CITY OF DOVER
TRANSPORTATION COMPONENT - MASTER PLAN

FINAL REPORT
TECHNICAL MEMORANDUM NO. 3
LITTLEWORTH ROAD (N.H. ROUTE 9)
CORRIDOR STUDY

Prepared for:

THE CITY OF DOVER, N.H.
DEPARTMENT OF PLANNING
AND COMMUNITY DEVELOPMENT

JULY, 1988

by:

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I. Introduction

A. Background

In January, 1988, the City of Dover retained the consulting firms of Storch Associates of Manchester, New Hampshire and Fredette Associates, Inc. of Salem, New Hampshire to provide technical input into the Transportation Component of the 1988 Master Plan. This technical input may be expressed in the following task objectives:

Task 1. Identify existing conditions and recommend improvements for twelve problem intersection locations.

Task 2. Investigate options for improving traffic flow in the downtown Central Avenue Corridor, including land widening, one-way circulation pattern, or new bypass roadway.

Task 3. Identify long range highway improvement needs for the Route 9 Corridor in the City of Dover per major industrial rezoning proposed in the Master Plan.

This Technical Memorandum No. 3 - Littleworth Road (N.H. Route 9) Corridor Study documents the results of Task 3 of the Transportation Component.

B. Methodology

The purpose of the report is to examine the long range traffic impacts of the proposed future zoning of lands located along the Route 9 Corridor west of Route 155 in the City of Dover. The study area is outlined on Figure 1.

In the 1985 report to the Dover Planning Department, the Strafford Regional Planning Commission presented the following comments on the Route 9 Corridor that remain relevant to date:

> "This corridor is one of the major industrial areas within the City. Two industrial parks are presently located within it, along with the General Electric manufacturing plant. Housing also exists in the corridor. It is primarily located on Littleworth Road, Bellamy Avenue, Old Littleworth Road and Columbus Avenue.

> In most urban areas, traffic peaks over an extended period of time. Also, since traffic usually originates from numerous locations it is spread over an entire road system and does not unduly congest one particular area. Traffic in an industrial area however, has a different pattern. It usually intensifies during short periods of time due to shift changes in the work force, in one particular corridor. The result is often brief periods of traffic congestion.
>
> Currently, the Littleworth traffic corridor is experiencing traffic congestion common to many industrial areas: traffic tie-ups during late afternoon shift changes. This problem is made even more difficult due to the fact that other individuals are also returning to their homes, located along the Littleworth traffic corridor, at approximately the same time.
>
> It is presently anticipated that significant economic development will occur in Dover over the next several years. Since some of this economic expansion could result in the location of new industrial facilities in the Littleworth traffic corridor, a great deal of public attention has been focused on the development of land in the general area of Littleworth Road.
>
> The purpose of this analysis is to provide Dover City officials with a more accurate understanding of traffic conditions within the Littleworth traffic corridor. However, as previously noted, additional information about traffic in the area is needed before a solution to present traffic problems can be designed."

This technical memorandum is an extension of the 1985 study and includes a review of existing traffic conditions, the projection of future traffic volumes generated by the proposed land use plan, the evaluation of the impacts of those projected volumes on the future roadway system, and the recommendation of roadway improvements as necessary to accommodate future traffic demands on the corridor.

The study process has consisted of the following steps:

- On-site investigations of existing roadway and traffic control features along the corridor.
- Review of the 1988 automatic recorder traffic counts on Route 9 (Littleworth Road), Bellamy Road and Cosby Road.
- Review of 1988 manual peak hour turning movement counts taken at the following intersections:

  Route 9/Route 155
  Route 9/Industrial Park Drive (East)
  Route 9/Industrial Park Drive (West)

- Estimation of the future (2008) traffic volumes that would be generated by both the present and proposed land use plan.
- Determination of the future traffic levels of service along the Route 9 corridor, in particular at the critical intersection of Route 9 and Route 155.

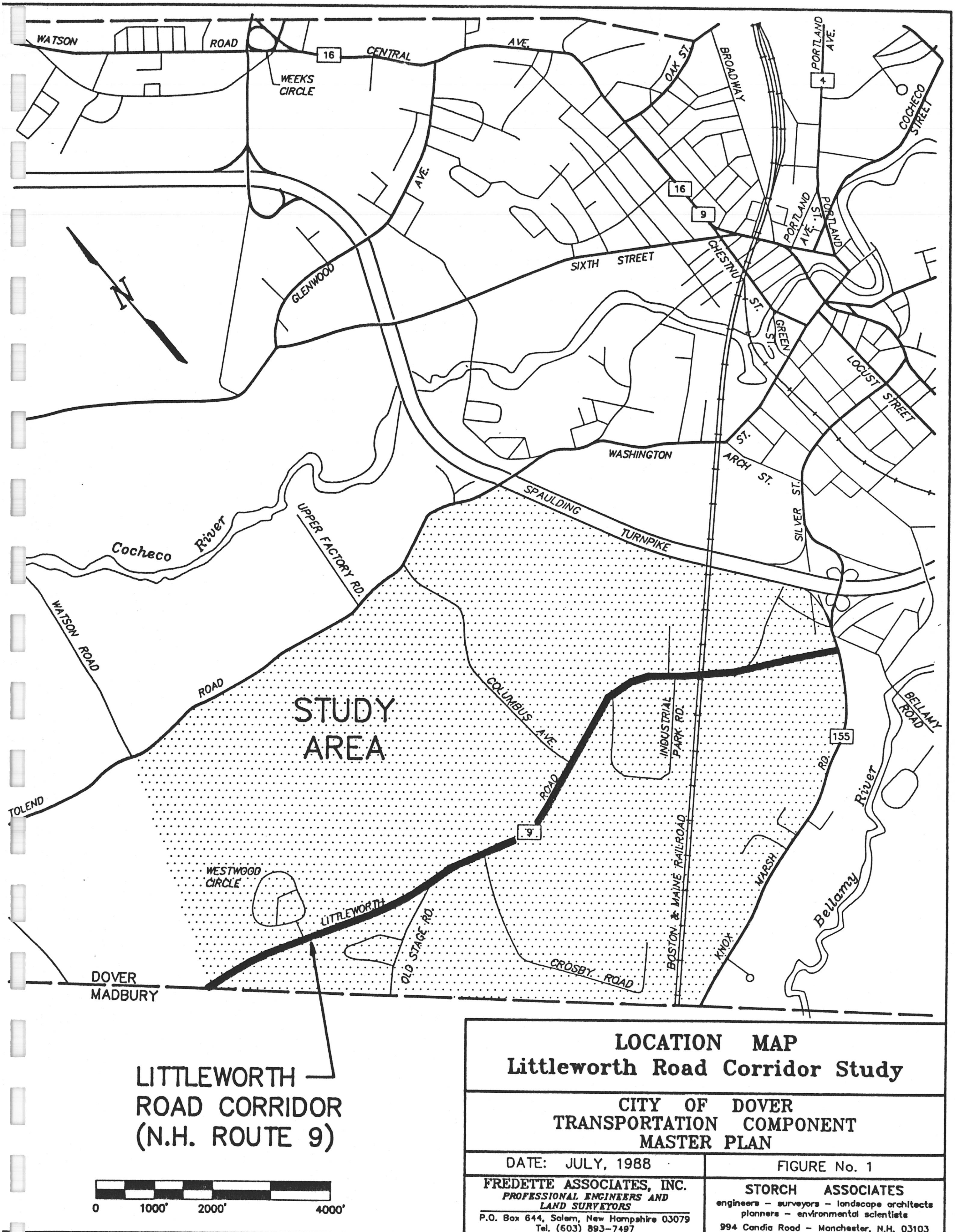
- Evaluation of the overall impact of the land use plan on the transportation system.
- Recommendation of improvements to the highway system to accommodate future corridor traffic demands.

The preliminary findings and recommendations of this study task were presented to the City of Dover Transportation Committee on June 29, 1988. This Final Report reflects the input provided by the Committee at that time.

C. Acknowledgements

We would like to acknowledge the advice and assistance provided by the following departments and organizations:

- City of Dover Department of Planning and Community Development.
- City of Dover Department of Public Works.
- City of Dover Department of Public Safety.
- City of Dover Transportation Committee and involved citizens.
- Strafford Regional Planning Commission.
- New Hampshire Department of Transportation, Bureau of Transportation Planning.



LOCATION MAP
Littleworth Road Corridor Study

CITY OF DOVER
TRANSPORTATION COMPONENT
MASTER PLAN

DATE: JULY, 1988

FIGURE No. 1

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II. Existing Conditions

A. Physical Roadway Conditions

Route 9 is a two lane highway providing connection between Route 155 in the City of Dover to points west in the Town of Madbury and the City of Rochester to the north via the Route 125 corridor. The posted speed limit in the study area is 35 mph east of Columbus Avenue and 40 mph to the west. The present pavement width is 24 feet with 4 foot treated shoulders within a basic 66 foot right-of-way.

Route 155 is a two lane highway providing connection to the Spaulding Turnpike and Downtown Dover to the north and points south and west through the adjacent Town of Madbury. Approximately 500 feet south of its interchange with the Spaulding Turnpike, Route 155 intersects with Route 9 at a signalized "T" intersection.

The general road layout and traffic control in the project area is illustrated on Figure 2.

The following basic lane approaches presently exist at the intersection of Route 9 and Route 155:

Northbound Route 155	1 Exclusive Left Turn Lane 1 Thru Lane
Southbound Route 155	2 Thru Lanes (Second lane presently under construction) 1 Free Flow Right Turn Lane
Eastbound Route 9	1 Exclusive Left Turn Lane 1 Exclusive Right Turn Lane

Further descriptions of existing road conditions are contained in a 1985 report prepared by the Strafford Regional Planning Commission and are included in Appendix A of this report.

B. Traffic Volumes and Operations

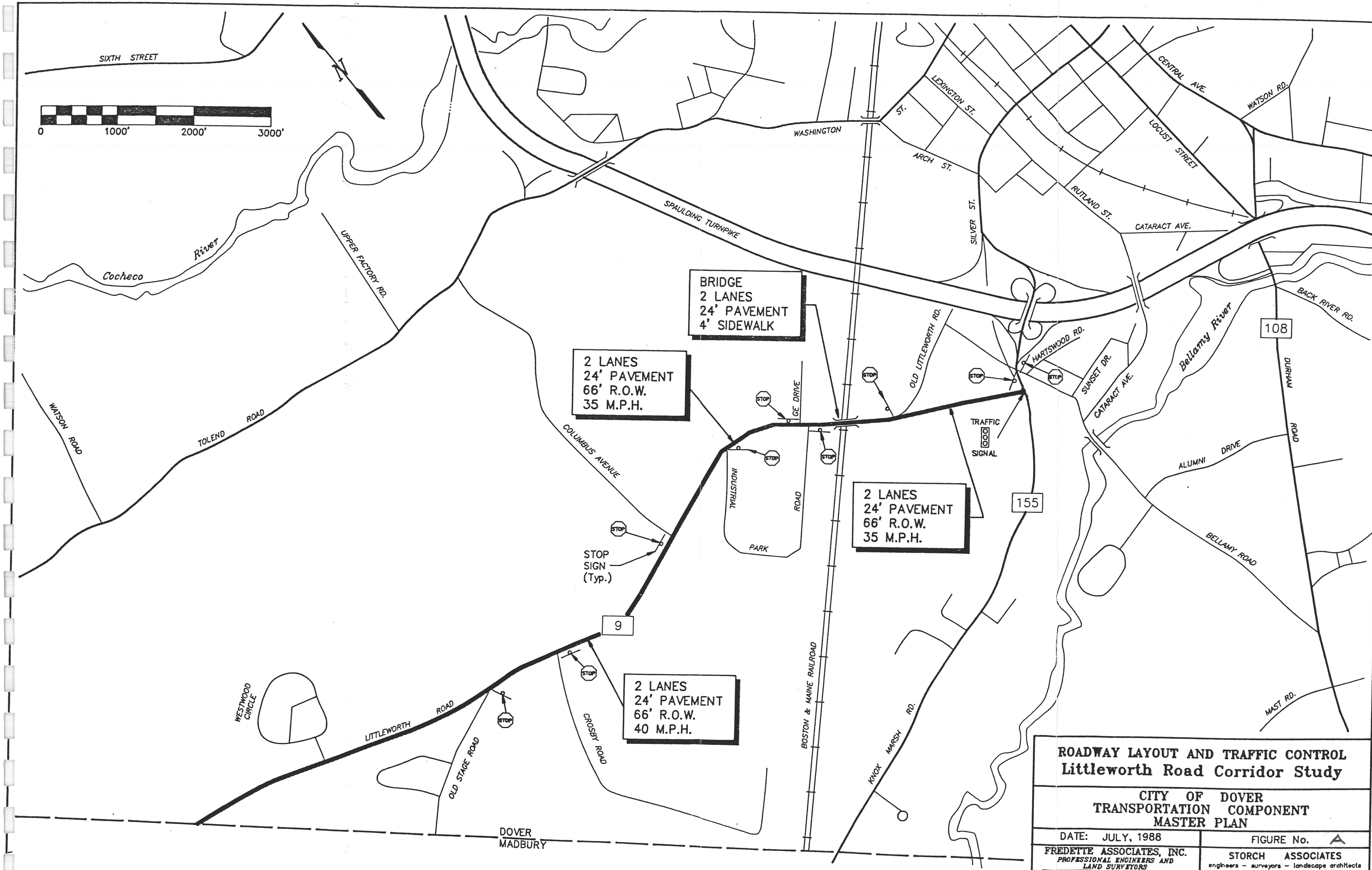
Automatic recorder traffic counts were conducted in April, 1988 for Route 9 near Route 155, Bellamy Road near Route 155 and Crosby Road near Route 9.

Weekday turning movement counts were conducted from 3:30 to 5:30 PM during the month of April, 1988 at the following intersections:

Route 9/Route 155
Route 9/Industrial Park Drive (East)
Route 9/Industrial Park Drive (West)

Summary results of the traffic counts are included in Appendix B.

The resultant 1988 Annual Average Weekday Traffic and PM Peak Hour design volumes were estimated utilizing monthly automatic traffic recorder reports published by the New Hampshire Department of Transportation for the permanent counting station along Route 16 in Dover (refer to Appendix B of Technical Memorandum No. 1) and are illustrated on Figure 3.



ROADWAY LAYOUT AND TRAFFIC CONTROL
Littleworth Road Corridor Study

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FIGURE No. A

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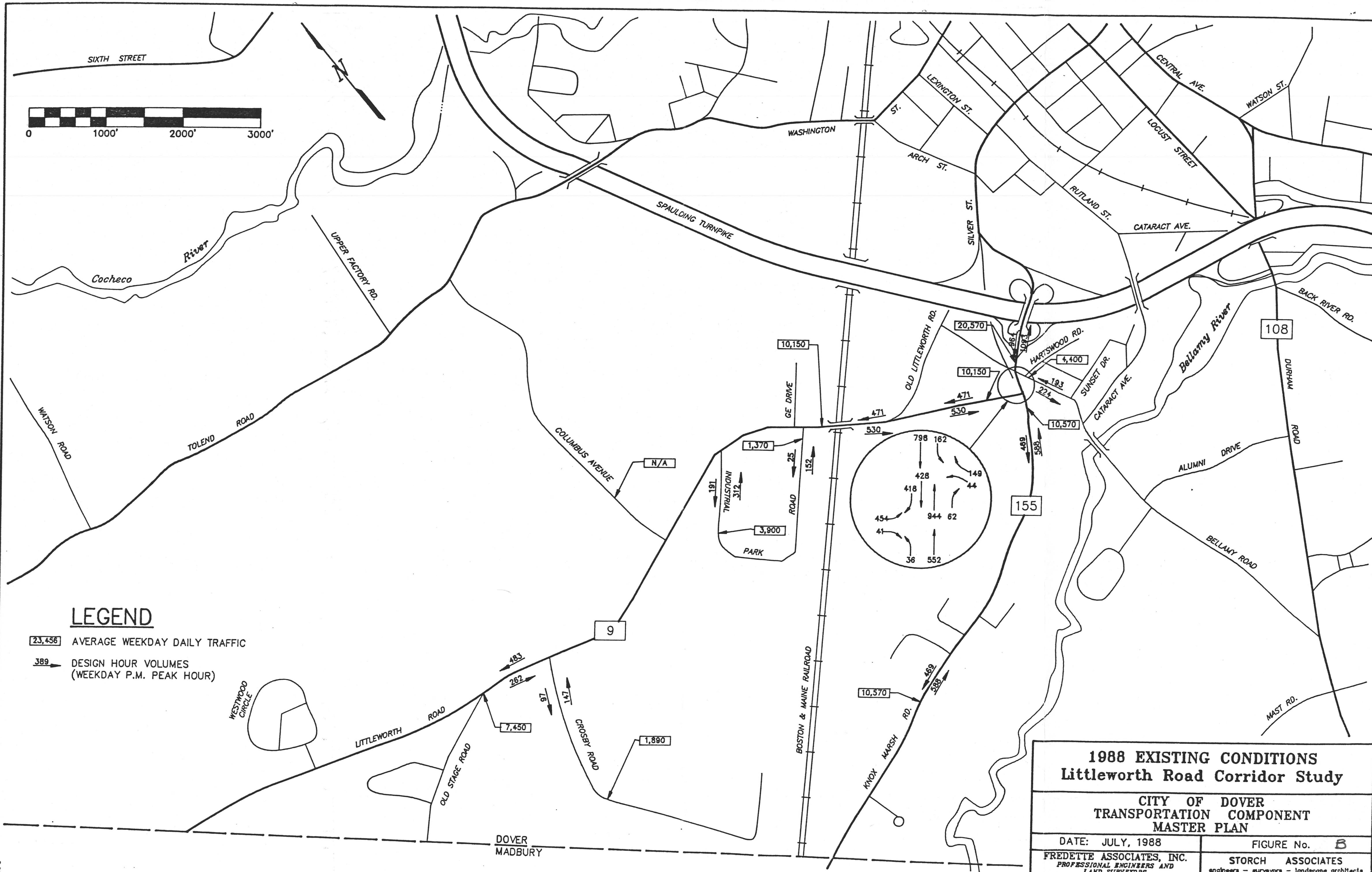

1988 EXISTING CONDITIONS
Littleworth Road Corridor Study

CITY OF DOVER
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FIGURE No. B

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III. Projected Traffic Conditions

A. Proposed Land Use Plan

The proposed corridor rezoning plan is illustrated in Figure 4. Four zonal areas are located on the corridor:

Area A. Presently zoned industrial, this large area extends on both sides of Route 9 and includes the present industrial sites along Crosby Road, Industrial Park Road, and the General Electric site. 300 undeveloped acres are available in this area.

Area B. This proposed industrial zone includes 232 acres and is situated just north of Route 9 and west of Columbus Avenue.

Area C. This proposed industrial zone includes 180 acres and is situated just east of Columbus Avenue, extending from Route 9 to Tolend Road.

