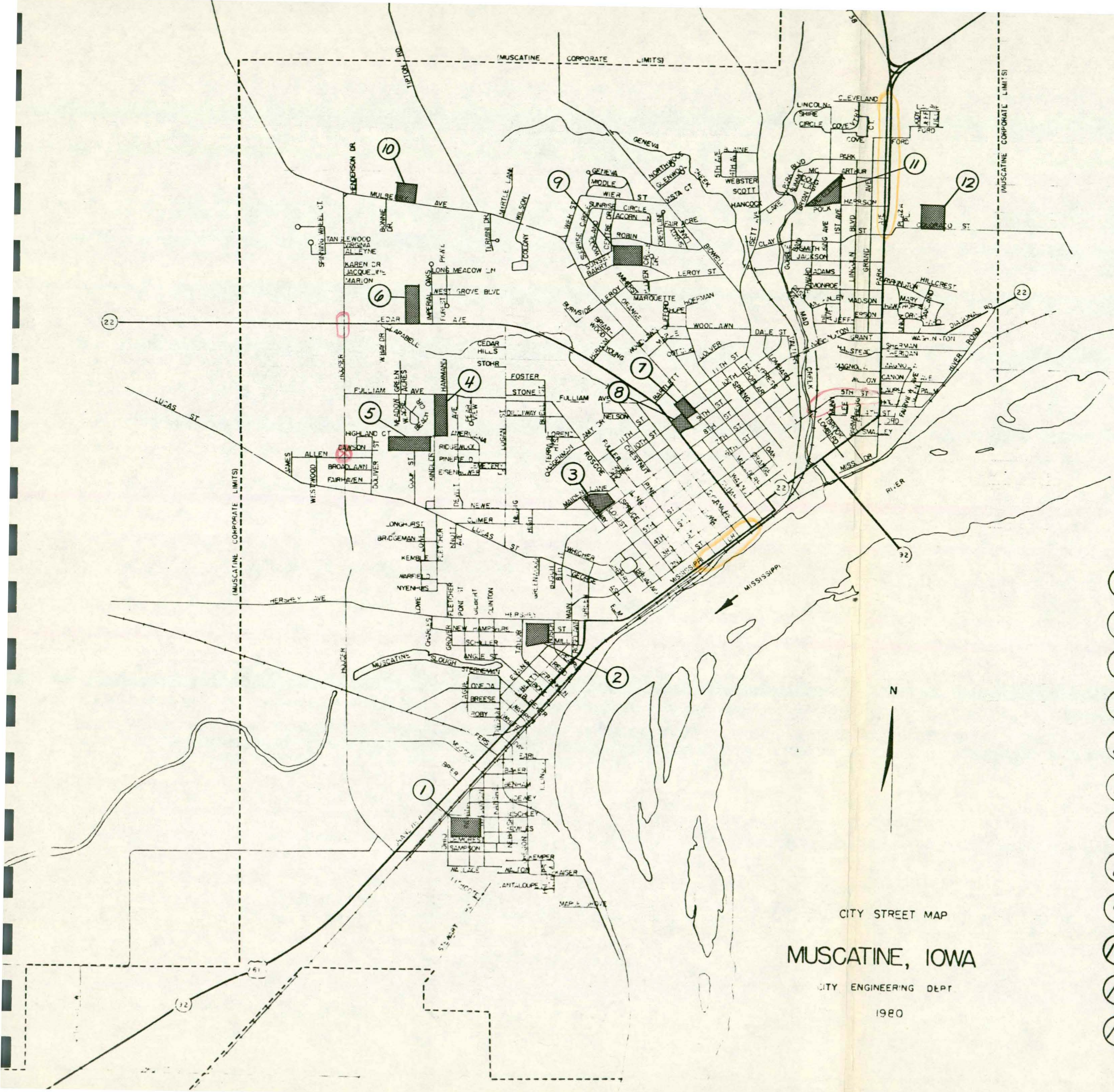
1980 FY	$ 22,400
1981 FY	282,100
1982 FY	470,500
1983 FY	453,000
1984 FY	480,000
TOTAL	$1,708,000

A rough "split" of the $1,708,000 by funding source would be:

FAUS	$339,000
USTEP	653,500
LOCAL	715,500
TOTAL	$1,708,000

FAUS; Federal Aid Urban System Funds
USTEP; Iowa DOT Funding (Urban-State Traffic Engineering Program)
Local; City of Muscatine and Muscatine Power and Water

APPENDIX



SCHOOL LOCATIONS

Traffic Safety Study

Muscatine, Iowa

LEGEND

(1) Garfield School

(2) Franklin School

(3) Washington School

(4) McKinley School

(5) West Junior High School

(6) Hayes Elementary School

(7) Jefferson School

(8) Central Junior High School

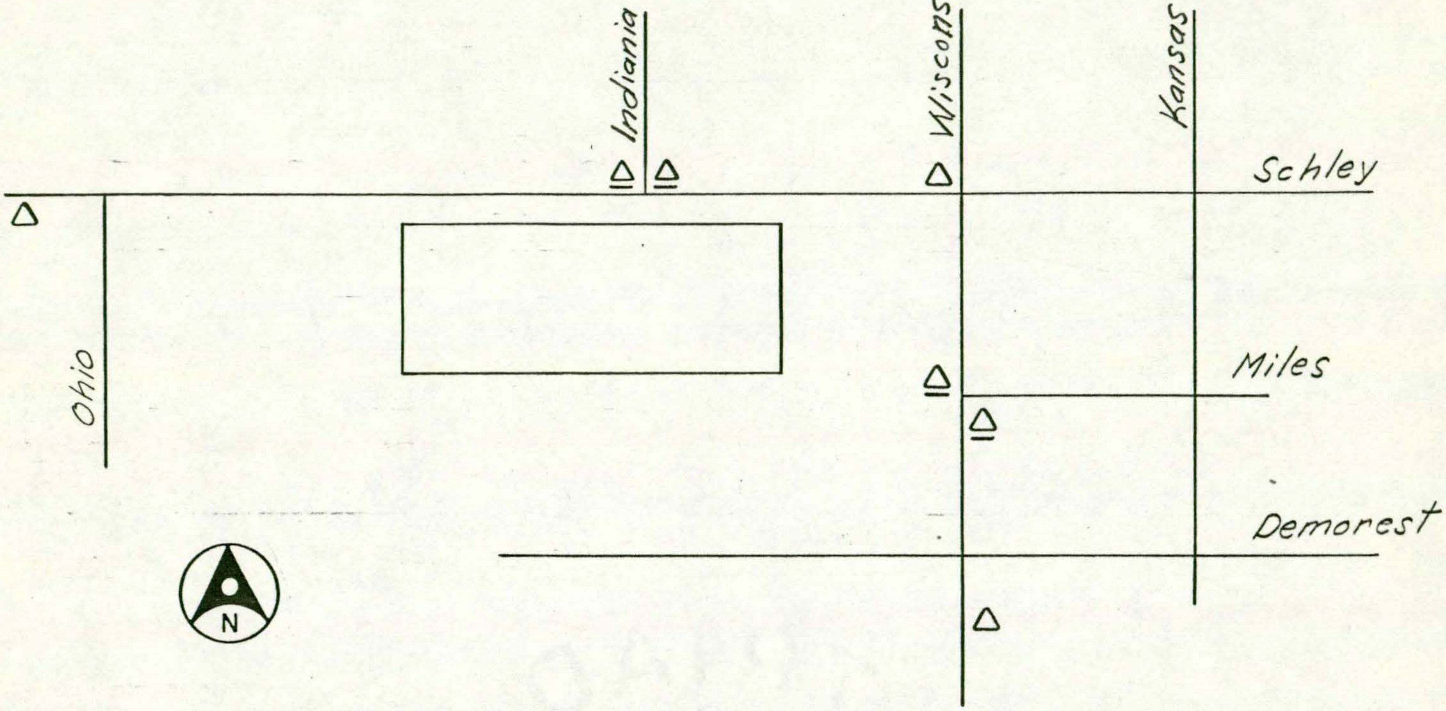
(9) Grant School

(10) Mulberry School

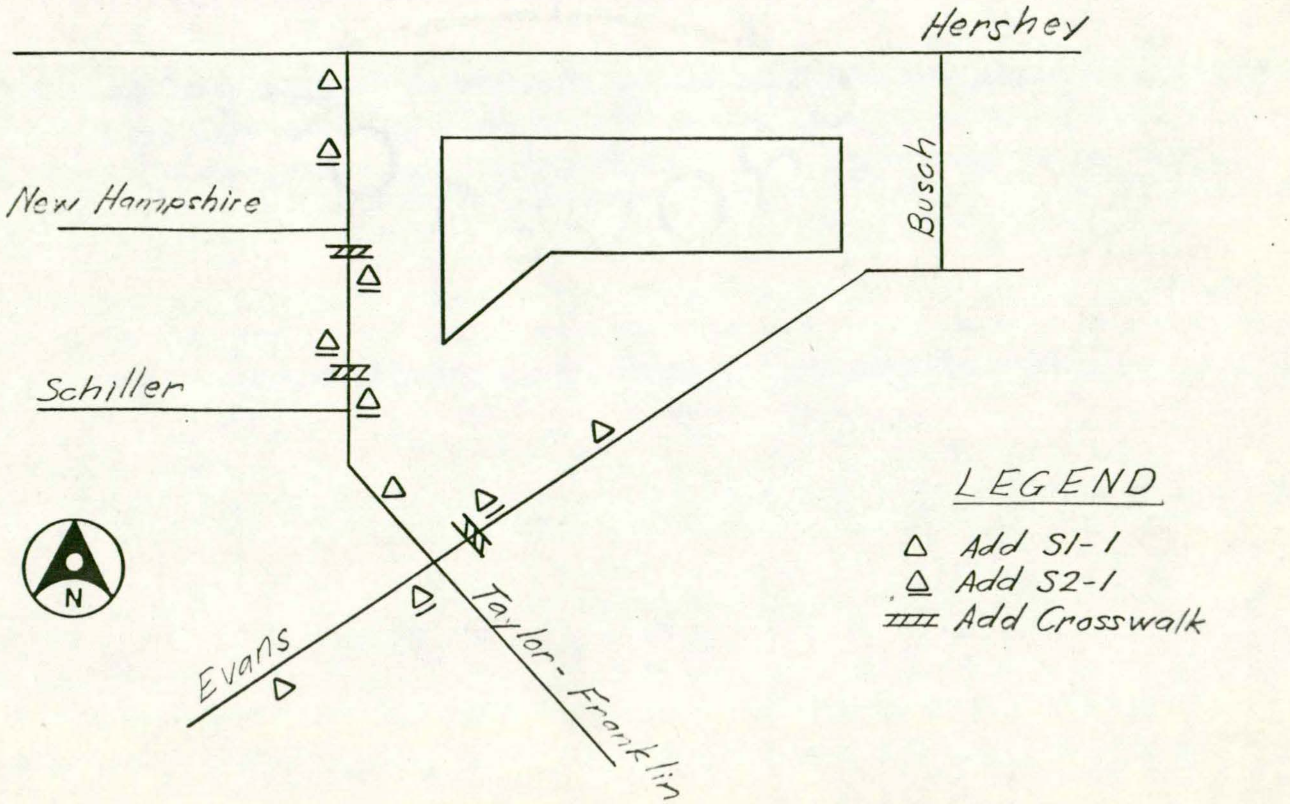