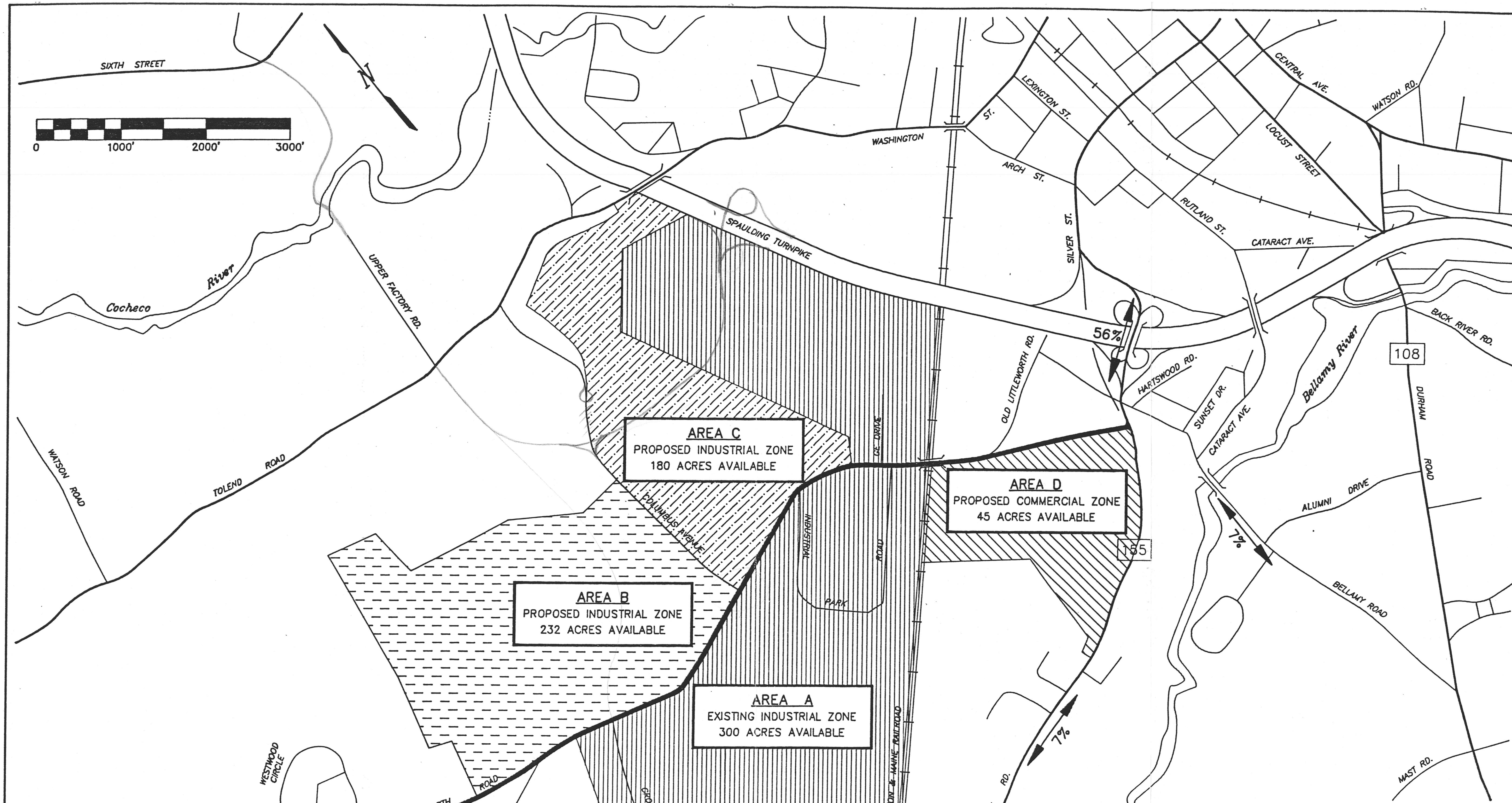
Area D. This proposed commercial zone includes 45 acres along the southwest corner of the Route 9/Route 155 intersection.

B. Traffic Generation

The estimate of increased traffic that would be generated by the additional future development along Route 9 is summarized in Table 1. Industrial zoned areas are assumed to be developed with light industrial facilities. The commercial zoned area is assumed to be developed with a shopping center development of approximately 650,000 square feet.

General estimates of vehicle trip generation have been developed utilizing trip generation rates published by the Institute of Transportation Engineers, "Trip Generation", 1982 (refer to Appendix C). Available industrial gross acres were reduced by 33 percent to account for existing wetland restrictions and other potential site restrictions. In addition, peak hour trip generation rates were utilized with consideration of staggered work shifts for the large industrial trip generators in the area (presently practiced by General Electric manufacturing plant).

In determining the number of additional vehicles that would be generated by the proposed commercial zone, it has been assumed that the majority of the users would be (1) residents of the immediate area or, (2) people who are currently travelling on Route 9 or Route 155. Therefore only 40 percent of the traffic generated by future commercial development has been added to the traffic system.



PROPOSED AREAS OF REZONING
Littleworth Road Corridor Study

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FIGURE No. D

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TABLE 1

CORRIDOR TRIP GENERATION

Proposed Development	gross	Net Devel. Area	Daily Factor	Daily Trips (AADT)	PM Factor In - Out	PM Trips In - Out
Existing Industrial (Area A)	300	200 Acres	60	12000	3.5 6.5	700 1300
Proposed Industrial (Area B)	232	155 Acres	60	9300	3.5 6.5	540 1010
Proposed Industrial (Area C)	180	120 Acres	60	7200	3.5 6.5	420 780
Proposed Commercial (Area D)		650,000 G.S.F.	40	26000	2.0 2.0	1300 1300

C. Trip Distribution and Assignment

In forecasting traffic growth, trip distribution refers to the origin and destination pattern of the trips that begin or return to the proposed developments. Trip distribution is dependent on the geographical locations of population, employment and other attractions.

Traffic assignment refers to the determination of which route will be used in travelling from the trip origin to its destination. Traffic assignment depends primarily on the travel time using available alternative routes.

For purposes of analysis, it is assumed that the additional generated trips entering and leaving the proposed industrial development will travel in each direction by a volume proportional to the percentage distribution shown on Figure 4. This distribution is based on measurements of directional flow of existing industrial traffic at the Industrial Park and Crosby Road intersections and existing directional traffic flow at the intersection of Route 9 and Route 155.

D. Projected Background Traffic Volumes

Existing background traffic volumes (excluding existing local industrial traffic volumes) were projected to a 20 year planning horizon (Year 2008) by assuming a 2 percent increase per year for traffic along Route 9 and Route 155 in the project area. This is a conservatively low growth assumption for the non-industrial traffic base as the documented historical growth in the area (NHDOT count station on Dover Point Road) indicates overall peak hour growth of 3.5 percent per year.

Addition to these volumes of present local industrial traffic and of projected local traffic growth for either the presently zoned corridor or the proposed corridor rezoning results in an effective minimum annual corridor growth of 3.8 percent or 6.6 percent, respectively, over the 20 year study period.

E. Road Network Improvements Scenarios

Preliminary analysis of the projected volumes utilizing the study area roadway network indicated that the capacity of the Route 9/Route 155 intersection would define the upper limits of Route 9 corridor growth potential under acceptable traffic operations. For the purpose of this analysis, a full build out of this intersection (maximum feasible roadway widening) includes the following basic lane approaches along with the planned relocation of Bellamy Road to the east to align with Route 9 at its new intersection with Route 155:

Northbound Route 155	1 Exclusive Left Turn Lane 2 Thru Lanes
Southbound Route 155	1 Exclusive Left Turn Lane 2 Thru Lanes
Eastbound Route 9	2 Exclusive Left Turn Lanes 1 Thru Lane
Westbound Route 9	1 Exclusive Left Turn Lane 1 Thru Lane 1 Right Turn Lane

It is anticipated that the above noted widening of Route 155 will require extension into or through the existing Spaulding Turnpike Interchange area. The projected 2008 traffic volumes along the Route 9 Corridor for the present and proposed zoning also indicate the need for a minimum 4 lane facility, including turning lanes at major intersections east of Crosby Road.

In order to supplement the projected capacity requirements at the Route 9/Route 155 intersection, the re-alignment of Route 9 via a new connector roadway to connect into a new interchange with the Spaulding Turnpike as shown on Figure 5, was considered as an optional design scenario. The indicated alignment and configuration of this interchange and approach roadway is for schematic purposes only, although the indicated interchange location allows a reasonable spacing of about one mile to adjacent interchanges at Route 155 and Route 16/Weeks Circle. The estimated cost (in 1988 dollars) of such a facility, exclusive of right-of-way costs,is approximately $5 to $8 million for the interchange and $1.5 to $2.0 million for a four-lane connector roadway.

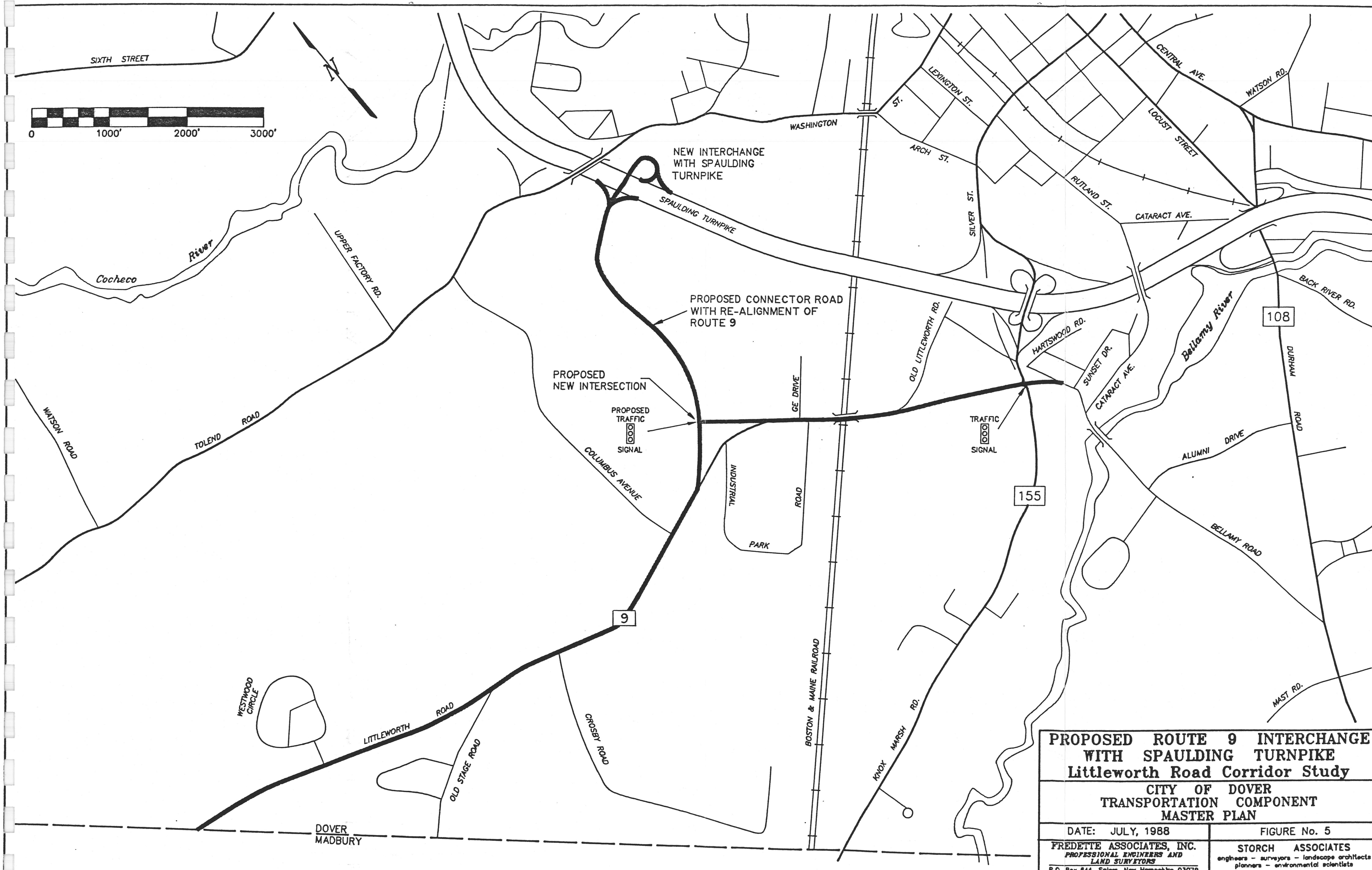
F. Traffic Levels of Service

Level of Service (LOS) is a qualitative measure describing driver satisfaction with a number of factors influencing the degree of traffic congestion. These factors include speed and travel time, traffic interruption, freedom to maneuver, safety, driving comfort and convenience, and delays. There are six levels of service describing traffic flow. The highest is LOS A, describing a free-flow condition. The lowest, LOS F, is described as forced flow, and is characterized by traffic volumes at the roadway capacity and extreme congestion.

LOS C, which is normally utilized for design purposes, describes a stable condition of traffic operation. It has a somewhat restricted movement due to higher traffic volumes, but flow conditions are not objectionable for motorists.

LOS D, which is acceptable for traffic operations in urban environments and during peak hours of traffic flow, reflects a more restricted movement for motorists. Queues and delays may occur during short peaks, but lower demands occur often enough to permit clearance of developing queues, thus preventing excessive backups. LOS E is defined as the actual capacity of the roadway and involves delay to all motorists due to congestion. Levels of Service E and F are generally considered unacceptable.

Level of Service for signalized intersections is defined in terms of average delay per vehicle entering the intersection. Delay is considered a measure of driver discomfort, frustration, fuel consumption and travel time. Table 2 summarizes the criteria for signalized intersection level of service.



PROPOSED ROUTE 9 INTERCHANGE WITH SPAULDING TURNPIKE
Littleworth Road Corridor Study

CITY OF DOVER
TRANSPORTATION COMPONENT
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FIGURE No. 5

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TABLE 2

LEVEL OF SERVICE CRITERIA FOR SIGNALIZED INTERSECTIONS

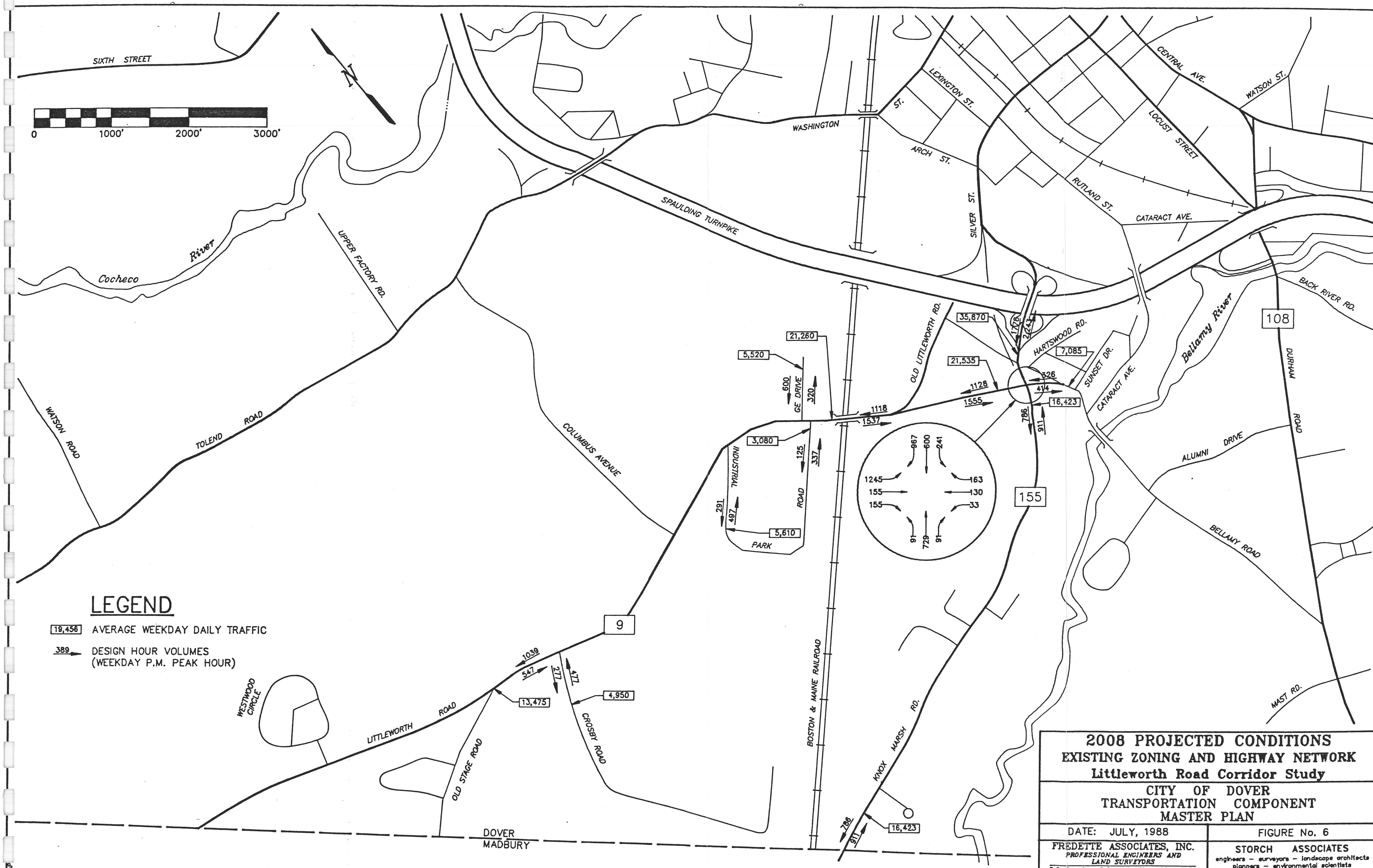
LEVEL OF SERVICE	STOPPED DELAY PER VEHICLE (SEC)
A	5.0
B	5.1 to 15.0
C	15.1 to 25.0
D	25.1 to 40.0
E	40.1 to 60.0
F	Greater than 60.0

SOURCE: 1985 Highway Capacity Manual

Capacity analyses were performed at the critical Route 9/Route 155 intersection for the following long range development scenarios:

- "1988 Conditions" - Based on current traffic volumes utilizing the adjacent roadways under existing conditions. Refer to Figure 3.
- "2008 Conditions - No Rezoning" - Assuming full build out of Route 9/Route 155 intersection only. Refer to Figure 6.
- "2008 Conditions - With Rezoning" - Assuming full build out of Route 9/Route 155 Intersection only. Refer to Figure 7.
- "2008 Conditions - No Rezoning" - Assuming Route 9 Interchange with Spaulding Turnpike and upgrade of Route 9/Route 155 Intersection. Refer to Figure 8.
- "2008 Conditions - With Rezoning" - Assuming Route 9 Interchange with Spaulding Turnpike and upgrade of Route 9/Route 155 Intersection. Refer to Figure 9.

The capacity analyses were conducted using the methodology of the 1985 Highway Capacity Manual and resulting levels of service are summarized in Table 3. Copies of the capacity calculations are included in Appendix D.