(11) Madison School

(12) Colorado School

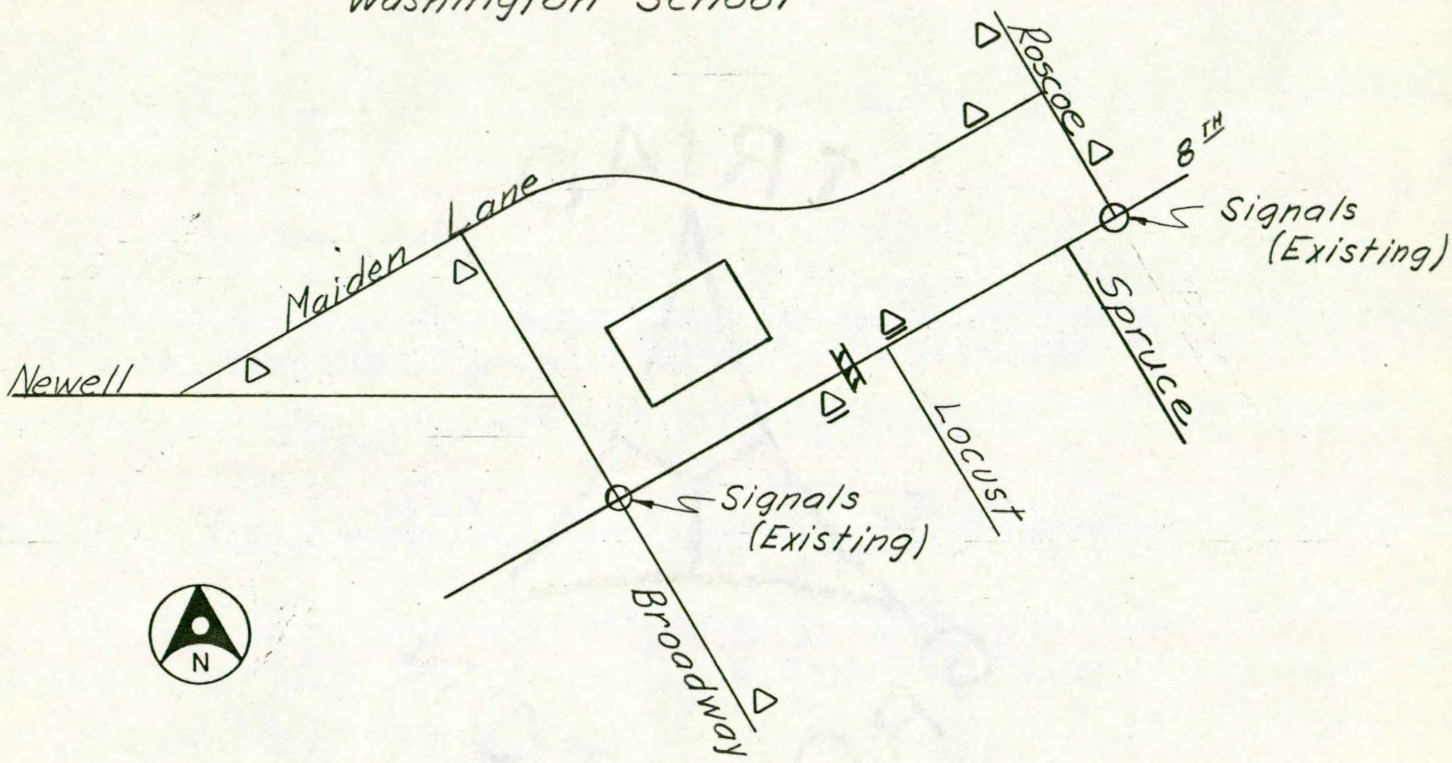
Location #1
Garfield School



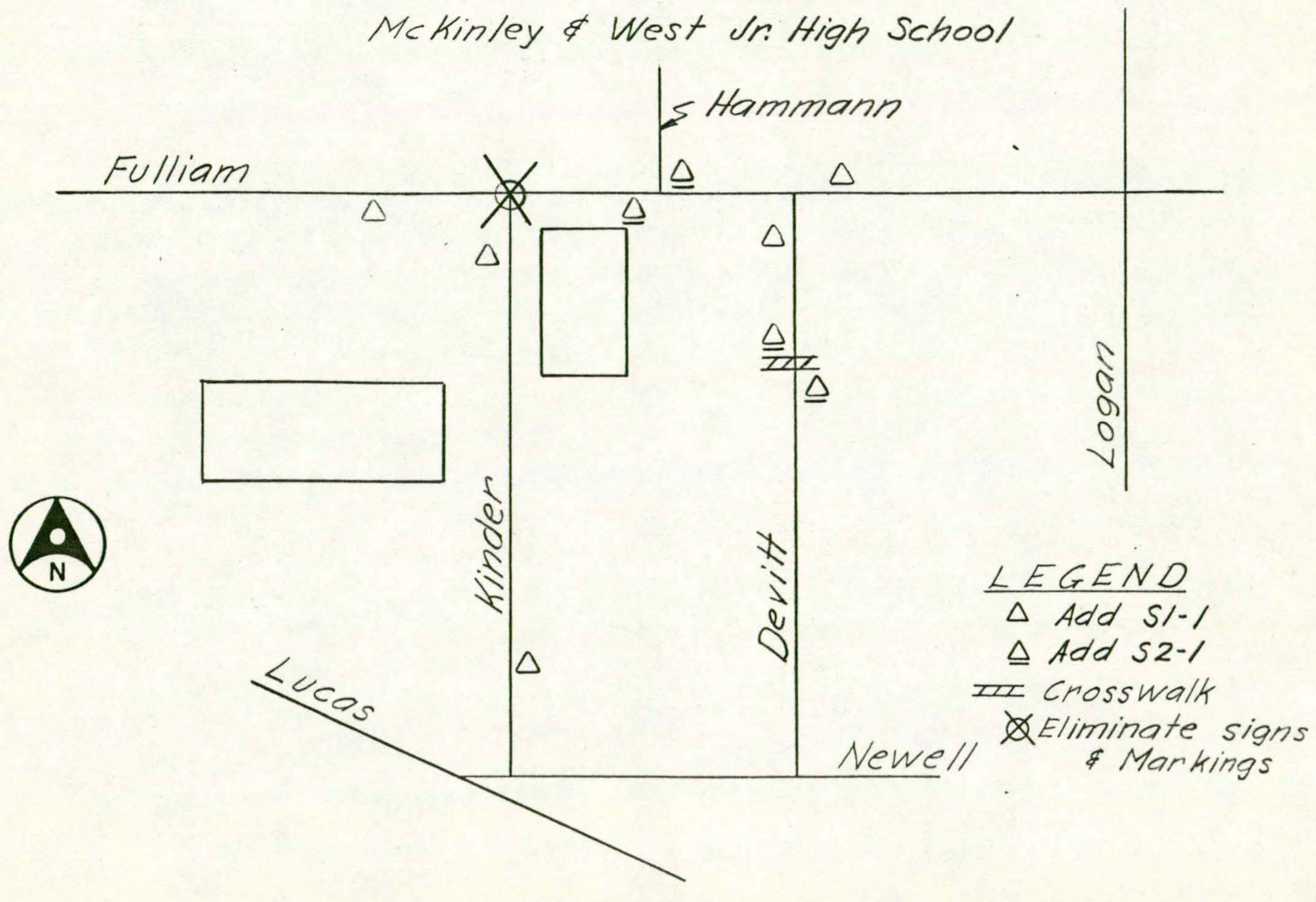
Location #2
Franklin School



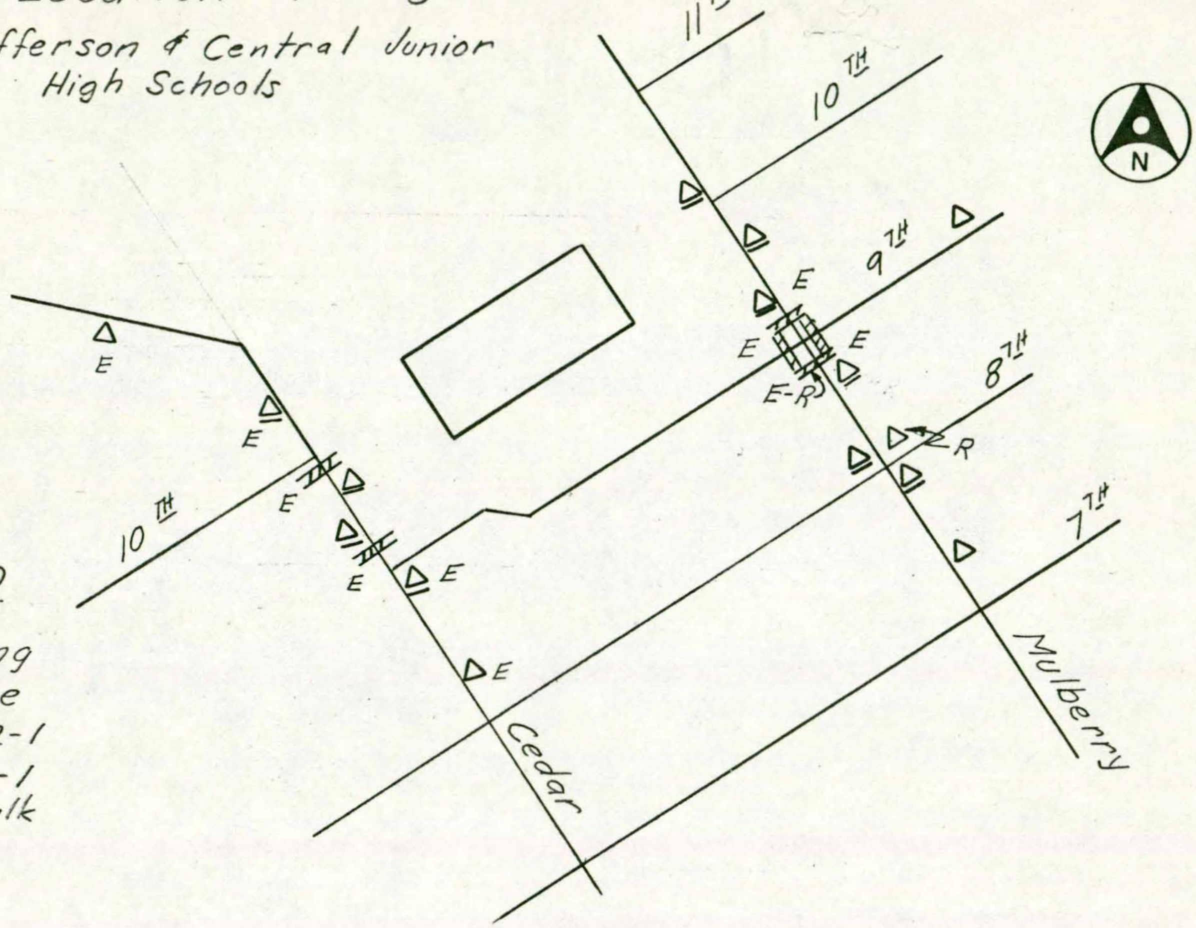
Location #3
Washington School



Location #4 & #5
McKinley & West Jr. High School



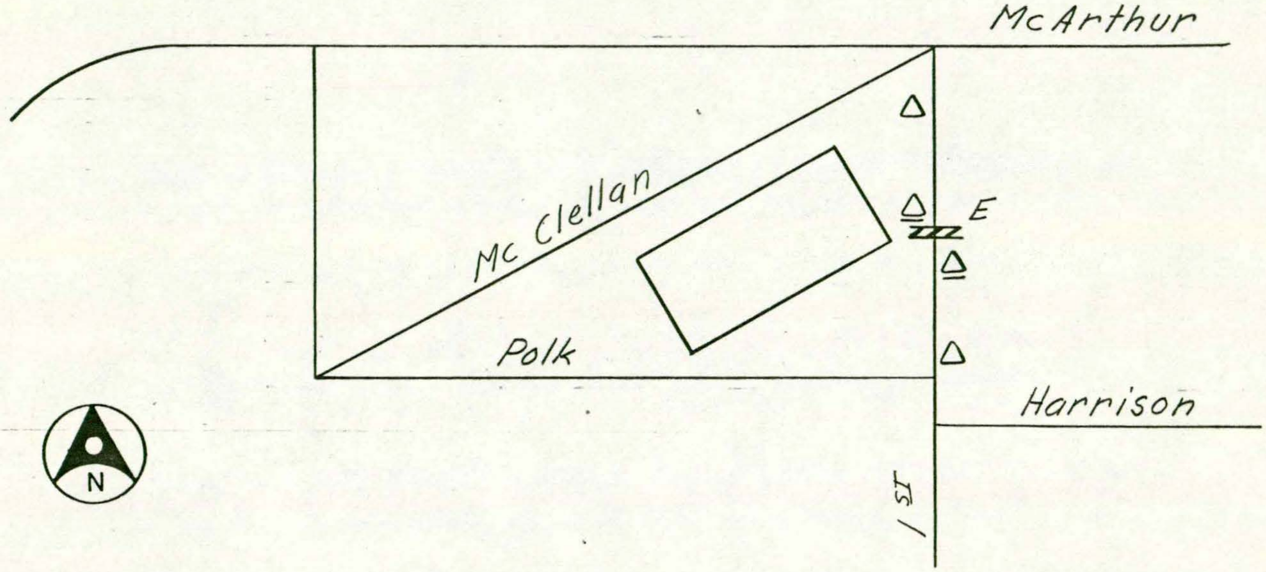
Location #7 & #8
Jefferson & Central Junior High Schools



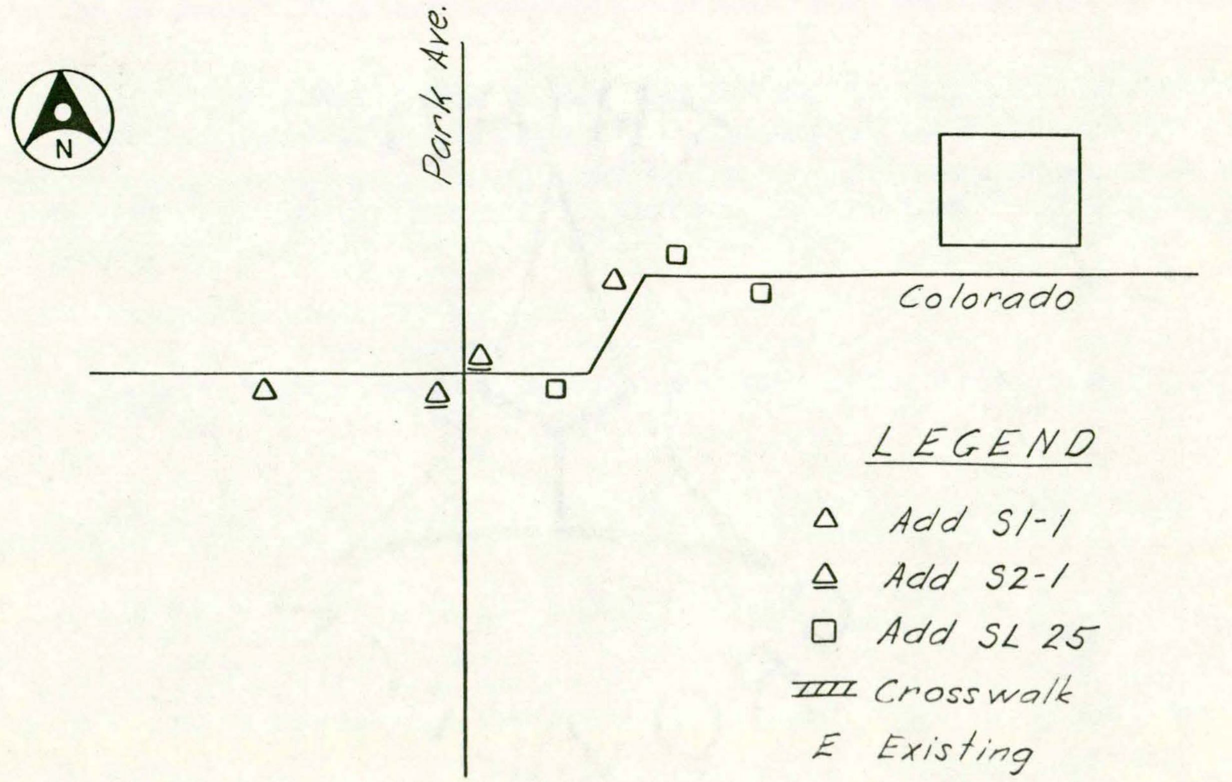
LEGEND

E Existing
R Remove
△ Add S2-1
△ Add S1-1
▥ Crosswalk

Location #11
Madison School



Location #12
Colorado School



SUMMARY OF TRAFFIC COUNTS FOR SIGNAL JUSTIFICATION

LOCATION Muscatine, Iowa DATE 1/80

INTERSECTION U.S. 61 (Grandview) and Houser

MAJOR STREET SPEED ______ (posted) ______ (85th percentile)

STREET NAMES

NO. OF APPROACH LANES

Hour Beginning	MAJOR STREET U.S. 61		MINOR STREET Houser			Warrant I	80% Warrant I	70% Warrant I	Warrant 2	80% Warrant 2	70% Warrant 2			
	Total of Both Approaches VPH	Pedestrians Crossing PPH	Higher Volume Approach VPH W	E	Pedestrians Crossing PPH									
8	443		197	80										
9	402		104											
12	380		59											
1	360		86											
3	654		83											
4	666		167											
5	553		89											
5	494		105											
6	563		114											

TOTAL NO. OF HOURS WARRANTS MET

WARRANT I

80% WARRANT I

70% WARRANT I

WARRANT 2

80% WARRANT 2

70% WARRANT 2

REMARKS

#1	500	350	150	105
#2	750	525	75	53

SUMMARY OF TRAFFIC COUNTS FOR SIGNAL JUSTIFICATION

LOCATION Muscatine, Iowa DATE 2/12/80

INTERSECTION Houser and Cedar

MAJOR STREET SPEED ____ (posted) ____ (85th percentile)

Cedar	Houser	STREET NAMES
		NO. OF APPROACH LANES

Hour Beginning	MAJOR STREET Total of Both Approaches VPH	MAJOR STREET WB	MINOR STREET Higher Volume Approach VPH	MINOR STREET N & S	Warrant 1	80% Warrant 1	70% Warrant 1	Warrant 2	80% Warrant 2	70% Warrant 2			
8A	354		225	363			x						
9	358		206	353			x						
10	198		120	221									
11	264		103										
12	244		141										
1P	264		160	290									
2	291		125	244									
3	305		162										
4	415		230	395			x						
5	376		211	363			x						
6	347		184	336			x						
7	218		102										
8	149		71										

TOTAL NO. OF HOURS WARRANTS MET

WARRANT I	
80% WARRANT I	
70% WARRANT I	
WARRANT 2	
80% WARRANT 2	
70% WARRANT 2	

REMARKS Warrant #1

500 x 0.7 = 350

150 x 0.7 = 105

INTERSECTION CAPACITY WORKSHEET

CITY: MUSCATINE STATE: IOWA

INTERSECTION: PARK + WASHINGTON DATE: 7-23-80

GENERAL DESCRIPTION: AM Peak Hour 1980 Year

2 Phases 8 Amber - Sec.

Street	PARK						WASHINGTON					
Approach	N			S			W			E		
Movements	L	SR		L	SR		L	LSR		L	SR	
Volume	11	431		2	313		25	78		137	73	
Volume Opposing Left Turns	313			431			73			53		

PHYSICAL CONDITIONS: ______ Existing X Proposed

Width of Approach	12	14		12	12			13		12	12	
Parking		-			-			-			-	
One - Way or Two - Way		2			2			2			2	

ENVIRONMENTAL CONDITIONS: OBD Type of Location

50 Metro Area Population (1,000's)

Peak Hour Factor												
Combined Adjustment Factor		.85			.85			.85			.86	

TRAFFIC CHARACTERISTICS: 25 47 13 25 18

Percent Trucks	5	5		5	5		5	5		5	5	
Percent Right Turns		6			15			17			25	
Percent Left Turns		-			-			32			-	

CALCULATIONS:

Phasing	A	A		A	A		B	B		B	B	
Charts Used	17	4		17	4		17	4		17	4	
Equivalent Chart Volume												
Max. Signal Cycle - Sec. (Left Turn)	490			270			216			39		
G/C Ratio Required - C	.28	.30		.38	.25		.07	.11		.17	.07	
G/C Ratio Required - D	.23	.26		.32	.22		.07	.10		.14	.06	
G/C Ratio Required - E	.22	.25		.29	.21		.07	.09		.13	.06	
Total G/C Ratio - C .47		.30								.17		
Total G/C Ratio - D												
Total G/C Ratio - E												

8 Sec. Amber/ .43 A/C - C = 19 Min. Signal Cycle Sec.

Sec. Amber/ A/C - D = Min. Signal Cycle Sec.