2008 PROJECTED CONDITIONS
EXISTING ZONING AND HIGHWAY NETWORK
Littleworth Road Corridor Study

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MASTER PLAN

DATE: JULY, 1988	FIGURE No. 6
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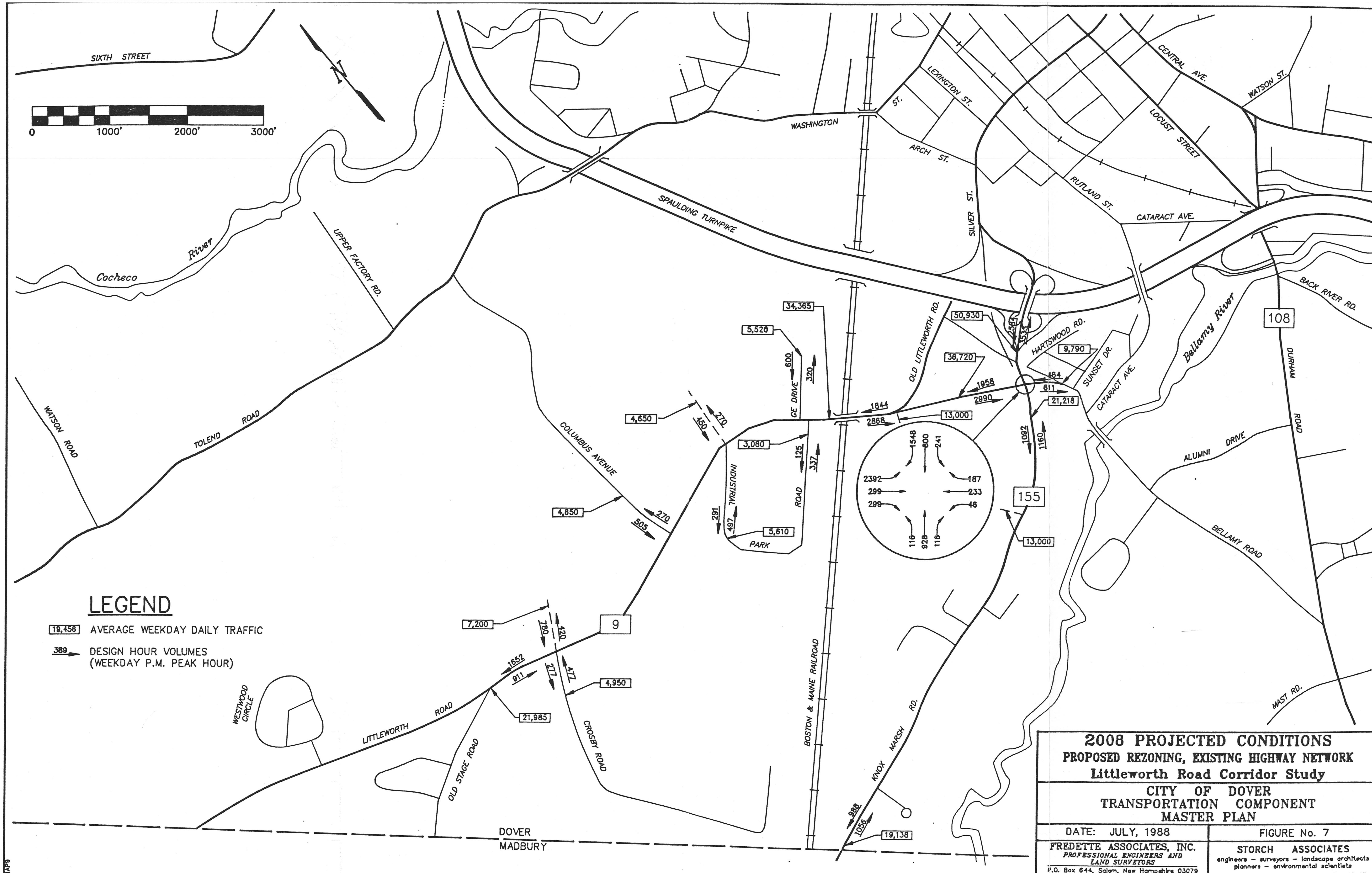

LEGEND

19,456 AVERAGE WEEKDAY DAILY TRAFFIC

389 → DESIGN HOUR VOLUMES (WEEKDAY P.M. PEAK HOUR)

2008 PROJECTED CONDITIONS

PROPOSED REZONING, EXISTING HIGHWAY NETWORK

Littleworth Road Corridor Study

CITY OF DOVER
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FIGURE No. 7

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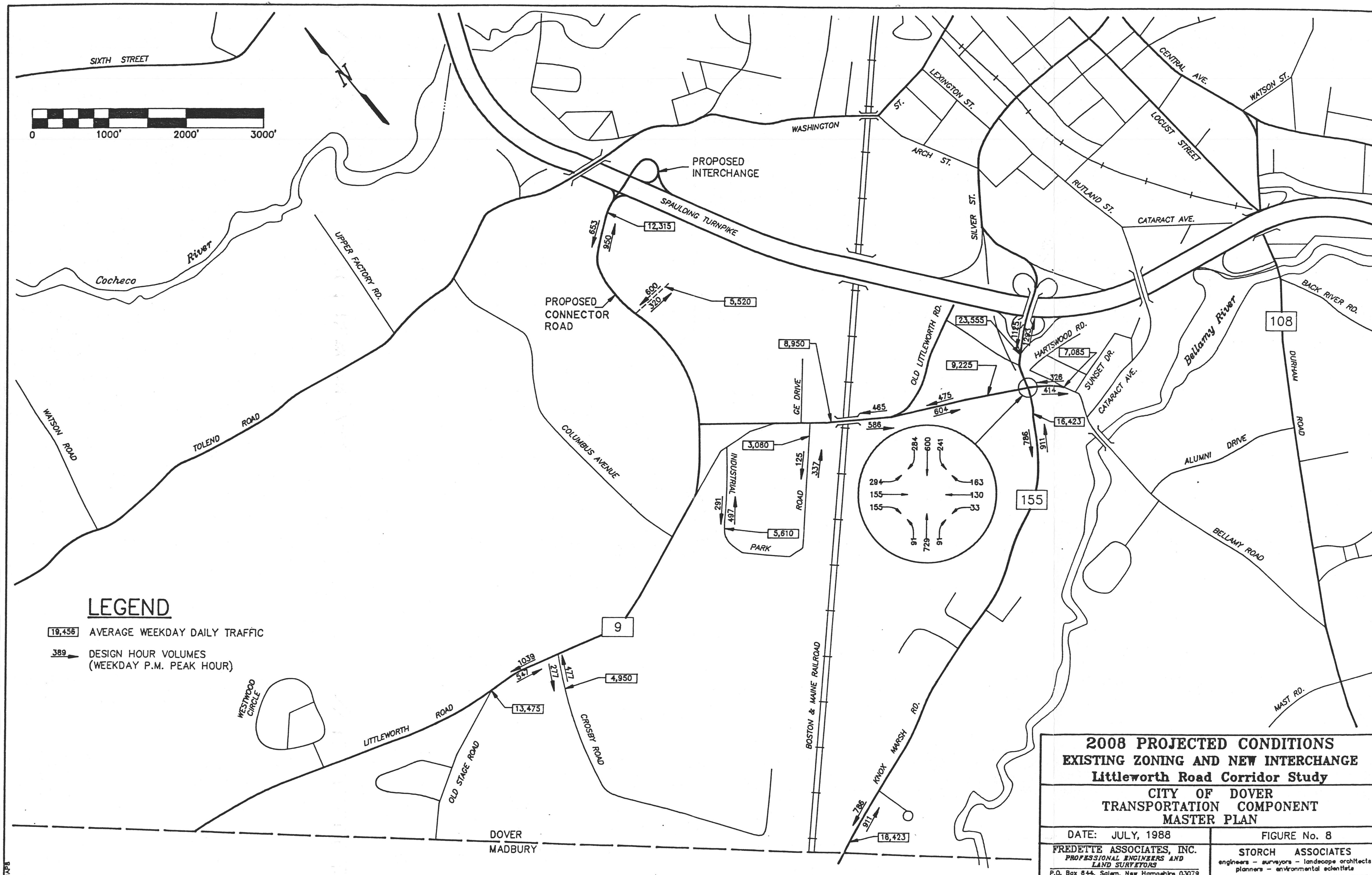
MAP9



2008 PROJECTED CONDITIONS
EXISTING ZONING AND NEW INTERCHANGE
Littleworth Road Corridor Study

CITY OF DOVER
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MASTER PLAN

DATE: JULY, 1988 | FIGURE No. 8

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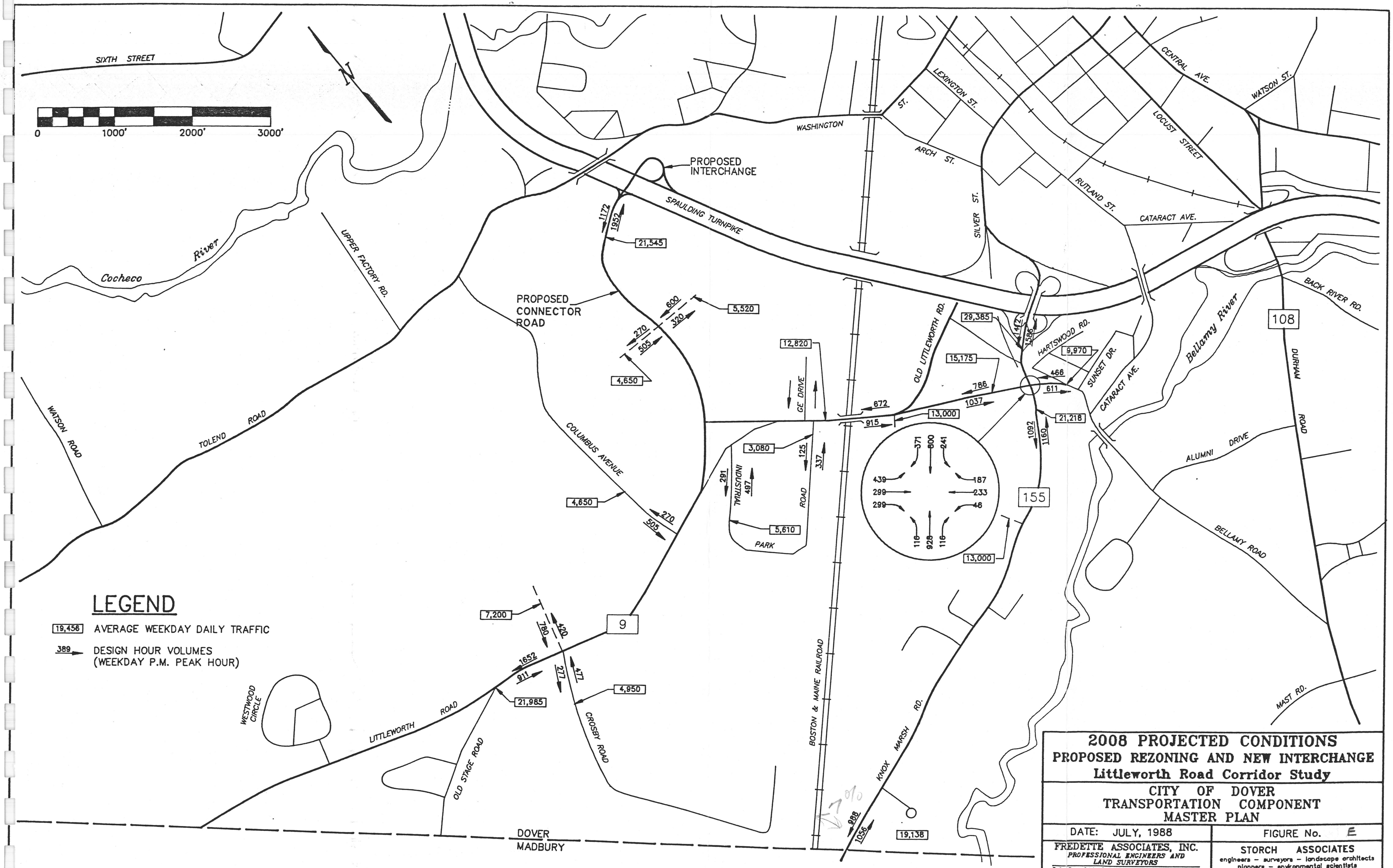

2008 PROJECTED CONDITIONS
PROPOSED REZONING AND NEW INTERCHANGE
Littleworth Road Corridor Study

CITY OF DOVER
TRANSPORTATION COMPONENT
MASTER PLAN

DATE: JULY, 1988

FIGURE No. E

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TABLE C

LEVEL OF SERVICE SUMMARY

ROUTE 9/ROUTE 155 INTERSECTION

	No Route 9 Interchange		With Route 9 Interchange	
Present 1988 LOS	No Rezoning 2008 LOS	With Rezoning 2008 LOS	No Rezoning 2008 LOS	With Rezoning 2008 LOS
PM	PM	PM	PM	PM
C	F	F	C	D/E

Turning movements from Route 9 onto Route 155 presently experience some delay with overall Level of Service C operations during the PM Peak Hour. With no proposed rezoning and the assumed growth in background traffic, the full build out of road improvements at this intersection will be operating at or over capacity (Level of Service F) by 2008.

With the total additional volumes generated by proposed rezoning, capacity conditions will be exceeded (Level of Service F) prior to the year 2008.

With the addition of a new Route 9 alignment and interchange with the Spaulding Turnpike, satisfactory Level of Service C operations are anticipated through the year 2008 assuming full build out of intersection improvements and no proposed rezoning. With the proposed rezoning plan the intersection will operate at Level of Service D/E.

G. Corridor Growth Implications

The key location constraining the potential capacity of the Route 9 Corridor is the Route 9/Route 155 intersection.

Based on the continued growth of highway traffic, turning movements from Route 9 to northbound Route 155 and the Spaulding Turnpike will cause the intersection of Route 9 and Route 155 (assumed full build out of intersection improvements) to reach capacity by the Year 2008. This condition will occur with no proposed rezoning of existing vacant lands in the City of Dover.

Utilizing the trip generation rates expected to be developed as a result of the implementation of the proposed rezoning, combined with an analysis of the existing surrounding traffic characteristics, it can be concluded that these new development areas will accelerate the timing when saturated conditions are reached at the intersection of Route 9 and Route 155.

However, assuming the full build out of improvements to the Route 9/Route 155 intersection is supplemented by the realignment of Route 9 to a new interchange on the Spaulding Turnpike, the former intersection will accommodate projected traffic growth with or without the City's proposed rezoning plan.

In light of the above findings, particularly with regard to the conservatively low estimate of potential corridor traffic growth utilized in the analysis, it is concluded that a new interchange with the Spaulding Turnpike is needed whether or not zoning changes are implemented along the Route 9 Corridor. It can also be concluded that without the new interchange, rezoning of the corridor for additional industrial or commercial growth cannot be reasonably accommodated by the present roadway system.

IV. Recommendations

Presented below are recommendations for highway improvements needed to accommodate the proposed traffic growth along the Littleworth Road corridor. Unless otherwise noted, these recommendations are based on accommodation of the proposed corridor rezoning plan as depicted in Figure 9. The implementation of a new interchange on the Spaulding Turnpike is also assumed which, at the time of this writing, is being discussed with the New Hampshire Department of Transportation.

1. Construct a new interchange with the Spaulding Turnpike in the vicinity of Tolend Road. The exact location and configuration of this interchange is beyond the scope of this memorandum although the indicated location between the Silver Street and Weeks Circle interchanges provides a reasonable interchange spacing of approximately one-mile.

2. Construct a new connector roadway (4-lanes minimum) between this interchange and a new signalized intersection with Littleworth Road east of Columbus Avenue. The New Hampshire Route 9 designation should be relocated to this new route.

3. Construct the aforementioned full build out of improvements to the Route 9/Route 155 intersection including: relocation of Bellamy Road to opposite Littleworth Road (presently being planned by NHDOT); widening of Route 155 and Littleworth Road to at least five-lane sections in the vicinity of the intersection; and extension of this widening of Route 155 into the present Spaulding Turnpike interchange to accommodate merging and weaving maneuvers. Bellamy Road north of Route 155 should be closed with access directed to Old Littleworth Road. These improvements will be required with or without rezoning.

4. Widen Route 155 south of Littleworth Road to at least a four lane section adjacent to the proposed commercial/retail zone. Localized widening to six lanes, for addition of left and right turn lanes, is recommended at a future primary entrance to the commercial site.

5. Except as noted below, widen Littleworth Road to at least a four-lane section (five lanes desirable for left turn lane implementation) from Route 155 through Old Stage Road. Localized widening to six lanes for addition of left and right turn lanes is recommended at key intersections (see Item 6 below). With implementation of the proposed interchange, the four-lane widening of the Littleworth Road bridge structure over the Boston and Maine Railroad tracks is not necessary, although minor widening for additional lateral roadway clearance would be desirable. Without the proposed rezoning and interchange, this four-lane widening could be limited to east of, and including, the Industrial Park Road (west) intersection.

6. To the extent practicable, minimize the proliferation of uncontrolled site entrances along the corridor. Recommended as a long term goal would be the concentration of future site and side street traffic at the following primary intersections, upgraded with exclusive turn lanes and signalization:

   a. <u>Littleworth Road at Old Littleworth Road and future commercial site.</u>

   b. <u>Littleworth Road at Industrial Park Road (East) and General Electric Drive.</u> The present offset between both site entrances (about 50 feet) should be eliminated. Widening of Littleworth Road for turn lanes at this intersection may need to be extended back to or through the railroad crossing structure.

   c. <u>Littleworth Road at Industrial Park Road (West)</u> should also be considered as a major intersection, although its ultimate traffic control requirements will depend largely on the final configuration of the Littleworth Road connection to the proposed interchange connector road.

   d. <u>Littleworth Road at Columbus Avenue.</u> Columbus Avenue will need to be reconstructed to serve as a major collector road for industrial site traffic to the north.

   e. <u>Littleworth Road at Crosby Road and future industrial site.</u>

f. Route 155 and future commercial/retail site (primary site access south of Littleworth Road intersection).

g. Interchange Connector Roadway and future industrial site entrance(s) (one major intersection).

The above intersection locations will provide an approximately one-quarter mile spacing between traffic signals. Coordination of signals along Littleworth Road is recommended.

7. The present 66 foot right of way along Littleworth Road is marginally adequate for a four lane curbed roadway with sidewalks. A continuous 5-lane section (central lane for left turn usage at key intersections) would be desirable as a long term goal with recommendations for a right-of-way width of 80 feet (for curbed roadway with sidewalks) or 100 feet (for uncurbed roadway with shoulders).

CITY OF DOVER
TRANSPORTATION COMPONENT - MASTER PLAN

APPENDIX
TECHNICAL MEMORANDUM NO. 3
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THE CITY OF DOVER, N.H.
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JULY, 1988

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TECHNICAL MEMORANDUM NO. 3

LITTLEWORTH ROAD (N.H. ROUTE 9) CORRIDOR STUDY

APPENDIX A

1985 LITTLEWORTH ROAD TRAFFIC CORRIDOR STUDY

STRAFFORD REGIONAL PLANNING COMMISSION

A PRELIMINARY ANALYSIS OF TRAFFIC CONDITIONS ON THE LITTLEWORTH ROAD TRAFFIC CORRIDOR IN DOVER, NEW HAMPSHIRE

January 9, 1985

Prepared by the
STRAFFORD REGIONAL PLANNING COMMISSION
County Courthouse County Farm Road
Dover, NH 03820

This report was prepared, and partially financed by funds provided through a contract with the New Hampshire Department of Public Works and Highways in cooperation with the U.S. Department of Transportation, Federal Highway Administration, the Urban Mass Transit Administration and SRPC local matching funds.