Sec. Amber/ A/C - E = Min. Signal Cycle Sec.

CONTROL MEASURES: ______ Signal Cycle Sec.

A/C Ratio												
G/C Ratio Used												
Green Interval - Sec.												
Auxiliary Lane Length - Desirable												
Auxiliary Lane Length - Minimum												

REMARKS:

INTERSECTION CAPACITY WORKSHEET

CITY: Muscatine STATE: Iowa

INTERSECTION: Park + Washington DATE: 4-25-80

GENERAL DESCRIPTION: AM Peak Hour 1980 Year

6 Phases 8 Amber - Sec.

Street	Park						Washington					
Approach	N			S			W			E		
Movements	L	LSR		L	LSR		L	LSR		L	LSR	
Volume	11	442		2	315		25	78		137	210	
Volume Opposing Left Turns	313			451			55			70		

PHYSICAL CONDITIONS: X Existing ____ Proposed

Width of Approach		20			20			13			18	
Parking		-			-			-			P	
One - Way or Two - Way		2			2			2			2	

ENVIRONMENTAL CONDITIONS: OBD Type of Location

50 Metro Area Population (1,000's)

Peak Hour Factor												
Combined Adjustment Factor		.85			.85			.86			.85	
TRAFFIC CHARACTERISTICS:		25 11			47 2			13 26			18 137	
Percent Trucks	5	5		5	5		5	5		5	5	
Percent Right Turns		6			15			17			9	
Percent Left Turns		2			0			32			65	

CALCULATIONS:

Phasing	A	A		A	A		B	B		B	B	
Charts Used	17	4		17	4		17	4		17	6	
Equivalent Chart Volume												
Max. Signal Cycle - Sec. (Left Turn)	490			2700			216			39		
G/C Ratio Required - C	.28	.27		.38	.20		.07	.11		.16	.27	
G/C Ratio Required - D	.23	.24		.32	.18		.06	.10		.13	.24	
G/C Ratio Required - E	.22	.23		.29	.17		.05	.09		.12	.23	
Total G/C Ratio - C .54		.27									.27	
Total G/C Ratio - D												
Total G/C Ratio - E												

8 Sec. Amber/ .46 A/C - C = 18 Min. Signal Cycle Sec.

Sec. Amber/ A/C - D = Min. Signal Cycle Sec.

Sec. Amber/ A/C - E = Min. Signal Cycle Sec.

CONTROL MEASURES: ____ Signal Cycle Sec.

A/C Ratio												
G/C Ratio Used												
Green Interval - Sec.												
Auxiliary Lane Length - Desirable												
Auxiliary Lane Length - Minimum												

REMARKS:

INTERSECTION CAPACITY WORKSHEET

CITY: MUSCATINE STATE: IOWA

INTERSECTION: PARK + CLAY - COLORADO DATE: 7-23-80

GENERAL DESCRIPTION: PM Peak Hour; 1980 Year; 2 Phases; 8 Amber - Sec.

Street	PARK						CLAY-COLORADO					
Approach	N			S			W			E		
Movements	L	LSR		L	LSR		L	SR		L	SR	
Volume	26	714		73	414		127	174		130	158	
Volume Opposing Left Turns	841			689			116			132		

PHYSICAL CONDITIONS: X Existing ____ Proposed

Width of Approach		20			20		10	10		10	10	
Parking		-			-			-			-	
One - Way or Two - Way		2			2			2			2	

ENVIRONMENTAL CONDITIONS: OBD Type of Location; 50 Metro Area Population (1,000's)

Peak Hour Factor												
Combined Adjustment Factor		.85			.85			.85			.85	
TRAFFIC CHARACTERISTICS:		144 25			147 73			42			42	
Percent Trucks	5	5		5	5		5	5		5	5	
Percent Right Turns		20			16			24			27	
Percent Left Turns		3			6			-			-	

CALCULATIONS:

Phasing	A	A		A	A		B	B		B	B	
Charts Used	17	4		17	4		17	4		17	4	
Equivalent Chart Volume												
Max. Signal Cycle - Sec. (Left Turn)	216			73			42			41		
G/C Ratio Required - C	.75	.47		.66	.62		.21	.22		.23	.20	
G/C Ratio Required - D	.62	.41		.56	.54		.18	.19		.19	.18	
G/C Ratio Required - E	.58	.39		.51	.52		.16	.18		.18	.17	
Total G/C Ratio - C .89				.66						.23		
Total G/C Ratio - D .74				.55						.19		
Total G/C Ratio - E .69				.51						.18		

8 Sec. Amber/.11 A/C - C = 73 Min. Signal Cycle Sec.

8 Sec. Amber/.26 A/C - D = 31 Min. Signal Cycle Sec.

8 Sec. Amber/.31 A/C - E = 26 Min. Signal Cycle Sec.

CONTROL MEASURES: ____ Signal Cycle Sec.

A/C Ratio												
G/C Ratio Used												
Green Interval - Sec.												
Auxiliary Lane Length - Desirable												
Auxiliary Lane Length - Minimum												

REMARKS:

INTERSECTION CAPACITY WORKSHEET

CITY: MUSCATINE STATE: IOWA

INTERSECTION: PARK + CLAY - COLORADO DATE: 7-23-80

GENERAL DESCRIPTION: PM Peak Hour 1980 Year
2 Phases 8 Amber - Sec.

Street	PARK						CLAY - COLORADO					
Approach	N			S			W			E		
Movements	L	SR		L	SR		L	SR		L	SR	
Volume	25	689		73	841		127	174		130	158	
Volume Opposing Left Turns	841			689			158			174		

PHYSICAL CONDITIONS: ____ Existing X Proposed

Width of Approach	12	14		12	14		12	12		12	12	
Parking		-			-			-			-	
One - Way or Two - Way		2			2			2			2	

ENVIRONMENTAL CONDITIONS: OBD Type of Location
50 Metro Area Population (1,000's)

Peak Hour Factor												
Combined Adjustment Factor		.85			.85			.85			.85	

TRAFFIC CHARACTERISTICS: 144 147 42 42

Percent Trucks	5	5		5	5		5	5		5	5	
Percent Right Turns		21			17			24			27	
Percent Left Turns		-			-			-			-	

CALCULATIONS:

Phasing	A	A		A	A		B	B		B	B	
Charts Used	17	4		17	4		17	4		17	4	
Equivalent Chart Volume												
Max. Signal Cycle - Sec. (Left Turn)	216			73			42			.41		
G/C Ratio Required - C	.75	.58		.66	.68		.25	.18		.26	.16	
G/C Ratio Required - D	.62	.51		.55	.60		.21	.16		.22	.14	
G/C Ratio Required - E	.58	.48		.51	.57		.19	.15		.20	.13	
Total G/C Ratio - C .94					.68					.26		
Total G/C Ratio - D .82					.60					.22		
Total G/C Ratio - E .77					.57					.20		

8 Sec. Amber/.06 A/C - C = 134 Min. Signal Cycle Sec.
8 Sec. Amber/.18 A/C - D = 45 Min. Signal Cycle Sec.
8 Sec. Amber/.23 A/C - E = 35 Min. Signal Cycle Sec.

CONTROL MEASURES: ____ Signal Cycle Sec.

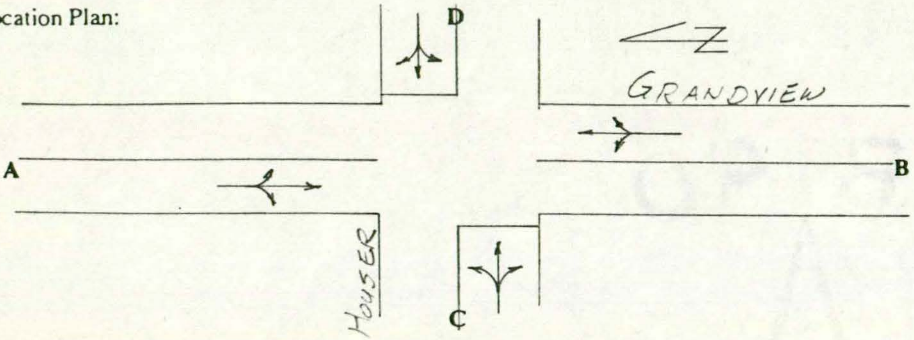
A/C Ratio							.12			.12		
G/C Ratio Used							.10			.10		
Green Interval - Sec.							.09			.09		
Auxiliary Lane* Length - Desirable					.68							
Auxiliary Lane Length - Minimum												

REMARKS:

Unsignalized Intersection Capacity Calculation Form

Intersection: HOUSER + GRANDVIEW

Location Plan:



Counts:
Date: 7-7-80
Day: ______
Time: ______
Control: ______
Prevailing Speed: 30

Hourly Demand Traffic Volumes from 4:15 to 5:15 p m

Approach	A			B			C			D		
Movement	A_L	A_T	A_R	B_L	B_T	B_R	C_L	C_T	C_R	D_L	D_T	D_R
Volume	57	300	52	60	251	8	23	27	34	17	96	60
pch (see Table 1)												

Step 1 — Right Turn from C/D	C_R	D_R
Conflicting Flows = M_H = (from Fig. 1)	½ A_R + A_T = ____ + ____ = 326 vph	½ B_R + B_T = ____ + ____ = 255 vph
Critical Gap from Table 2 T_g =	6 sec	6 sec
Capacity from Fig. 2 =	$M_{No} = M_1$ = 674 pch	$M'_{No} = M'_1$ = 736 pch
Demand =	C_R = ____ pch	D_R = ____ pch
Capacity Used =	100 (C_R/M_1) = 5 %	100 (D_R/M'_1) = 9 %
Impedance Factor from Fig. 3 =	P_1 = .96	P'_1 = .94
____ Shared Lane – See Step 3		
____ No Shared Lane – Available Reserve	$M_1 - C_R$ = 637 pch	$M'_1 - D_R$ = 670 pch
Delay & Level of Service (Table 3)	____ [ ]	____ [ ]

Step 2 — Left Turn from B/A	B_L	A_L
Conflicting Flows = M_H = (from Fig. 1)	A_R + A_T = ____ + ____ = 352 vph	B_R + B_T = - + ____ = 259 vph
Critical Gap from Table 2 T_g =	5 sec	5 sec
Capacity from Fig. 2 =	$M_{No} = M_2$ = 838 pch	$M'_{No} = M'_2$ = 923 pch
Demand =	B_L = ____ pch	A_L = ____ pch
Capacity Used =	100 (B_L/M_2) = 8 %	100 (A_L/M'_2) = 7 %
Impedance Factor from Fig. 3 =	P_2 = .95	P'_2 = .96
Available Reserve =	$M_2 - B_L$ = 772 pch	$M'_2 - A_L$ = 860 pch
Delay & Level of Service (Table 3)	____ [A]	____ [A]

Step 3 — Thru Movement from C/D	C_T	D_T
Conflicting Flows = M_H = (from Fig. 1)	½A_R + A_T + A_L + B_L + B_T + B_R = __ + __ + __ + __ + __ + __	½B_R + B_T + B_L + A_L + A_T + A_R = __ + __ + __ + __ + __ + __
(M_T & M'_T are used in Step 4)	$M_H = M_T$ = 714 vph	$M_H = M'_T$ = 736 vph
Critical Gap from Table 2 T_g =	7 sec	7 sec
Capacity from Fig. 2 =	M_{No} = ____ pch	M'_{No} = ____ pch
Adjust for Impedance	$M_{No} \times P_2 \times P'_2 = M_3$ = 275 pch	$M'_{No} \times P'_2 \times P_2 = M'_3$ = 267 pch
Demand =	C_T = ____ pch	D_T = ____ pch
Capacity Used =	100 (C_T/M_3) = 11 %	100 (D_T/M'_3) = 40 %
Impedance Factor from Fig. 3	P_3 = .93	P'_3 = .68

Unsignalized Intersection Capacity Calculation Form (continued)

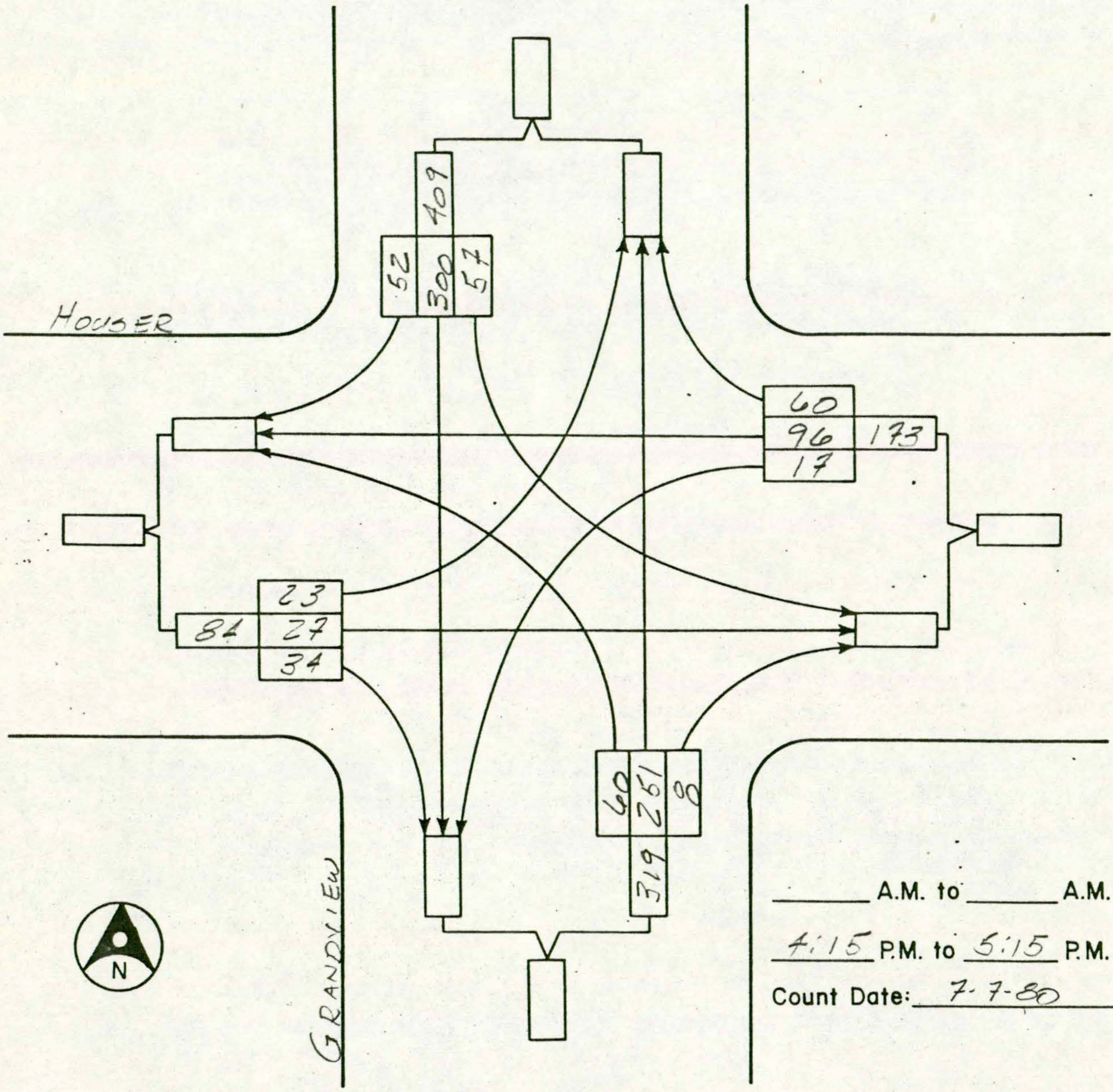
Step 3 (Continued)	C_T ↑	D_T ↓
____ No Shared Lane Available Reserve = Delay & Level of Service (Table 3)	 $M_3 - C_T =$ ____ pch ____ [ ]	 $M'_3 - D_T =$ ____ pch ____ [ ]
____ Shared Lane with Left Turn See Step 4		
Shared Lane Demand = ____ Shared Lane with Right Turn Capacity of Shared Lane = Available Reserve = Delay & Level of Service (Table 3)	$C_R + C_T = C_{RT} =$ ____ pch $M_{13} = \frac{(C_R + C_T)}{(C_R/M_1) + (C_T/M_3)}$ $M_{13} =$ ____ pch $M_{13} - C_{RT} =$ ____ pch ____ [ ]	$D_R + D_T = D_{RT} =$ ____ pch $M'_{13} = \frac{(D_R + D_T)}{(D_R/M'_1) + (D_T/M'_3)}$ $M'_{13} =$ ____ pch $M'_{13} - D_{RT} =$ ____ pch ____ [ ]