SRPC

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Strafford Regional Planning Commission

January 9, 1985

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Planning Director
City Hall
Dover, New Hampshire 03820

Dear Tim,

Please find attached the preliminary study, prepared by the Strafford Regional Planning Commission, of traffic conditions in the Littleworth Road traffic corridor.

As outlined in the report, the primary cause of traffic congestion in the study area is the increased traffic flow related to shift changes at industrial facilities along the Littleworth Road traffic corridor.

As was noted in the report, the purpose of this study was to provide Dover City officials with an accurate understanding of traffic conditions along Littleworth Road. However, we would strongly recommend that additional analysis be performed in order that a solution to existing and future traffic problems can be properly designed.

We look forward to working with you in this matter and we appreciate all of the assistance provided by the Dover Police and Planning Departments in completing this study in such a short time period.

Sincerely,

Jimmy E. Hicks

Jimmy E. Hicks
Executive Director

cc: Robert Steele

attachment

JEH/ec

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INTRODUCTION

In December 1984, the Dover Planning Department,(see Appendix A) requested that the Strafford Regional Planning Commission (SRPC) provide assistance in analyzing traffic conditions along the Littleworth Road traffic corridor. In making this request, the Planning Director stated that the Dover Planning Board was particularly intersted in understanding present traffic volumes on Littleworth Road, the road's overall traffic capacity, as well as the impacts of numerous intersections within the corridor.

On January 2, 3 and 4, 1985, SRPC and Dover Planning Department staff conducted traffic counts at various intersections along Littleworth Road. Additionally, the Dover Police Department collected information on vechile speed.

The following report is an analysis of the collected data. However, before discussing specific results of the analysis, several limiting factors must be noted. First, sufficient time to collect statistically supportable data was not available. Traffic counts had to be made in a three day period in which one was the first day after a long holiday vacation and another was on a Friday. Second, the University of New Hampshire, a major taffic generator in the area was not in operation. While this last factor does not affect traffic on Littleworth Road significantly, it does have an impact on the use of Route 155.

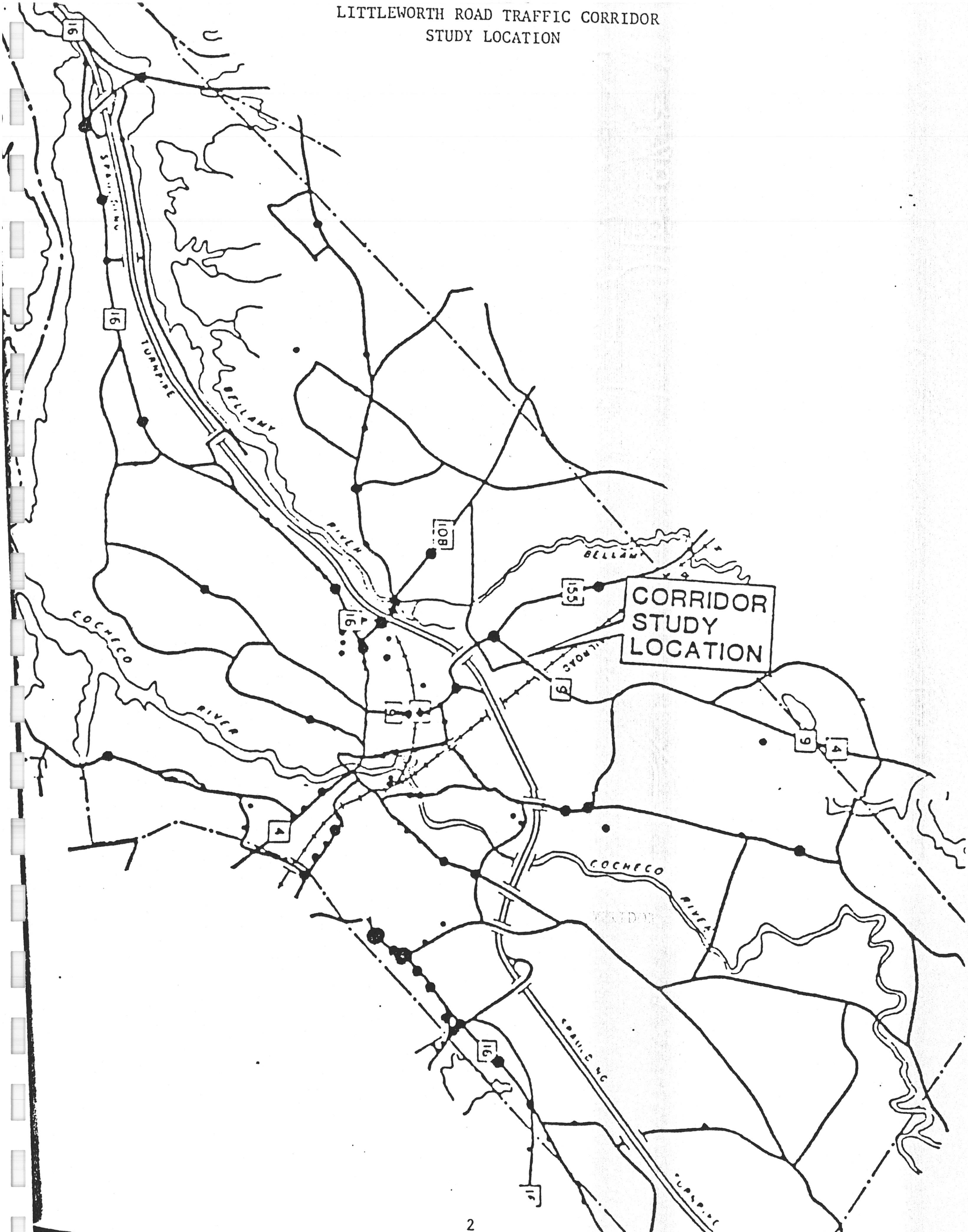
BACKGROUND

The Littleworth Road traffic corridor is located along the western boundary in the city of Dover, New Hampshire (see Figure 1). It begins at the intersection of Knox Marsh Road (Route 155) with Littleworth Road (Route 9) just west of Exit 8 on the Spaulding Turnpike. It continues for 1.5 miles west-northwest along Littleworth Road (see Figure 2).

This corridor is one of the major industrial areas within the City. Two industrial parks are presently located within it, along with the General Electric manufacturing plant. Housing also exists in the corridor. It is primarily located on Littleworth Road, Bellamy Avenue, Old Littleworth Road and Columbus Avenue.

In most urban areas, traffic peaks over an extended period of time. Also, since traffic usually originates from numerous locations it is spread over an entire road system and does not unduley congest one particular area. Traffic in an industrial area however, has a different pattern. It usually intensifies during short periods of time due to shift changes in the workforce, in one particular corridor. The result is often brief periods of traffic congestion.

LITTLEWORTH ROAD TRAFFIC CORRIDOR
STUDY LOCATION

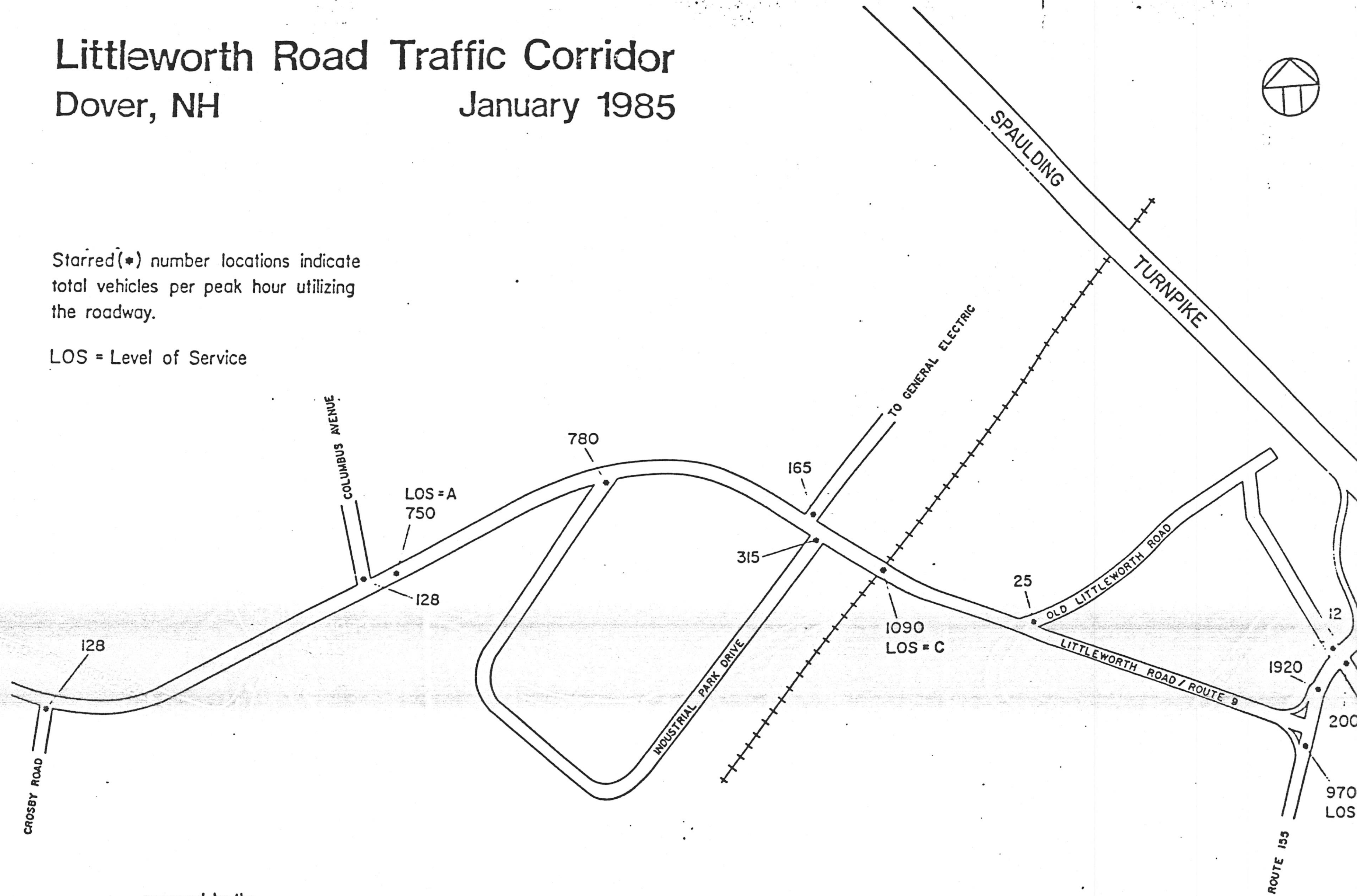


Littleworth Road Traffic Corridor

Dover, NH — January 1985

Starred(*) number locations indicate total vehicles per peak hour utilizing the roadway.

LOS = Level of Service



prepared by the
Strafford Regional Planning Commission

Figure 2

Currently, the Littleworth traffic corridor is experiencing traffic congeston common to many industrial areas; traffic tie-ups during late afternoon shift changes. This problem is made even more difficult due to the fact that other individuals are also returning to their homes, located along the Littleworth traffic corridor, at approximately the same time.

It is presently anticipated that significant economic development will occur in Dover over the next several years. Since some of this economic expansion could result in the location of new industrial facilities in the Littleworth traffic corridor, a great deal of public attention has been focused on the development of land in the general area of Littleworth Road.

The purpose of this analysis is to provide Dover City officials with a more accurate understanding of traffic conditions within the Littleworth traffic corridor. However, as previously noted, additional information about traffic in the area is needed before a solution to present traffic problems can be designed.

ANALYSIS

Based on discussions with Dover Planning Department staff and a visual inspection of the site, it was decided that a four step approach would be used in this analysis. The first step was the development of capacity ratings for the corridor. This would provide a basis to determine the maximum number of vehicles able to use Littleworth Road safely and efficiently. These ratings were developed for two different locations on Littleworth Road as well as for Route 155.

The second step was the measurement of the present volumes of traffic within the corridor. This was done by counting the number of vehicles on each roadway for a standard period of time. Comparing present volumes to the capacity ratings indicates a level of service provided by a particular road. This data allows an assessesment of present operating conditions of the roadway at the point of analysis.

The third step was the analysis of the operation of the intersections located within the corridor. This step is very crucial since the "link capacity is equal to the capacity of the most restricted intersection on the link."[1] In the Littleworth Road corridor there were eight (8) intersections of interest. Beginning on the west end of the corridor, the first intersection analyzed was Littleworth Road and the entrance to the Crosby Road Industrial Park. Second was the intersection of Littleworth Road and Columbus Avenue. Third and fourth were the intersections of Littleworth Road and the two entrances accessing the Southeast New Hampshire

1 National Cooperative Highway Research Progam Report 187: Quick-Response Urban Travel Estimation Techniques User's Guide, page 146.

Industrial Park. Fifth was the intersection of Littleworth Road and the entrance to the General Electric Plant. Sixth was the intersection of Littleworth Road and Old Littleworth Road. Seventh was the intersection of Littleworth Road and Route 155. Eighth, and last, was the intersection of Route 155 with Bellamy Road (see Figure 2).

The fourth and final step was an examiniation of other situations which could interfere with traffic flow in the corridor. Possible examples of these types of problems are sharp curves, steep hills, excess speed or commercial establishments with access problems.

A. Capacity Ratings

Capacity ratings were developed for three different locations within the Littleworth Road traffic corridor. These ratings are based on the lane width of a roadway, the width of the shoulder, the percentage of trucks on the roadway and the grade to determine the total number of vehicles that could use the roadway safely and efficiently.

Analysis was conducted on Littleworth Road at two locations. The first was at Columbus Avenue which was judged to be an average section of the roadway. The second was for the narrower section found at the B&M Railroad bridge. A final capacity rating was developed for Route 155 west of the intersection with Littleworth Road. East of this intersection, traffic movements become too complicated to conduct this type of analysis. Results of the capacity ratings (see Appendix B for computations) are listed below:.

1. Littleworth Road, Columbus Avenue Capacity = 1,748 vehicles per hour;
2. Littleworth Road, railroad bridge; Capacity = 1,414 vehicles per hour;
3. Route 155, west of Littleworth Road; Capacity = 1,610 vehicles per hour.

B. Level of Service Ratings

Once the capacity of a roadway has been computed, the results can be used with present volumes to develop a level of service rating. This rating compares computed values against a benchmark value and then stratifies them into various levels of service. Table 1 demonstrates how operating conditions relate to different levels of service.

TABLE 1

LEVEL OF SERVICE	OPERATING CONDITIONS
A	Free flow, low volume, high-operating speed, high maneuverability.
B	Stable flow, moderate volume; speed somewhat restricted by traffic conditions, high maneuverability.
C	Stable flow, high volumes; speed and maneuverability determined by traffic conditions.
D	Unstable flow, high volumes, tolerable but fluctuating operating speed and maneuverability.
E	Unstable flow, high volumes approaching roadway capacity, limited speed (30 mph), intermittent vehicle queuing.
F	Forced flow, volumes lower than capacity due to very low speeds. Heavy queuing of vehicles, frequent stoppages.

For each of the locations where capacities were developed in the last section, levels of service were computed. Present traffic volumes were derived from counts taken on January 3 and 4, 1985. Results (see Appendix B for computations) of the Level of Service (LOS) Ratings are listed below:

1. Littleworth Road; Columbus Avenue LOS = A
2. Littlworth Road,2 railroad bridge LOS = C
3. Route 155, west of Littleworth Road LOS = A

C. <u>Intersections</u>

1. <u>Littleworth Road and Route 155</u>. It has previously been noted that "link capacity is equal to the capacity of the most restricted intersection on the link." The intersection of Littleworth Road and Route 155 provides strong support for this statement. Alleviating the congestion at this intersection would substantially reduce congestion within the entire traffic corridor.

2 There are other factors that interfere with the operation of Littleworth Road in this area. They are discussed further in the next section of the report.

The most predominant factor causing traffic congestion at this intersection is the 4-5:00 P.M. shift change. This shift change occurs in conjunction with regular peak hour traffic causing substantial backups on the Littleworth Road leg of the intersection.

A second factor leading to congestion is that a high percentage of the shift change traffic in the Littleworth Road traffic corridor follows the same route. This route is east on Littleworth Road to Route 155 and left on Route 155 into Dover or onto the Spaulding Turnpike. It is the predominance of left turns onto Route 155 that forces traffic to back up.

The traffic signal presently located at the intersection allows only an average of 15 vehicles through per green phase. This causes the stacking of vehicles which, at its worse, can back traffic up beyond the B&M railroad bridge. This stacking then often inhibits traffic movements into or out of Old Littleworth Road and the first entrance into the Southeast New Hampshire Industrial Park.

The other two parts of the intersection do not have the problems of the Littleworth Road section. However, they do both have substantial peak hour traffic. Forty-five percent of the traffic flowing into the intersection from Dover on Route 155 continues straight, while 55 percent turns onto Littleworth Road. A right turn lane exists from Route 155 to Littleworth Road allowing free flowing right turns thus decreasing traffic back up on this leg.

Traffic traveling east on Route 155 primarily continues straight through the intersection. Only eight percent left turns were made and a separate left turn lane and signal phase exist for these movements.

2. <u>Bellamy Road and Route 155</u>. The amount of traffic using Bellamy Road is not very large. Due to its proximity to the intersection of Littleworth Road and Route 155 however, left turn movements are often difficult at peak hours. Observation made during this study indicated that traffic on Route 155 at the intersection of Littleworth Road never backed-up across Bellamy Road. This does not totally inhibit left turns but it does limit them and force some backing-up of cars on the southern leg of Bellamy Road.

The southern leg of Bellamy Road is frequently used as a short cut between Routes 155 and 108. Because of this access, traffic on this leg is substantailly larger than on the north leg. It would not take a very substantial increase in traffic on either Bellamy Road or Route 155 however, to make this intersection a substantial traffic problem.

3. <u>Old Littleworth Road and Littleworth Road</u>. Old Littleworth Road receives very little traffic since it services only a residential area.

Traffic counts showed that over the peak hour, only four vehicles turned into the road and only one vehicle pulled out.

Pulling out onto Littleworth Road is no problem if one wants to head west. If one wants to head east, it is very difficult during the peak hour however. This is due to the backup problem found on Littleworth Road at the intersection of Route 155. To bypass this problem, one can travel down Old Littleworth Road to Bellamy Road accessing Route 155 east of the Littleworth Road intersection. Turning onto Route 155 here is somewhat difficult but at the present time it is much better than Littleworth Road.

4. General Electric and Littleworth Road. The General Electric Company has recognized the traffic problems on Littleworth Road. To accommdate their employees, they have established a 3:30 P.M. shift change. Because of the size of the shift change, a backup does occur as employees exit the plant onto Littleworth Road. The backup is very short however as traffic on Littleworth Road at this time is quite moderate. The number of employees at the General Electric Plant is also not large enough to create congestion at the Route 155-Littleworth Road intersection as occurs later in the day. Staggering shift times is a very easy, low cost solution to peak traffic congestion problems.

5. Southeast New Hampshire Industrial Park and Littleworth Road. The Southeast New Hampshire Industrial Park is the prime cause of traffic congestion within the Littlewoth Road traffic corridor. Many employees within this park change shifts at the same hour. This causes substantial traffic to backup at the two exits from the park. Over 70 percent of this traffic turns east onto Littleworth Road moving towards the intersection of Route 155 while less than 30 percent turns west towards Barrington.