Step 4 Left Turn from C/D	C_L ↰	D_L ↳
Conflicting Flows = M_H = (M_T & M'_T were calculated in Step 3) Critical Gap from Table 2 T_g = Capacity from Fig. 2 = Adjust for Impedance	M_T + D_T + D_R = ____ + ____ + ____ = 886 vph 7.5 sec $M_{No} =$ ____ pch $M_{No} \times P_2 \times P'_2 \times P'_1 \times P'_3 = M_4$ $M_4 =$ 113 pch	M'_T + C_T + C_R = ____ + ____ + ____ = 803 vph 7.5 sec $M'_{No} =$ ____ pch $M'_{No} \times P'_2 \times P_2 \times P_1 \times P_3 = M'_4$ $M'_4 =$ 184 pch
____ No Shared Lane Demand = Available Reserve = Delay & Level of Service (Table 3)	$C_L =$ ____ pch $M_4 - C_L =$ ____ pch ____ [ ]	$D_L =$ ____ pch $M'_4 - D_L =$ ____ pch ____ [ ]
Shared Lane Demand = ____ Shared Lane with Thru Capacity of Shared Lane = Available Reserve = Delay & Level of Service (Table 3)	$C_T + C_L = C_{TL} =$ ____ pch $M_{34} = \frac{(C_T + C_L)}{(C_T/M_3) + (C_L/M_4)}$ $M_{34} =$ ____ pch $M_{34} - C_{TL} =$ ____ pch ____ [ ]	$D_T + D_L = D_{TL} =$ ____ pch $M'_{34} = \frac{D_T + D_L}{(D_T/M'_3) + (D_L/M'_4)}$ $M'_{34} =$ ____ pch $M'_{34} - D_{TL} =$ ____ pch ____ [ ]
Shared Lane Demand = ____ Shared Lane with Thru & Right Capacity of Shared Lane = Available Reserve = Delay & Level of Service (Table 3)	$C_R + C_T + C_L = C_{RTL} =$ ____ pch $M_{134} = \frac{C_R + C_T + C_L}{(C_R/M_1) + (C_T/M_3) + (C_L/M_4)}$ $M_{134} =$ 242 pch $M_{134} - C_{RTL} =$ 150 pch ____ [D]	$D_R + D_T + D_L = D_{RTL} =$ ____ pch $M'_{134} = \frac{D_R + D_T + D_L}{(D_R/M'_1) + (D_T/M'_3) + (D_L/M'_4)}$ $M'_{134} =$ 324 pch $M'_{134} - D_{RTL} =$ 133 pch ____ [D]

Overall Evaluation ______________________________

PEAK HOUR TRAFFIC FLOW DIAGRAM

INTERSECTION Houser + Grandview DATE 7-22-80



_____ A.M. to _____ A.M.

4:15 P.M. to 5:15 P.M.

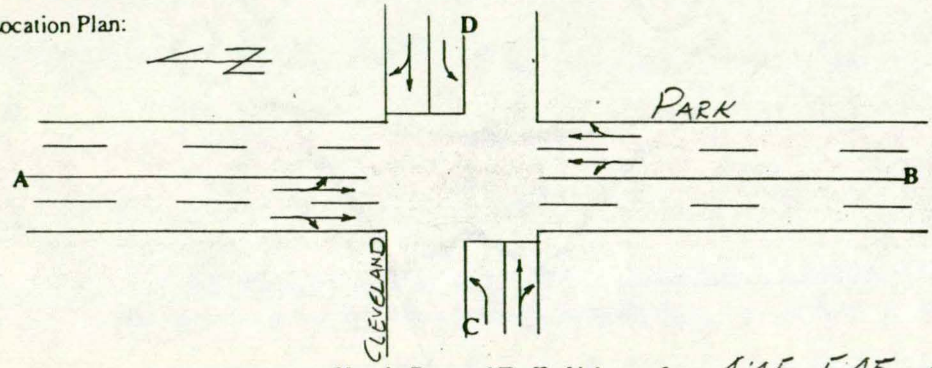
Count Date: 7-7-80

REMARKS

Unsignalized Intersection Capacity Calculation Form

Intersection: PARK + CLEVELAND — 7-23-80

Location Plan:



Counts:
Date: 7-7-80
Day:
Time:
Control:
Prevailing Speed: 45

Hourly Demand Traffic Volumes from 4:45 to 5:45 p m

Approach	A			B			C			D		
Movement	A_L	A_T	A_R	B_L	B_T	B_R	C_L	C_T	C_R	D_L	D_T	D_R
Volume	3	515	24	78	515	66	19	2	33	38	3	21
pch (see Table 1)												

Step 1 — Right Turn from C/D	C_R	D_R
Conflicting Flows = M_H = (from Fig. 1)	$\frac{1}{2} A_R + A_T$ = ___ + ___ = 270 vph	$\frac{1}{2} B_R + B_T$ = ___ + ___ = 291 vph
Critical Gap from Table 2 T_g =	6.5 sec	6.5 sec
Capacity from Fig. 2 =	$M_{No} = M_1$ = 654 pch	$M'_{No} = M'_1$ = 637 pch
Demand =	C_R = ___ pch	D_R = ___ pch
Capacity Used =	$100 (C_R/M_1)$ = 6 %	$100 (D_R/M'_1)$ = 4 %
Impedance Factor from Fig. 3 =	P_1 = .96	P'_1 = .97
C+D Shared Lane — See Step 3		
___ No Shared Lane — Available Reserve	$M_1 - C_R$ = ___ pch	$M'_1 - D_R$ = ___ pch
Delay & Level of Service (Table 3)		

Step 2 — Left Turn from B/A	B_L	A_L
Conflicting Flows = M_H = (from Fig. 1)	$A_R + A_T$ = ___ + ___ = 539 vph	$B_R + B_T$ = ___ + ___ = 581 vph
Critical Gap from Table 2 T_g =	5 sec	5 sec
Capacity from Fig. 2 =	$M_{No} = M_2$ = 679 pch	$M'_{No} = M'_2$ = 645 pch
Demand =	B_L = ___ pch	A_L = ___ pch
Capacity Used =	$100 (B_L/M_2)$ = 13 %	$100 (A_L/M'_2)$ = 0 %
Impedance Factor from Fig. 3 =	P_2 = .92	P'_2 = 1
Available Reserve =	$M_2 - B_L$ = 593 pch	$M'_2 - A_L$ = 642 pch
Delay & Level of Service (Table 3)	A	A

Step 3 — Thru Movement from C/D	C_T	D_T
Conflicting Flows = M_H = (from Fig. 1)	$\frac{1}{2}A_R + A_T + A_L + B_L + B_T + B_R$ = ___ + ___ + ___ + ___ + ___ + ___	$\frac{1}{2}B_R + B_T + B_L + A_L + A_T + A_R$ = ___ + ___ + ___ + ___ + ___ + ___
(M_T & M'_T are used in Step 4)	$M_H = M_T$ = 1197 vph	$M_H = M'_T$ = 1176 vph
Critical Gap from Table 2 T_g =	7.5 sec	7.5 sec
Capacity from Fig. 2 =	M_{No} = ___ pch	M'_{No} = ___ pch
Adjust for Impedance	$M_{No} \times P_2 \times P'_2 = M_3$ = 102 pch	$M'_{No} \times P'_2 \times P_2 = M'_3$ = 106 pch
Demand =	C_T = ___ pch	D_T = ___ pch
Capacity Used =	$100 (C_T/M_3)$ = 2 %	$100 (D_T/M'_3)$ = 3 %
Impedance Factor from Fig. 3	P_3 = .98	P'_3 = .98