This predominant eastward flow is responsible for the backup found at the intersection of Littleworth Road and Route 155. If traffic flowed more heavily westward, congestion at Route 155 would decrease. However, the increase in left turns onto Littleworth Road would slow the egress of traffic substantially from the industrial park roadway.

This is easily demonstrated by observing present traffic patterns at the second (further west) industrial park roadway. Here, an island has been placed at the intersection with Littleworth Road. This island separates left turning traffic from right turning traffic. When operating propertly, left turning traffic waits in its own separate lane for a gap. Since a left turn requires a gap in both intersecting lanes and a right turn only one, separation allows for greater traffic flow in the right turn lane.

Unfortunately, at this intersection the left turn island is only large enough for three or four vehicles. Once this queue is full, left turn traffic is forced to wait in the right turning traffic lane defeating the purpose of the island. This problem is compounded by the fact that the second roadway receives much greater use than the first. This is because the major employee parking lot is located closer to the second roadway.

Because of the backup problem at Littleworth Road and Route 155, it is definately better to keep the traffic at the second driveway. This increases the distance of the backup from the bulk of the industrial park traffic thus allowing easier access to Littleworth Road. Changing the design of the separate left turn lane would ease access onto Littleworth Road even more.

6. <u>Columbus Avenue and Littleworth Road</u>. Columbus Avenue is a residential road linking Littleworth and Tollend Roads. At the present time the intersection with Littleworth Road is poorly designed. A traffic island separates right turning traffic from left turning. However a similar problem exists here with the island as found at the second Southeast Industrial Park roadway. There is also a short, steep downward slope on Columbus Avenue just prior to the intersection with Littleworth Road limiting safety and restricting sight distance.

Presently this intersection receives little traffic so its poor design is not a severe problem. If traffic on this road should increase, a substantial redesign of the intersection would be required.

7. <u>Crosby Road Industrial Park and Littleworth Road</u>. Currently this intersection has no operatinal difficulties. Shifts at the companies within the industrial park change prior to the peak hour and traffic is very moderate. As development continues to increase in the industrial park and employment rises, this intersection will have a greater impact on the overall Littleworth Road traffic corridor. It is far enough west of Route 155 that it will not be tied up in congestion at that intersection, however it will help compound it.

D. <u>Other Problems</u>

There are two other problems that also interfere with the operation of the traffic corridor. Each of these is noted briefly below.

1. The service station east of the B&M Railroad bridge has unlimited access onto Littleworth Road causing problems with vehicles seeking entrance onto Littleworth Road.

2. Because of curves and hills in the traffic corridor, sight distance problems often occur at intersectons and driveways.

CONCLUSIONS

As was previously noted this is a preliminary traffic study with much of the analysis based on simple observations. From these observations it has become obvious that a traffic problem exists within the corridor that is related to shift changes at the manufacturing companies within the corridor. These shift changes release large quanitites of traffic into the corridor in a short period of time all predominantly following the same route.

Specific recommendations to address this problem can not be made from the analysis conducted thus far. More detailed information about the corridor and its traffic patterns must be collected. Once further study has been completed, recommendations can be made and the process of instituting improvements can begin.

DEPARTMENT OF PLANNING AND COMMUNITY DEVELOPMENT
CITY OF DOVER, NEW HAMPSHIRE 03820

TIMOTHY C. SHELDON
DIRECTOR

LINDA L. CLARK
CD COORDINATOR

TEL. (603) 742-3551

December 20, 1984

Jim Hicks
Executive Director
Strafford Regional Planning Commission
County Farm Road
Dover, New Hampshire 03820

Dear Jim:

The City of Dover's Planning Board, at the request of the Dover Industrial Development Authority, has proposed a rezoning of 110 acres of land along the Littleworth Road, from residential to restricted industrial. (Please see attachment.)

A Public Hearing has been held and concerns have been raised relative to the operating capacity of Littleworth Road, and particularly the Routes 9 and 155 intersection.

The Planning Board would like to have a handle on the Littleworth Road's design capacity, operating capacity (on-off peak), as well an an assessment of the aforementioned intersection's operating characteristics.

Given the above, I would request we schedule a meeting as soon as possible to determine whether or not assistance is available and the study parameters.

Thank you for your consideration of this matter.

Very truly yours,

Timothy C. Sheldon

Timothy C. Sheldon
Planning Director

TABLE 1

CAPACITY RATINGS, COMPUTATIONS

from: Special Report 87; Highway Capacity Manual 1965

C=2000 WcTc

in which

c = capacity (mixed vehicles per hour, total in both directions);

w = adjustment for lane width and lateral clearance at capacity.

t = truck factor at capacity, for overall highway sections.

Wc Factors

Littleworh Road, at

1. Columbus Avenue - 12 foot lanes, 4 foot shoulders, side obstructions Wc= .94.

2. B&M Railroad bridge - 12 foot lanes, no shoulder, side obstructions Wc= .83.

3. Route 155, west of Littleworth Road - 11 foot shoulders, side obstructions Wc= .76.

Tc Factors

1. Littleworth Road - three percent trucks, slightly hilly Tc= .93.

2. Route 155, west of Littleworth Road - three percent trucks, level Tc= .97.

3. Littleworth Road, at Columbus Avenue - C=2000 (.94) (.93) = 1748 vehicles (both directions).

4. Littleworth Road at B&M Railroad Bridge - C=2000 (.76) (.93) = 1414 vehicles (both directions).

3. Route 155, west of Littleworth Road - c=2000 (.83) (.97) = 1610 vehicles (both directions.

<u>Level of Service Ratings</u>
from: National Cooperative Highway Research Program
Report 187; Quick-Response Urban Travel Estimation
Techniques User's Guide

V/C = Volume/Capacity = Level of Service

1. Littleworth Road at Columbus Avenue - V/C = 750/1748 = .43 = Level of Service A.

2. Littleworth Road at B&M Railroad Bridge - V/C = 1090/1414 = .77 = Level of Service C.

3. Route 155, west of Littleworth Road - V/C = 970/1610 = .60 = Level of Service A.

TECHNICAL MEMORANDUM NO. 3

LITTLEWORTH ROAD (N.H. ROUTE 9) CORRIDOR STUDY

APPENDIX B

1988 TRAFFIC COUNT DATA

TRAFFIC ANALYSIS SYSTEM VOLUME COUNT

FOR

LITTLEWORTH ROAD NEAR ROUTE 155
BELLAMY ROAD NEAR ROUTE 155
CROSBY ROAD NEAR LITTLEWORTH ROAD

CITY OF DOVER, NEW HAMPSHIRE
ENGINEERING DEPARTMENT
PAUL VLASICH & CARL QUIRAM
APRIL 8, 1988

WEATHER : DRIZZLY
ENG. DEPT.: PV & CQ

FILE: lwrd2

DATE: 4/06/88

TIME BEGIN	WEDNESDAY- 6 : EB AM	EB PM	WB AM	WB PM	COMBINED AM	COMBINED PM
12:00	*	148	*	69	*	217
12:15	*	82	*	92	*	164
12:30	*	80	*	88	*	168
12:45	*	54	*	77	*	131
1:00	*	71	*	95	*	166
1:15	*	63	*	55	*	118
1:30	*	67	*	56	*	123
1:45	*	69	*	76	*	145
2:00	*	65	*	76	*	141
2:15	*	79	*	96	*	175
2:30	*	86	*	99	*	185
2:45	*	94	*	90	*	184
3:00	*	112	*	91	*	203
3:15	*	113	*	111	*	224
3:30	*	132	*	137	*	269
3:45	*	146	*	115	*	261
4:00	*	179	*	109	*	288
4:15	*	85	*	109	*	194
4:30	*	108	*	105	*	213
4:45	*	105	*	115	*	220
5:00	*	149	*	109	*	258
5:15	*	106	*	122	*	228
5:30	*	85	*	102	*	187
5:45	*	72	*	71	*	143
6:00	*	69	*	58	*	127
6:15	*	60	*	51	*	111
6:30	*	57	*	49	*	106
6:45	*	72	*	40	*	112
7:00	*	38	*	41	*	79
7:15	*	61	*	41	*	102
7:30	*	35	*	35	*	70
7:45	*	36	*	45	*	81
8:00	103	30	101	42	204	72
8:15	79	24	71	31	150	55
8:30	102	38	76	32	178	70
8:45	111	22	58	40	169	62
9:00	66	18	46	38	112	56
9:15	53	20	45	30	98	50
9:30	60	17	41	22	101	39
9:45	60	17	57	27	117	44
10:00	46	16	42	29	88	45
10:15	70	9	43	13	113	22
10:30	61	9	56	15	117	24
10:45	37	11	47	16	84	27
11:00	70	26	44	17	114	43
11:15	57	12	63	31	120	43
11:30	62	10	64	40	126	50
11:45	101	20	84	22	185	42
TOTALS	1138	3077	938	3060	2076	6137
DAY TOTALS	4215		3998		8213	
% TOTAL	54.8	50.1	45.2	49.9		
PEAK HOUR	8:00	3:15	8:00	3:15	8:00	3:15
VOLUME	395	570	306	472	701	1042
P.H.F.	0.89	0.80	0.76	0.85	0.86	0.90

TIME BEGIN	THURSDAY- 7 : EB AM	EB PM	WB AM	WB PM	COMBINED AM	COMBINED PM
12:00	41	120	4	79	45	199
12:15	5	73	7	83	12	156
12:30	14	69	14	60	28	129
12:45	8	55	9	101	17	156
1:00	11	61	2	83	13	144
1:15	5	56	2	78	7	134
1:30	4	74	2	58	6	132
1:45	3	62	3	64	6	126
2:00	10	65	2	79	12	144
2:15	4	72	3	92	7	164
2:30	11	94	2	98	13	192
2:45	17	92	0	94	17	186
3:00	31	108	6	88	37	196
3:15	8	122	11	99	19	221
3:30	5	141	3	140	8	281
3:45	10	147	6	99	16	246
4:00	3	120	4	133	7	253
4:15	6	92	9	119	15	211
4:30	8	117	37	93	45	210
4:45	13	85	41	111	54	196
5:00	12	123	48	118	60	241
5:15	21	96	35	97	56	193
5:30	18	87	36	91	54	178
5:45	21	72	43	67	64	139
6:00	40	52	26	59	66	111
6:15	71	62	52	60	123	122
6:30	80	56	88	53	168	109
6:45	103	49	104	45	207	94
7:00	95	48	78	42	173	90
7:15	133	38	109	35	242	73
7:30	103	35	103	39	206	74
7:45	121	38	152	37	273	75
8:00	112	33	112	44	224	77
8:15	75	35	69	42	144	77
8:30	102	36	63	42	165	78
8:45	108	23	47	36	155	59
9:00	72	22	45	34	117	56
9:15	60	16	40	26	100	42
9:30	66	14	50	29	116	43
9:45	46	12	46	26	92	38
10:00	64	12	57	19	121	31
10:15	55	13	51	36	106	49
10:30	53	16	42	17	95	33
10:45	57	18	47	19	104	37
11:00	70	22	48	26	118	48
11:15	77	12	69	29	146	41
11:30	72	8	76	30	148	38
11:45	100	37	55	21	155	58
TOTALS	2224	2910	1958	3070	4182	5980
DAY TOTALS	5134		5028		10162	
% TOTAL	53.2	48.7	46.8	51.3		
PEAK HOUR	7:15	3:15	7:15	3:30	7:15	3:15
VOLUME	469	530	476	491	945	1001
P.H.F.	0.99	0.90	0.78	0.88	0.87	0.89

WEATHER : drizzly
ENG. DEPT.: PV & CQ

FILE: IWRD2

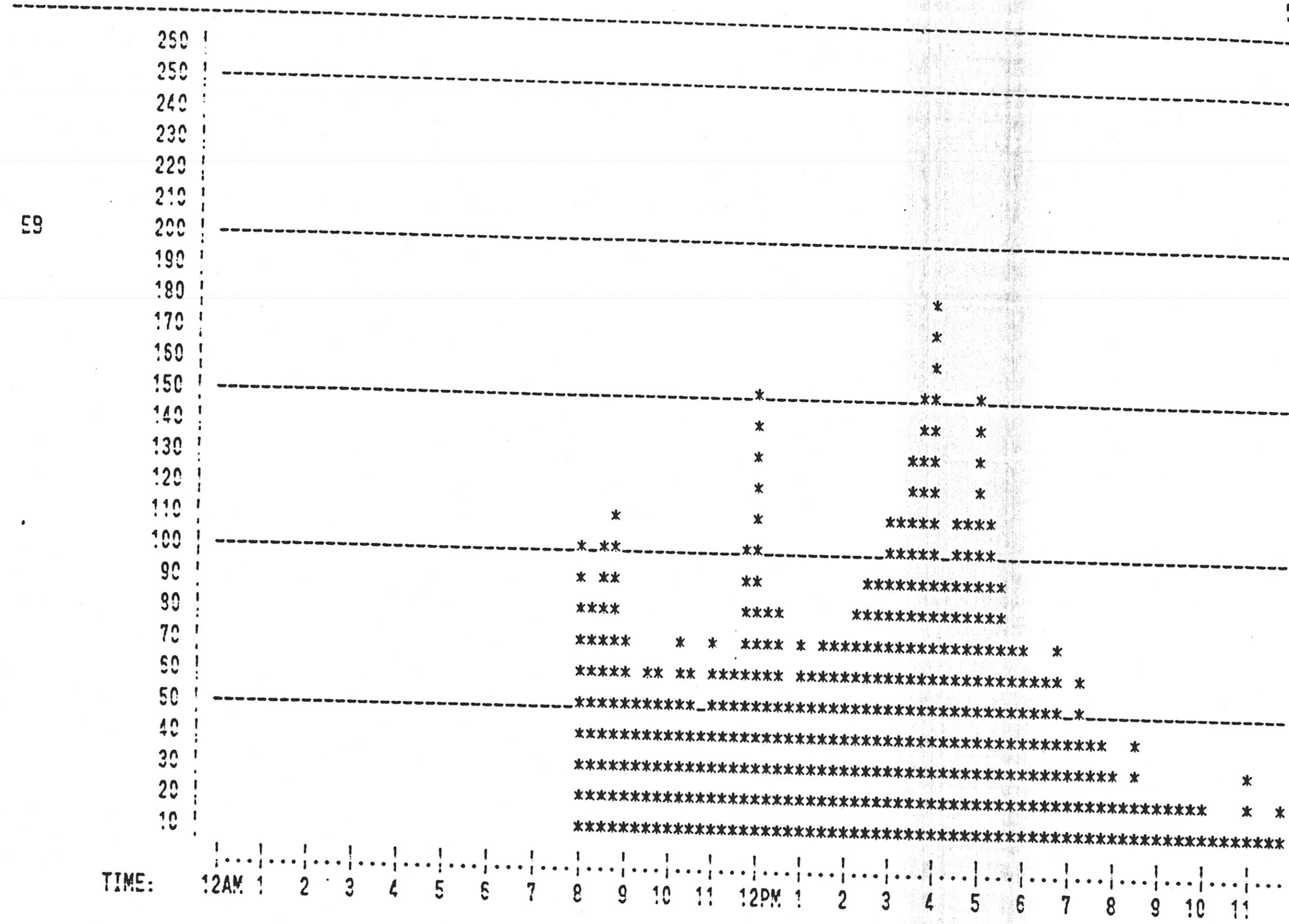
DATE: 4/08/88

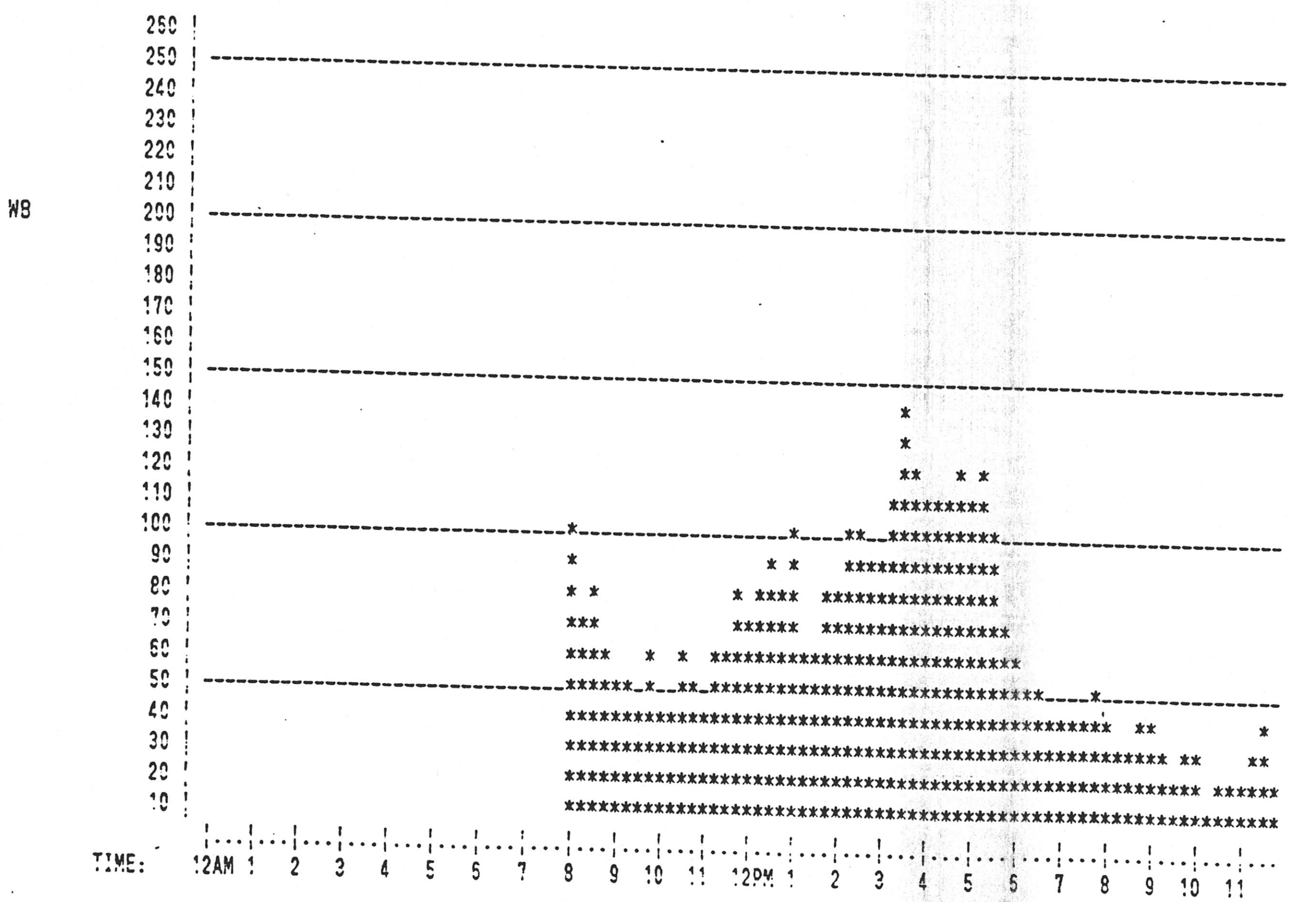
TIME BEGIN	FRIDAY- 8 : EB AM	EB PM	WB AM	WB PM	COMBINED AM	COMBINED PM	SATURDAY- 9 : EB AM	EB PM	WB AM	WB PM	COMBINED AM	COMBINED PM
12:00	25	*	11	*	36	*	*	*	*	*	*	*
12:15	11	*	14	*	25	*	*	*	*	*	*	*
12:30	11	*	10	*	21	*	*	*	*	*	*	*
12:45	22	*	14	*	36	*	*	*	*	*	*	*
1:00	9	*	3	*	12	*	*	*	*	*	*	*
1:15	3	*	4	*	7	*	*	*	*	*	*	*
1:30	1	*	4	*	5	*	*	*	*	*	*	*
1:45	6	*	2	*	8	*	*	*	*	*	*	*
2:00	12	*	0	*	12	*	*	*	*	*	*	*
2:15	7	*	3	*	10	*	*	*	*	*	*	*
2:30	12	*	4	*	16	*	*	*	*	*	*	*
2:45	20	*	4	*	24	*	*	*	*	*	*	*
3:00	27	*	8	*	35	*	*	*	*	*	*	*
3:15	7	*	12	*	19	*	*	*	*	*	*	*
3:30	6	*	7	*	13	*	*	*	*	*	*	*
3:45	6	*	7	*	13	*	*	*	*	*	*	*
4:00	1	*	3	*	4	*	*	*	*	*	*	*
4:15	4	*	12	*	16	*	*	*	*	*	*	*
4:30	7	*	24	*	31	*	*	*	*	*	*	*
4:45	6	*	46	*	52	*	*	*	*	*	*	*
5:00	12	*	48	*	60	*	*	*	*	*	*	*
5:15	12	*	35	*	47	*	*	*	*	*	*	*
5:30	15	*	22	*	37	*	*	*	*	*	*	*
5:45	23	*	40	*	63	*	*	*	*	*	*	*
6:00	36	*	29	*	65	*	*	*	*	*	*	*
6:15	71	*	52	*	123	*	*	*	*	*	*	*
6:30	91	*	87	*	178	*	*	*	*	*	*	*
6:45	88	*	103	*	191	*	*	*	*	*	*	*
7:00	87	*	77	*	164	*	*	*	*	*	*	*
7:15	117	*	132	*	249	*	*	*	*	*	*	*
7:30	116	*	93	*	209	*	*	*	*	*	*	*
7:45	133	*	155	*	288	*	*	*	*	*	*	*
8:00	114	*	98	*	212	*	*	*	*	*	*	*
8:15	47	*	48	*	95	*	*	*	*	*	*	*
8:30	*	*	*	*	*	*	*	*	*	*	*	*
8:45	*	*	*	*	*	*	*	*	*	*	*	*
9:00	*	*	*	*	*	*	*	*	*	*	*	*
9:15	*	*	*	*	*	*	*	*	*	*	*	*
9:30	*	*	*	*	*	*	*	*	*	*	*	*
9:45	*	*	*	*	*	*	*	*	*	*	*	*
10:00	*	*	*	*	*	*	*	*	*	*	*	*
10:15	*	*	*	*	*	*	*	*	*	*	*	*
10:30	*	*	*	*	*	*	*	*	*	*	*	*
10:45	*	*	*	*	*	*	*	*	*	*	*	*
11:00	*	*	*	*	*	*	*	*	*	*	*	*
11:15	*	*	*	*	*	*	*	*	*	*	*	*
11:30	*	*	*	*	*	*	*	*	*	*	*	*
11:45	*	*	*	*	*	*	*	*	*	*	*	*
TOTALS	1165	*	1211	*	2376	*	*	*	*	*	*	*
DAY TOTALS	1165		1211		2376		*		*		*	
% TOTAL	49.0	*	51.0	*			*	*	*	*		
PEAK HOUR	7:15	*	7:15	*	7:15	*	*	*	*	*	*	*
VOLUME	480	*	479	*	958	*	*	*	*	*	*	*
P.H.F.	0.90	*	0.77	*	0.83	*	*	*	*	*	*	*