Unsignalized Intersection Capacity Calculation Form (continued)

Step 3 (Continued)	C_T ↑	D_T ↓
____ No Shared Lane Available Reserve = Delay & Level of Service (Table 3)	$M_3 - C_T =$ ____ pch ____ [ ]	$M'_3 - D_T =$ ____ pch ____ [ ]
____ Shared Lane with Left Turn See Step 4		
Shared Lane Demand = C+D Shared Lane with Right Turn Capacity of Shared Lane = Available Reserve = Delay & Level of Service (Table 3)	$C_R + C_T = C_{RT} =$ ____ pch $M_{13} = \frac{(C_R + C_T)}{(C_R/M_1) + (C_T/M_3)}$ $M_{13} =$ 475 pch $M_{13} - C_{RT} =$ 437 pch ____ [A]	$D_R + D_T = D_{RT} =$ ____ pch $M'_{13} = \frac{(D_R + D_T)}{(D_R/M'_1) + (D_T/M'_3)}$ $M'_{13} =$ 371 pch $M'_{13} - D_{RT} =$ 345 pch ____ [B]
Step 4 **Left Turn from C/D**	C_L ↰	D_L ↳
Conflicting Flows = M_H = (M_T & M'_T were calculated in Step 3) Critical Gap from Table 2 T_g = Capacity from Fig. 2 = Adjust for Impedance	$M_T + D_T + D_R =$ ____ + ____ + ____ = 1223 vph 8 sec $M_{No} =$ ____ pch $M_{No} \times P_2 \times P'_2 \times P'_1 \times P'_3 = M_4$ $M_4 =$ 75 pch	$M'_T + C_T + C_R =$ ____ + ____ + ____ = 1214 vph 8 sec $M'_{No} =$ ____ pch $M'_{No} \times P'_2 \times P_2 \times P_1 \times P_3 = M'_4$ $M'_4 =$ 75 pch
C+D No Shared Lane Demand = Available Reserve = Delay & Level of Service (Table 3)	$C_L =$ ____ pch $M_4 - C_L =$ 54 pch ____ [E]	$D_L =$ ____ pch $M'_4 - D_L =$ 33 pch ____ [E]
Shared Lane Demand = ____ Shared Lane with Thru Capacity of Shared Lane = Available Reserve = Delay & Level of Service (Table 3)	$C_T + C_L = C_{TL} =$ ____ pch $M_{34} = \frac{(C_T + C_L)}{(C_T/M_3) + (C_L/M_4)}$ $M_{34} =$ ____ pch $M_{34} - C_{TL} =$ ____ pch ____ [ ]	$D_T + D_L = D_{TL} =$ ____ pch $M'_{34} = \frac{D_T + D_L}{(D_T/M'_3) + (D_L/M'_4)}$ $M'_{34} =$ ____ pch $M'_{84} - D_{TL} =$ ____ pch ____ [ ]
Shared Lane Demand = ____ Shared Lane with Thru & Right Capacity of Shared Lane = Available Reserve = Delay & Level of Service (Table 3)	$C_R + C_T + C_L = C_{RTL} =$ ____ pch $M_{134} = \frac{C_R + C_T + C_L}{(C_R/M_1) + (C_T/M_3) + (C_L/M_4)}$ $M_{134} =$ ____ pch $M_{134} - C_{RTL} =$ ____ pch ____ [ ]	$D_R + D_T + D_L = D_{RTL} =$ ____ pch $M'_{134} = \frac{D_R + D_T + D_L}{(D_R/M'_1) + (D_T/M'_3) + (D_L/M'_4)}$ $M'_{134} =$ ____ pch $M'_{134} - D_{RTL} =$ ____ pch ____ [ ]

Overall Evaluation ____

____

____

INTERSECTION CAPACITY WORKSHEET

CITY: Muscatine STATE: Iowa

INTERSECTION: Park + Cleveland DATE: 7-23-80

GENERAL DESCRIPTION: PM Peak Hour 1980 Year
2 Phases 8 Amber - Sec.

Street	Park						Cleveland					
Approach	N			S			W			E		
Movements	L	SR		L	SR		L	SR		L	SR	
Volume	3	539		78	581		19	35		38	24	
Volume Opposing Left Turns	581			539			3			2		

PHYSICAL CONDITIONS: ______ Existing X Proposed

Width of Approach	12	24		12	24		12	12		10	10	
Parking		–			–			–			–	
One - Way or Two - Way		2			2			2			2	

ENVIRONMENTAL CONDITIONS: CBD Type of Location
50 Metro Area Population (1,000's)

Peak Hour Factor												
Combined Adjustment Factor		.85			.85			.85			.85	

TRAFFIC CHARACTERISTICS:

		24			46			33			21	
Percent Trucks	5	5		5	5		5	5		5	5	
Percent Right Turns		4			11			94			88	
Percent Left Turns		–			–			–			–	

CALCULATIONS:

Phasing	A	A		A	A		B	B		B	B	
Charts Used	17	4		17	4		17	4		17	4	
Equivalent Chart Volume												
Max. Signal Cycle - Sec. (Left Turn)	1800			69			284			142		
G/C Ratio Required - C	.51	.27		.54	.30		.02	.04		.03	.03	
G/C Ratio Required - D	.43	.24		.45	.26		.02	.04		.03	.03	
G/C Ratio Required - E	.39	.23		.42	.25		.02	.03		.02	.03	
Total G/C Ratio - C .58				.51				.04				
Total G/C Ratio - D												
Total G/C Ratio - E												

8 Sec. Amber/ .42 A/C - C = 20 Min. Signal Cycle Sec.

Sec. Amber/ A/C - D = Min. Signal Cycle Sec.

Sec. Amber/ A/C - E = Min. Signal Cycle Sec.

CONTROL MEASURES: ______ Signal Cycle Sec.

A/C Ratio												
G/C Ratio Used												
Green Interval - Sec.												
Auxiliary Lane Length - Desirable												
Auxiliary Lane Length - Minimum												

REMARKS:

B/C ANALYSIS WORKSHEET

Evaluation No:

Project No:

Date/Evaluator:

1. Initial Implementation Cost, I: $__________

2. Annual Operating and Maintenance Costs Before Project Implementation: $__________

3. Annual Operating and Maintenance Cost After Project Implementation: $__________

4. Net Annual Operating and Maintenance Costs, K (3-2): $__________

5. Annual Safety Benefits in Number of Accidents Prevented:

Severity	Expected - Actual = Annual Benefit
a) Fatal Accidents (Fatalities)	
b) Injury Accidents (Injuries)	
c) PDO Accidents	

6. Accident Cost Values (Source__________):

Severity	Cost
a) Fatal Accident (Fatality)	$
b) Injury Accident (Injury)	$
c) PDO Accident	$

7. Annual Safety Benefits in Dollars Saved, $\overline{B}$:

5a) x 6a) =

5b) x 6b) =

5c) x 6c) =

Total = $

Figure S-12 Sample B/C Analysis Work Sheet

8. Services life, n: ________________ yrs

9. Salvage Value, T: $________________

10. Interest Rate, i: ________ % = 0.________

---

11. EUAC Calculation:

CR_n^i = ________________

SF_n^i = ________________

EUAC = $I\ (CR_n^i) + K - T\ (SF_n^i)$

12. EUAB Calculation:

EUAB = $\overline{B}$

=

13. B/C = EUAB/EUAC =

---

14. PWOC Calculation:

PW_n^i =

SPW_n^i =

PWOC = $I + K\ (SPW_n^i) - T\ (PW_n^i)$

15. PWOB Calculation:

PWOB = $\overline{B}(SPW_n^i)$

16. B/C = PWOB/PWOC =

Figure S-12 Sample B/C Analysis Work Sheet (Cont'd.)