WEATHER : Grizzly
ENG. DEPT.: PV & CQ

FILE: lwrd2

DATE: 4/06/88

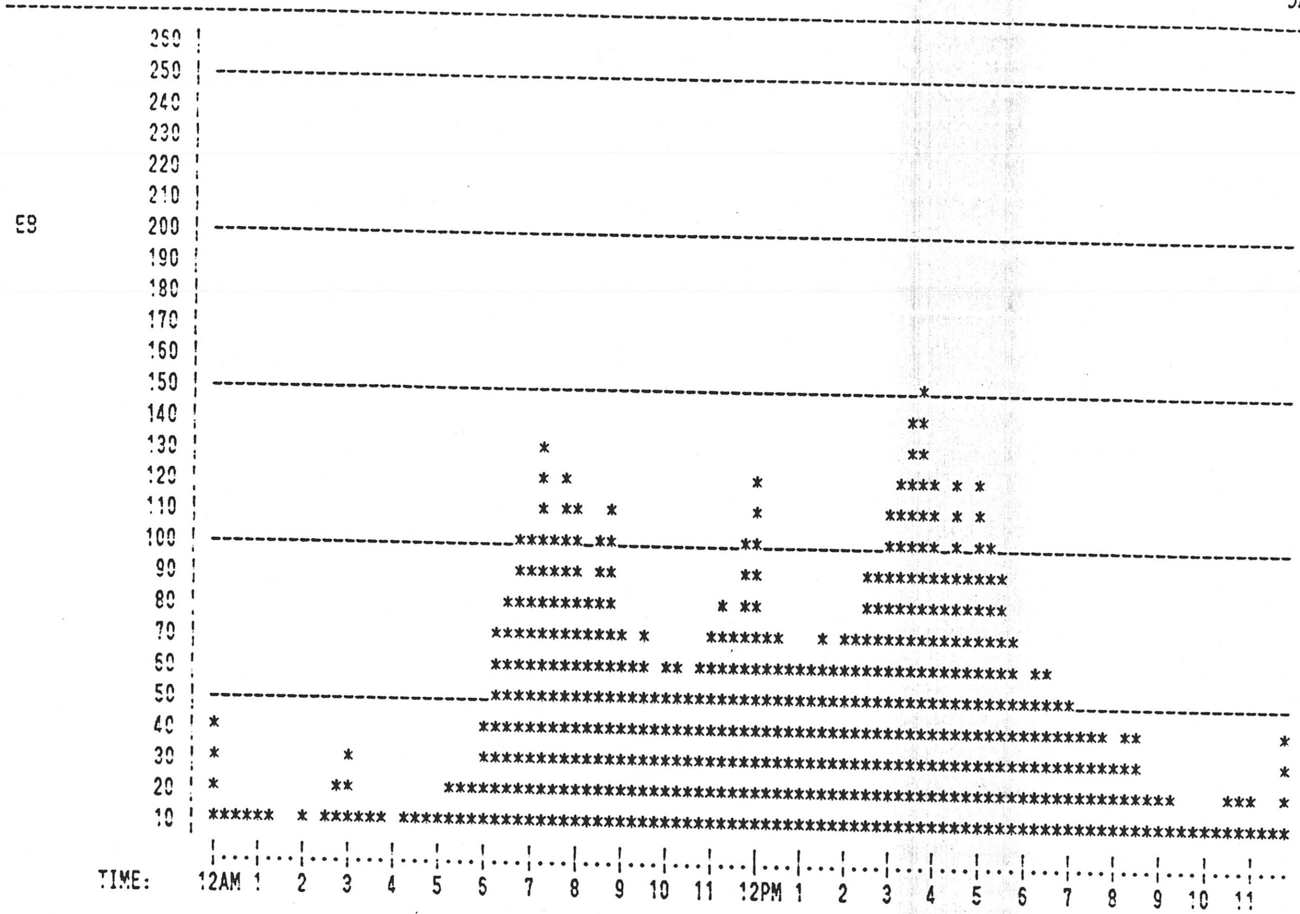


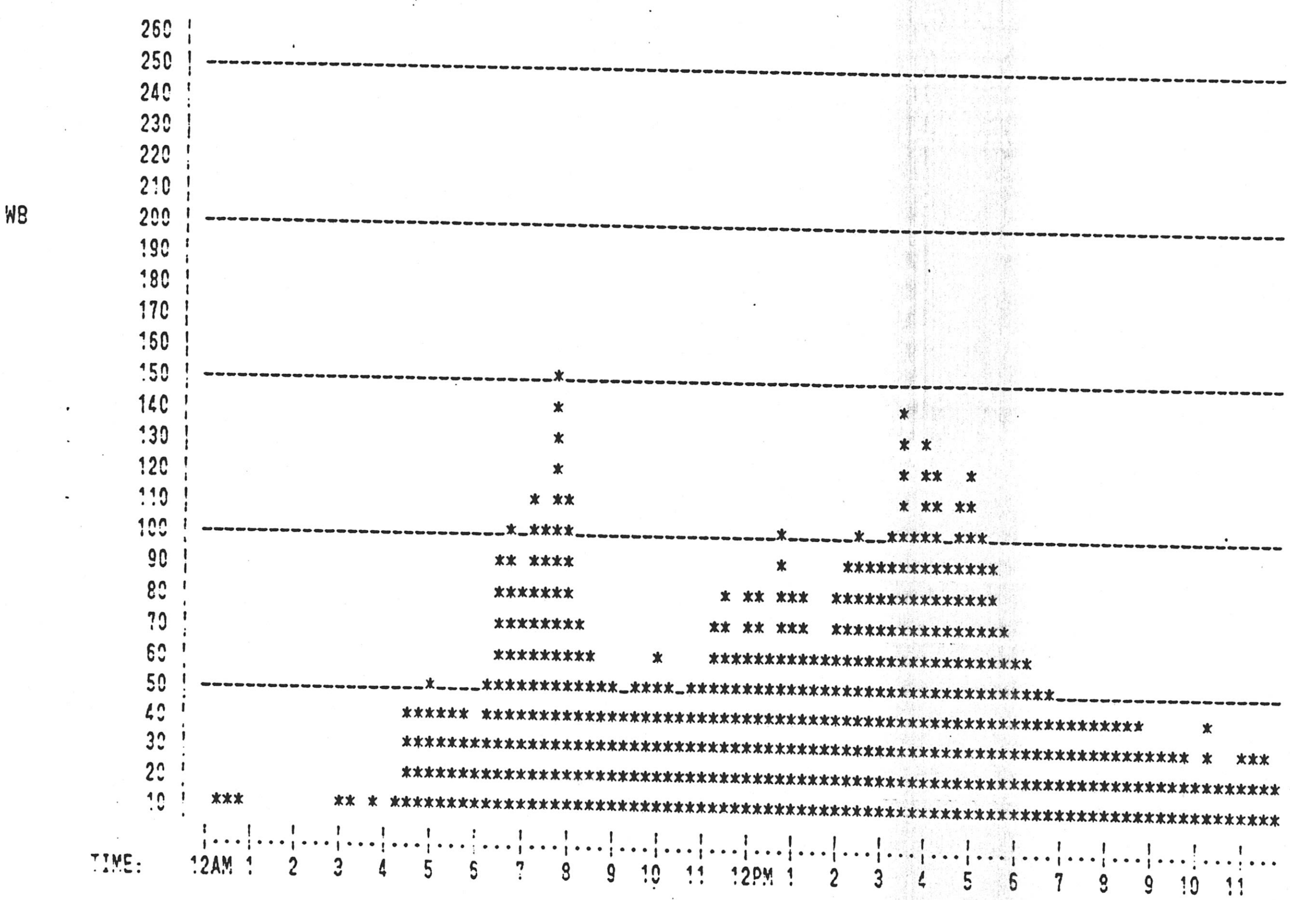


WEATHER : drizzly
ENG. DEPT.: PV & CQ

FILE: lwrd2

DATE: 4/07/88

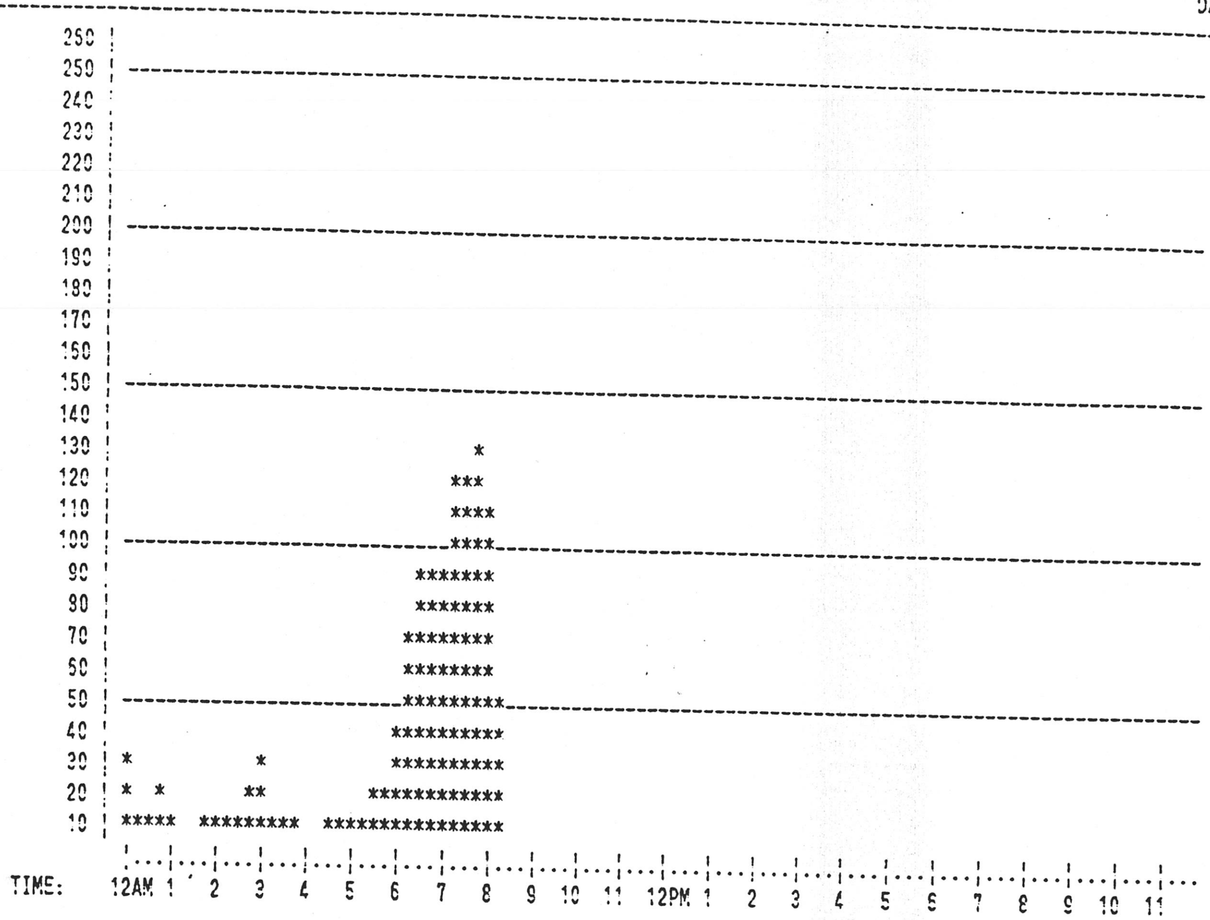




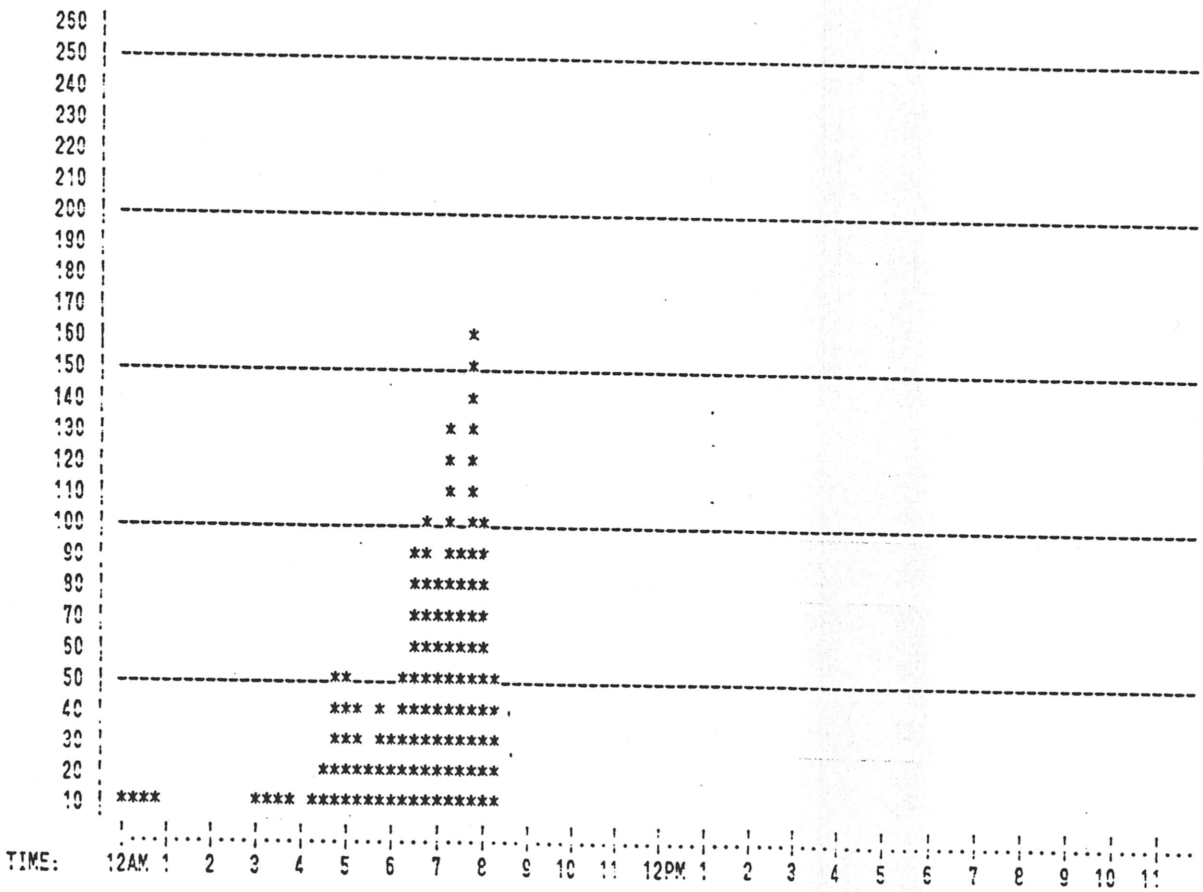
ENG. DEPT.: PV & CQ

DATE: 4/08/88

EB



WB



LOCATION : Bellamy Rd. near [illegible]
WEATHER : drizzly
ENG. DEPT.: PV & CQ

PAGE: [illegible]
FILE: bellamy
DATE: 4/11/88

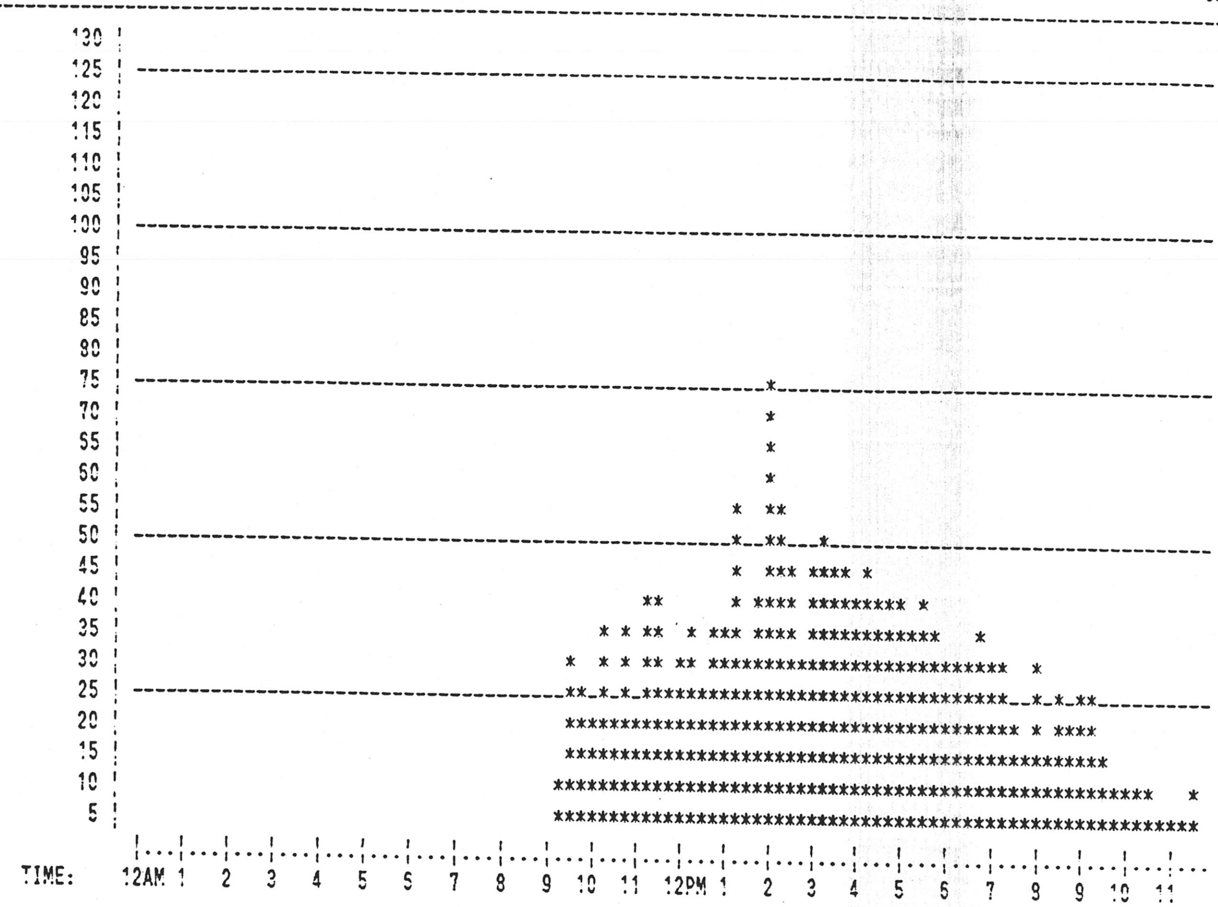
TIME BEGIN	MONDAY-11 : Ch 1 AM	Ch 1 PM	Ch 2 AM	Ch 2 PM	COMBINED AM	COMBINED PM	TUESDAY-12 : Ch 1 AM	Ch 1 PM	Ch 2 AM	Ch 2 PM	COMBINED AM	COMBINED PM
12:00	*	30	*	32	*	62	0	*	5	*	5	*
12:15	*	25	*	29	*	54	2	*	1	*	3	*
12:30	*	29	*	20	*	49	2	*	3	*	5	*
12:45	*	33	*	23	*	56	3	*	3	*	6	*
1:00	*	36	*	24	*	60	2	*	4	*	6	*
1:15	*	54	*	33	*	87	3	*	1	*	4	*
1:30	*	28	*	21	*	49	2	*	4	*	6	*
1:45	*	39	*	37	*	76	3	*	2	*	5	*
2:00	*	73	*	40	*	113	3	*	1	*	4	*
2:15	*	54	*	44	*	98	2	*	1	*	3	*
2:30	*	44	*	32	*	76	3	*	0	*	3	*
2:45	*	29	*	44	*	73	10	*	0	*	10	*
3:00	*	43	*	41	*	84	2	*	1	*	3	*
3:15	*	52	*	46	*	98	1	*	1	*	2	*
3:30	*	44	*	38	*	82	0	*	0	*	0	*
3:45	*	45	*	48	*	93	0	*	0	*	0	*
4:00	*	38	*	44	*	82	0	*	2	*	2	*
4:15	*	43	*	41	*	84	1	*	1	*	2	*
4:30	*	38	*	42	*	80	4	*	5	*	9	*
4:45	*	38	*	45	*	83	2	*	2	*	4	*
5:00	*	42	*	42	*	84	1	*	1	*	2	*
5:15	*	34	*	50	*	84	5	*	6	*	11	*
5:30	*	38	*	46	*	84	2	*	14	*	16	*
5:45	*	34	*	54	*	88	8	*	11	*	19	*
6:00	*	31	*	42	*	73	5	*	16	*	21	*
6:15	*	29	*	39	*	68	15	*	16	*	31	*
6:30	*	28	*	28	*	56	25	*	33	*	58	*
6:45	*	34	*	33	*	67	23	*	44	*	67	*
7:00	*	29	*	27	*	56	29	*	70	*	99	*
7:15	*	28	*	24	*	52	51	*	119	*	170	*
7:30	*	18	*	30	*	48	56	*	67	*	123	*
7:45	*	13	*	17	*	30	51	*	39	*	90	*
8:00	*	28	*	15	*	43	42	*	31	*	73	*
8:15	*	17	*	9	*	26	33	*	34	*	67	*
8:30	*	25	*	22	*	47	*	*	*	*	*	*
8:45	*	22	*	10	*	32	*	*	*	*	*	*
9:00	*	23	*	20	*	43	*	*	*	*	*	*
9:15	9	27	9	13	18	40	*	*	*	*	*	*
9:30	30	16	30	19	60	35	*	*	*	*	*	*
9:45	24	12	29	18	53	30	*	*	*	*	*	*
10:00	21	9	16	9	37	18	*	*	*	*	*	*
10:15	34	12	24	11	58	23	*	*	*	*	*	*
10:30	22	12	23	7	45	19	*	*	*	*	*	*
10:45	33	7	24	4	57	11	*	*	*	*	*	*
11:00	19	7	19	10	38	17	*	*	*	*	*	*
11:15	39	3	23	7	52	10	*	*	*	*	*	*
11:30	39	9	23	2	62	11	*	*	*	*	*	*
11:45	27	2	29	0	56	2	*	*	*	*	*	*
TOTALS	297	1411	249	1332	546	2743	391	*	538	*	929	*
DAY TOTALS	1708		1581		3289		391		538		929	
% TOTAL	54.4	51.4	45.6	48.6			42.1	*	57.9	*		
PEAK HOUR	10:45	1:45	9:30	5:00	10:45	1:45	7:15	*	6:45	*	7:00	*
VOLUME	130	210	99	192	219	363	200	*	300	*	492	*
P.H.F.	0.83	0.72	0.82	0.89	0.89	0.80	0.89	*	0.63	*	0.71	*

LOCATION : Bellamy Rd. near RT 155
WEATHER : drizzly
ENG. DEPT.: PV & CQ

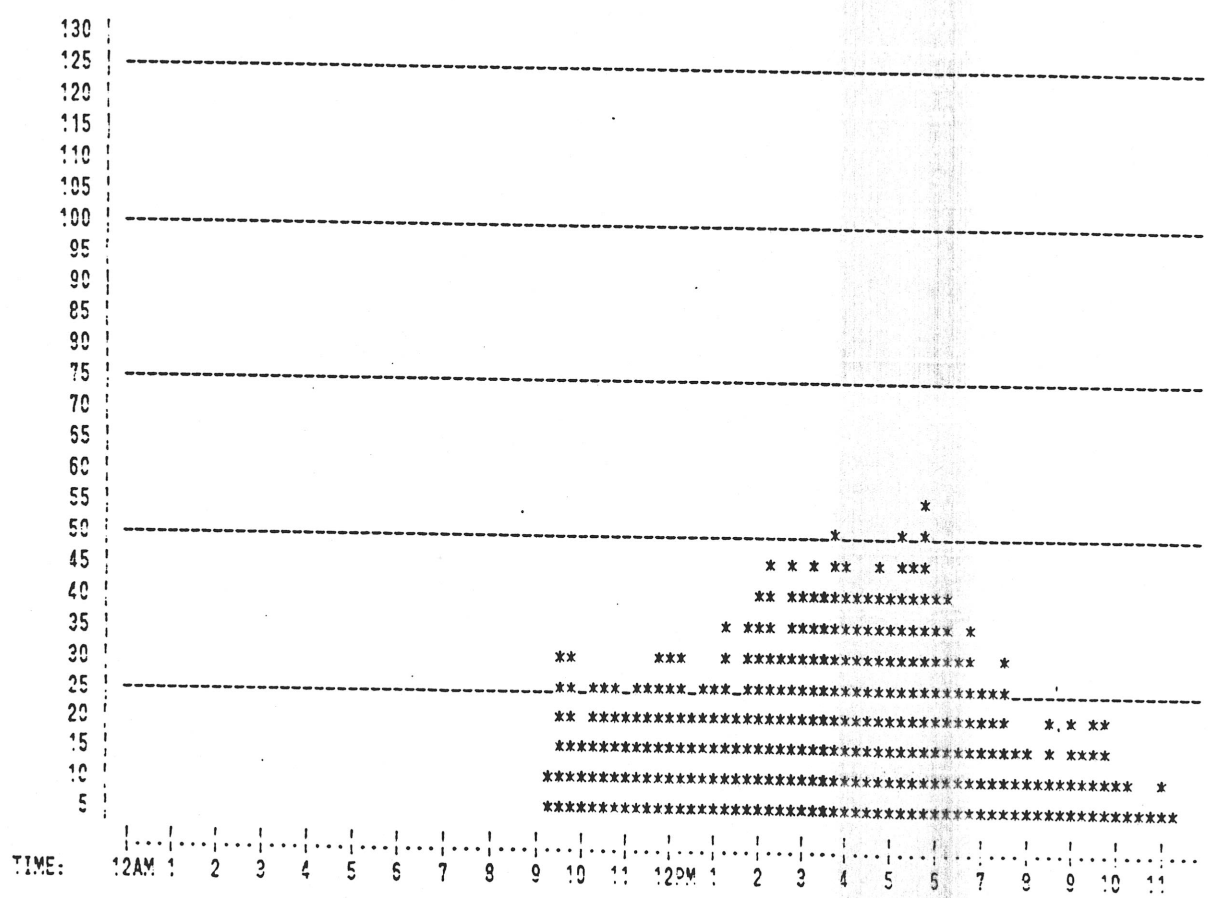
FILE: bellamy

DATE: 4/11/88

Ch 1



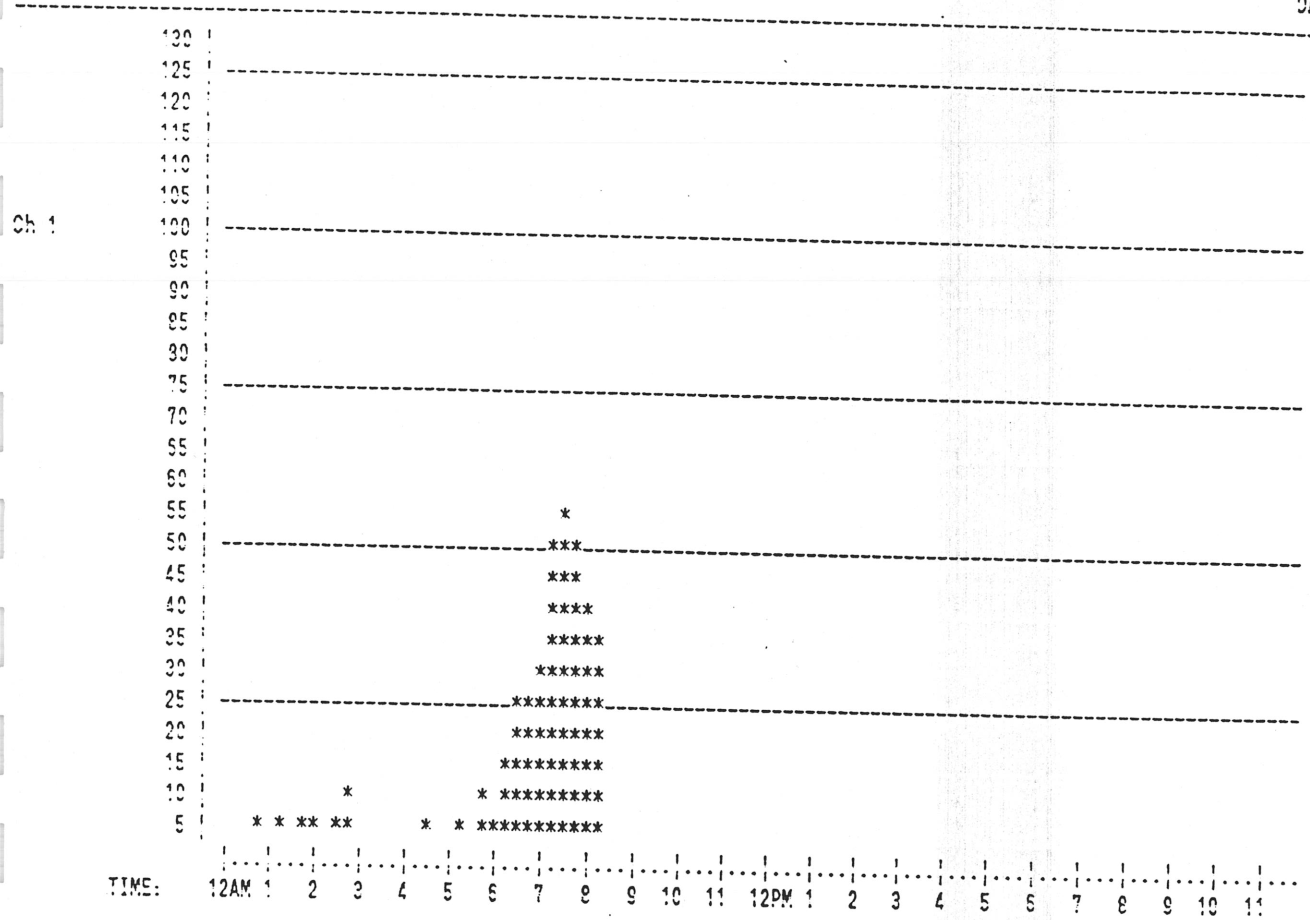
Ch 2

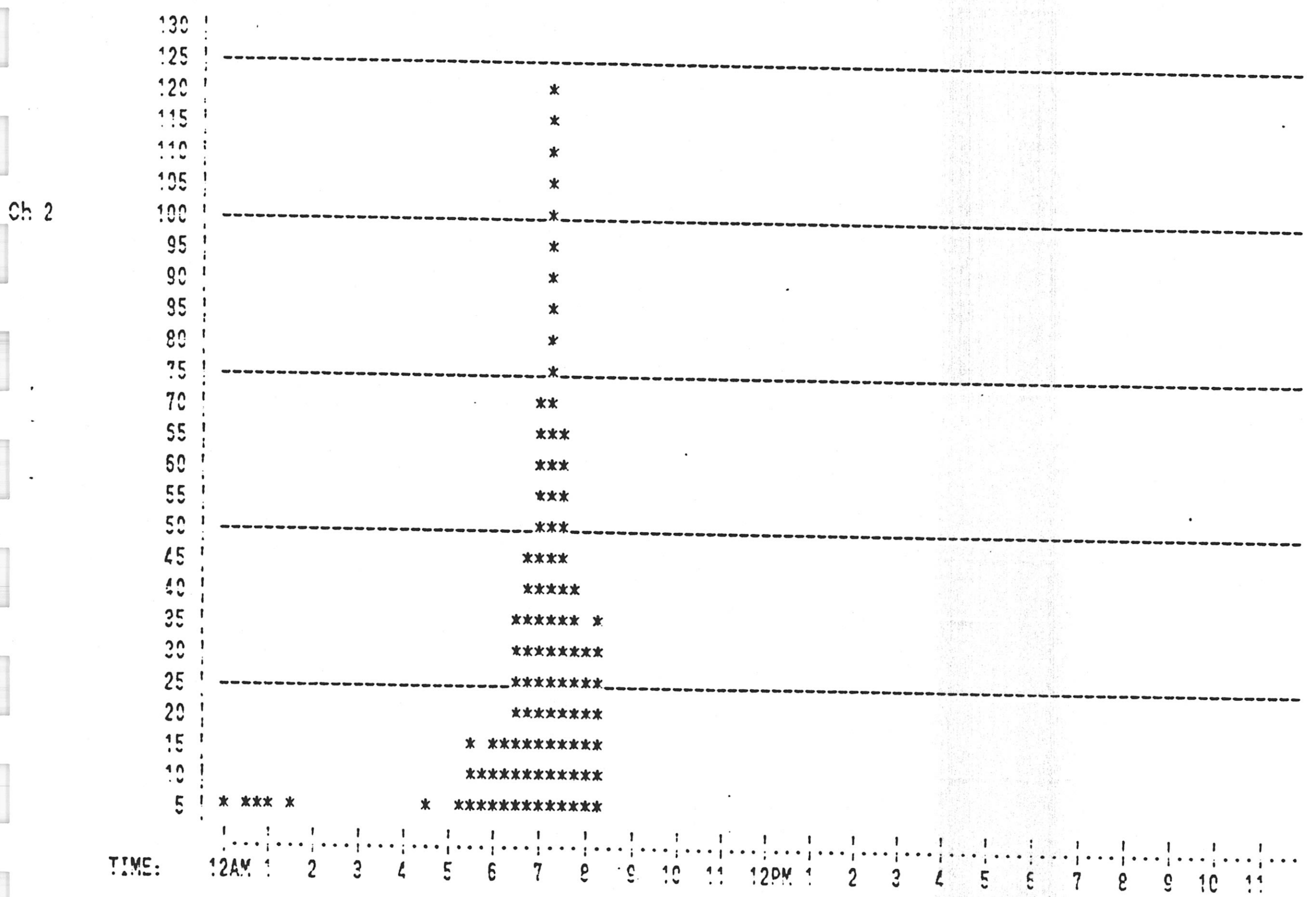


WEATHER : drizzly
ENG. DEPT.: PV & CQ

PAGE: 2
FILE: bellamy

DATE: 4/12/88





LOCATION : Crosby Road s/o Littleworth
WEATHER : Drizzle
ENG. DEPT.: C.Q. & P.V.

FILE: crosby2

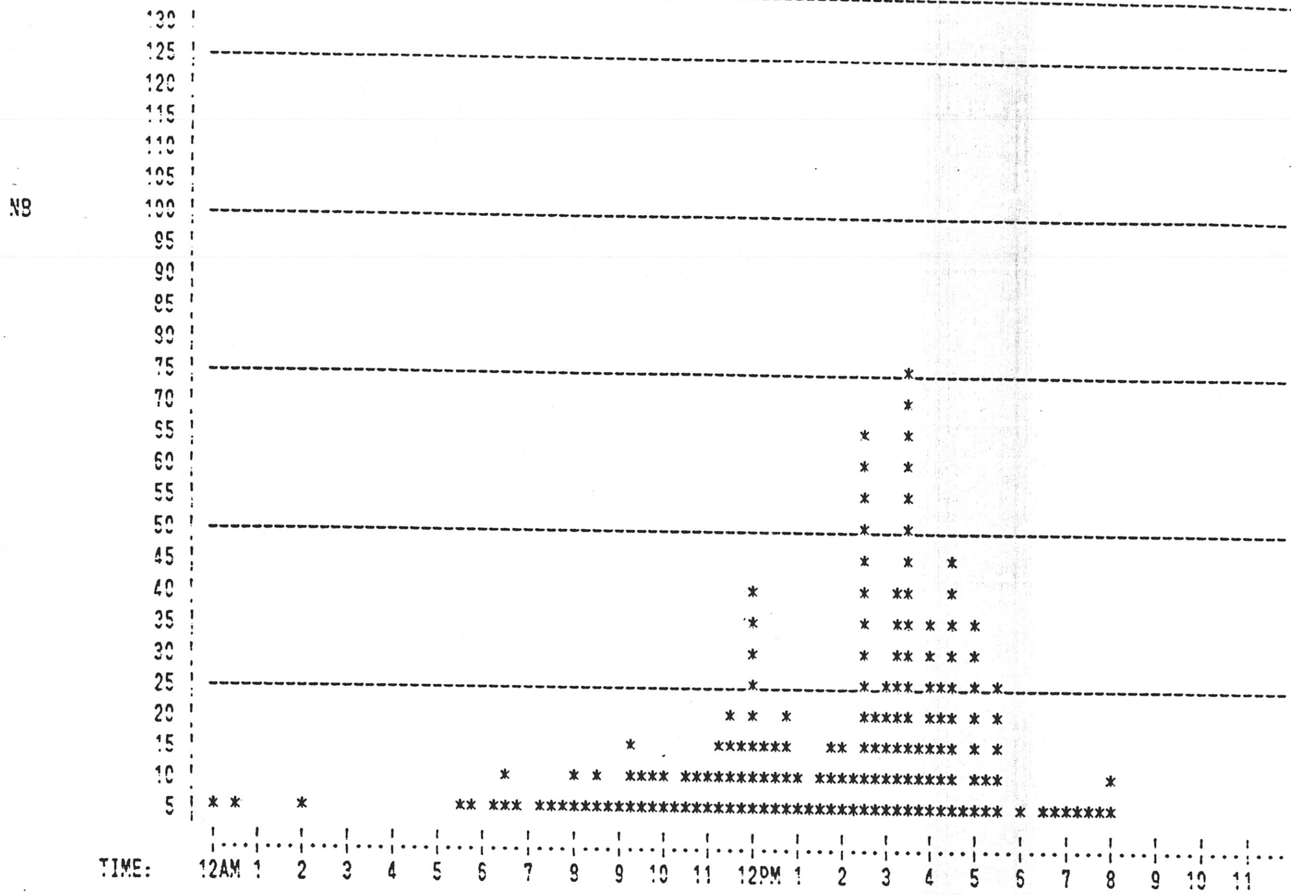
DATE: 4/13/88

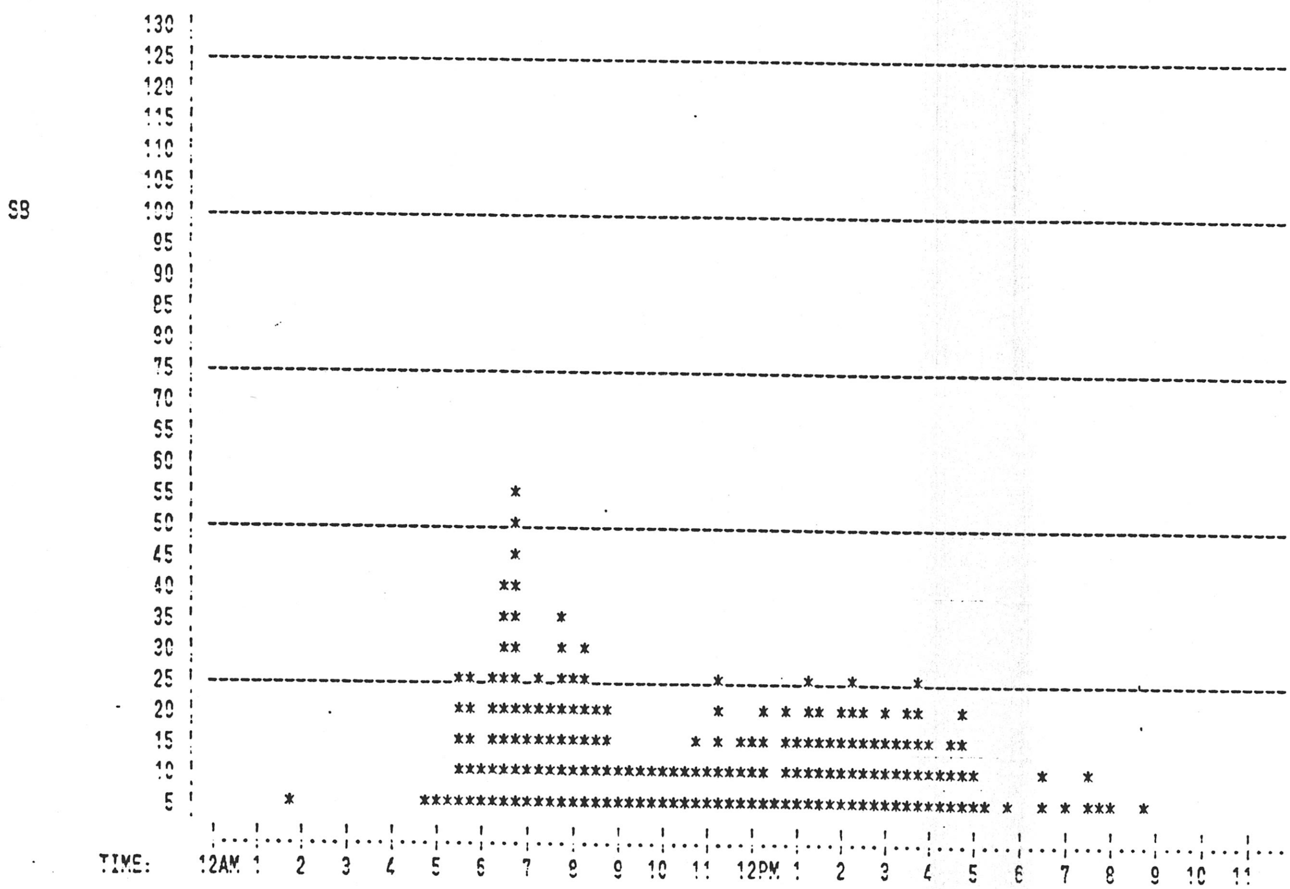
TIME BEGIN	WEDNESDAY-13 : NB AM	NB PM	SB AM	SB PM	COMBINED AM	COMBINED PM	THURSDAY-14 : NB AM	NB PM	SB AM	SB PM	COMBINED AM	COMBINED PM
12:00	3	42	1	16	4	58	1	46	1	29	2	75
12:15	0	14	0	21	0	35	1	15	0	32	1	47
12:30	5	17	1	7	6	24	4	11	2	18	6	29
12:45	2	18	0	22	2	40	4	19	1	26	5	45
1:00	0	10	0	17	0	27	1	13	0	40	1	53
1:15	0	3	0	23	0	26	0	17	0	23	0	40
1:30	0	8	0	18	0	26	0	8	0	21	0	29
1:45	1	14	3	15	4	29	1	10	1	19	2	29
2:00	6	14	1	18	7	32	2	14	2	22	4	36
2:15	0	9	0	27	0	36	0	13	0	39	0	52
2:30	0	64	0	21	0	85	1	57	1	23	2	80
2:45	0	20	0	14	0	34	0	12	0	20	0	32
3:00	0	26	0	18	0	44	0	27	0	20	0	47
3:15	0	40	0	17	0	57	0	30	0	15	0	45
3:30	0	75	0	18	0	93	0	62	0	32	0	94
3:45	0	15	0	27	0	42	0	20	0	27	0	47
4:00	0	37	0	13	0	50	0	35	0	23	0	58
4:15	0	27	0	11	0	38	0	27	0	11	0	38
4:30	0	44	1	15	1	59	0	47	2	15	2	62
4:45	0	7	7	21	7	28	1	22	5	5	6	27
5:00	0	36	3	8	3	44	1	32	3	8	4	40
5:15	2	12	7	3	9	15	1	13	1	3	2	16
5:30	6	25	23	2	29	27	3	11	10	1	13	12
5:45	5	1	27	5	32	6	7	4	23	6	30	10
6:00	2	4	9	0	11	4	1	3	8	0	9	3
6:15	3	2	27	1	30	3	4	1	18	1	22	2
6:30	9	5	40	8	49	13	7	0	30	1	37	1
6:45	7	4	54	2	61	6	13	1	43	2	56	3
7:00	2	5	19	3	21	8	5	3	24	1	29	4
7:15	4	3	26	1	30	4	3	4	22	4	25	8
7:30	5	6	19	9	24	15	3	5	14	3	17	8
7:45	3	4	35	6	38	10	5	5	35	3	40	8
8:00	8	9	23	3	31	12	9	4	32	3	41	7
8:15	5	0	31	1	36	1	7	0	26	2	33	2
8:30	10	2	19	1	29	3	15	1	22	2	37	3
8:45	7	2	18	3	25	5	6	2	16	0	22	2
9:00	7	2	10	1	17	3	7	3	16	0	23	3
9:15	14	0	11	0	25	0	14	0	12	0	26	0
9:30	10	1	11	0	21	1	5	1	10	0	15	1
9:45	8	2	12	0	20	2	7	0	17	0	24	0
10:00	8	2	10	2	18	4	9	3	16	0	25	3
10:15	5	2	11	2	16	4	13	1	12	0	25	1
10:30	12	0	8	1	20	1	6	0	5	0	11	0
10:45	10	2	14	1	24	3	11	0	29	0	40	0
11:00	12	2	12	1	24	3	16	4	18	0	34	4
11:15	13	0	23	0	36	0	14	0	15	0	29	0
11:30	19	0	12	0	31	0	16	0	12	0	28	0
11:45	13	0	16	0	29	0	14	2	31	1	45	3
TOTALS	226	637	544	423	770	1060	238	608	535	501	773	1109
DAY TOTALS	863		967		1830		846		1036		1882	
% TOTAL	29.4	60.1	70.6	39.9			30.8	54.8	69.2	45.2		
PEAK HOUR	11:00	3:15	6:15	1:45	6:15	3:15	11:00	3:15	6:30	12:15	7:45	3:15
VOLUME	57	167	140	91	161	242	60	147	119	116	151	244
P.H.F.	0.75	0.59	0.65	0.75	0.66	0.65	0.94	0.59	0.69	0.73	0.92	0.65

LOCATION : Crosby Road
WEATHER : Drizzle
ENG. DEPT.: C.Q. & P.V.

FILE: crosby2

DATE: 4/13/88





TRAFFIC MOVEMENT SUMMARY TABLE

TOWN........DOVER LOCATION..RT9/INDUSTRIAL(W) DATE:......4/13/88
DAY OF WEEK:WED WEATHER... ROAD SURFACE....
COMPLETED BY:M

TIME PERIODS	A EAST-BOUND ON RTE 9 S	R	TOT.	B WEST-BOUND ON RTE 9 L	S	TOT.	C NORTH-BOUND ON IND. (W) L	R	TOT.	TOTAL 15 MIN. TALLY	HOURLY TOTALS
3:30-3:45	92	23	115	33	84	117	11	22	33	265	
3:45-4:00	50	17	67	32	86	118	58	95	153	338	
4:00-4:15	74	6	80	40	114	154	52	48	100	334	
4:15-4:30	60	14	74	26	95	121	7	19	26	221	1158
4:30-4:45	66	2	68	6	86	92	11	12	23	183	1076
4:45-5:00	59	8	67	14	102	116	9	17	26	209	947
5:00-5:15	67	3	70	11	85	96	28	18	46	212	825
5:15-5:30	47	3	50	8	95	103	12	9	21	174	778
TOTAL	515	76	591	170	747	917	188	240	428	1936	
TOTAL OF L,S,R			591			917			428		

FILE NAME: RT9-IW

TRAFFIC MOVEMENT SUMMARY TABLE

TOWN........DOVER LOCATION..RT9/INDUSTRIAL(E) DATE:......4/13/88
DAY OF WEEK:WED WEATHER... ROAD SURFACE....
COMPLETED BY:S

TIME PERIODS	A EAST-BOUND ON RTE 9 S	R	TOT.	B WEST-BOUND ON RTE 9 L	S	TOT.	C NORTH-BOUND ON IND. (E) L	R	TOT.	TOTAL 15 MIN. TALLY	HOURLY TOTALS
3:30-3:45	129	0	129	6	106	112	4	29	33	274	
3:45-4:00	138	0	138	7	137	144	1	16	17	299	
4:00-4:15	177	0	177	8	141	149	19	55	74	400	
4:15-4:30	75	0	75	4	126	130	6	22	28	233	1206
4:30-4:45	100	2	102	4	108	112	2	29	31	245	1177
4:45-5:00	65	0	65	5	111	116	3	18	21	202	1080
5:00-5:15	88	0	88	5	100	105	1	56	57	250	930
5:15-5:30	67	1	68	2	106	108	1	26	27	203	900
TOTAL	839	3	842	41	935	976	37	251	288	2106	
TOTAL OF L,S,R			842			976			288		

FILE NAME: RT9-IE

TRAFFIC MOVEMENT SUMMARY TABLE

TOWN........DOVER LOCATION.......ROUTE 9/ROUTE 155 DATE:.....4/14/88
DAY OF WEEK:THURS WEATHER........ ROAD SURFACE.... COMPLETED BY....S+M+J

TIME PERIODS	A EAST-BOUND ON RTE 9 L	S	R	TOT.	B NORTH-BOUND ON RTE 155 L	S	R	TOT.	C SOUTH-BOUND ON RTE 155 L	S	R	TOT.	D WEST-BOUND ON BELLEMY RD L	S	R	TOT.	TOTAL 15 MIN. TALLY	HOURLY TOTALS
3:30-3:45	152		11	163	19	169	18	206	37	96	110	243	12		31	43	655	
3:45-4:00	91		5	96	8	115	7	130	31	104	113	248	9		27	36	510	
4:00-4:15	194		15	209	9	141	10	160	31	94	97	222	7		37	44	635	
4:15-4:30	93		4	97	8	87	8	103	31	82	104	217	10		44	54	471	2271
4:30-4:45	109		8	117	8	115	16	139	24	92	98	214	10		39	49	519	2135
4:45-5:00	89		12	101	7	149	17	173	42	108	121	271	16		31	47	592	2217
5:00-5:15	137		11	148	9	129	17	155	45	96	101	242	8		43	51	596	2178
5:15-5:30	119		10	129	12	159	12	183	51	132	98	281	10		36	46	639	2346
TOTAL	984	0	76	1060	80	1064	105	1249	292	804	842	1938	82	0	288	370	4617	
TOTAL OF L,S,R				1060				1249				1938				370		

FILE NAME: RT9-115

TECHNICAL MEMORANDUM NO. 3

LITTLEWORTH ROAD (N.H. ROUTE 9) CORRIDOR STUDY

APPENDIX C

TRIP GENERATION FACTORS

Reference: Institute of Transporation Engineers
"Trip Generation", 1982

100—Industrial/Agricultural

Industrial

The categories of industrial activities surveyed include light industry, industrial parks, manufacturing and warehouses. Many of the categories overlap, for example, manufacturing and warehousing facilities often occupy the same building. Occasionally, there is a problem in distinguishing between comparable land uses such as light industrial and manufacturing. In cases where doubt exists as to the exact category of industrial use, it is suggested that the following composite rates of average weekday trip ends be used:

Measure	*Average Weekday Trip Ends*
Per employee	3.0
Per 1,000 gross square feet of floor area	5.43
Per acre	59.9

The following tables summarize composite trip generation rates for all industrial categories from the data assembled to date.

Nearly all of the more than 80 cases analyzed were on the East and West Coasts of the United States. Additional data from noncoastal states are needed to verify the accuracy of the information acquired up to this time.

Little data were found with regard to weekend trip generation for industrial facilities. Except in unusual circumstances, however, it may be assumed that weekend trips to and from industrial areas will be nominal in comparison with weekday rates.

Finally, substantially more information is needed with regard to traffic movements during shift changes at industrial facilities operated around the clock. While the trip rates described herein refer to peak directional movements, the transportation planner should be cognizant of potential opposing traffic as well as the need for surplus parking space during shift overlap.

SUMMARY OF TRIP GENERATION RATES

Land Use/Building Type Industrial ITE Land Use Code 100

Independent Variable—Trips per Acre

			Average Trip Rate	Maximum Rate	Minimum Rate	Correlation Coefficient	Number of Studies	Average Size of Independent Variable/Study
Average Weekday Vehicle Trip Ends			59.9	441.2	3.5		87	
Peak Hour of Adjacent Street Traffic	A.M. Between 7 and 9	Enter						
		Exit						
		Total	9.3	124.0	0.5		66	
	P.M. Between 4 and 6	Enter						
		Exit						
		Total	12.0	148.0	0.6		62	
One Hour	A.M. Between 6:00 and 7:30	Enter						
		Exit						
		Total	11.5	124.0	0.5		84	
	P.M. Between 3:00 and 4:30	Enter						
		Exit						
		Total	10.0	148.0	0.6		84	
Saturday Vehicle Trip Ends								
Peak Hour of Generator		Enter						
		Exit						
		Total						
Sunday Vehicle Trip Ends								
Peak Hour of Generator		Enter						
		Exit						
		Total						

Source Numbers

ITE Technical Committee 6A-6—Trip Generation Rates

Date: 1975, Rev. 1979

110—General Light Industrial

Description: Light industrial facilities usually employ less than 500 persons with an emphasis on other than manufacturing. Nevertheless, the distinction between light industrial and manufacturing (Category 140) land uses is sometimes vague. Light industries typical of those included in this category are printing plants, material testing laboratories, assemblers of data processing equipment and power stations.

All of the light industries surveyed were free-standing facilities devoted to one use. The number of employees ranged from 76 to 413 with an average of 202. Average gross floor space per employee was 587 square feet—or 1.7 employees per 1,000 square feet of floor space. The employee density per acre of developed land was 16.4. Buildings ranged in size from 21,000 to 328,000 square feet.

Trip Characteristics: Since parking spaces are usually determined by the size of the building, it is recommended that parking spaces should not be used as a predictive independent variable for calculating average weekday vehicle trip ends.

On the average, light industrial facilities generate 3.2 weekday vehicle trip ends per employee and 5.5 vehicle trip ends per 1,000 gross square feet of floor area. See the following table for daily and peak hour trip generation rates.

Light industrial facilities usually generate trips at the same time as adjacent street traffic (7 to 9 A.M. and 4 to 6 P.M.), as indicated in the following tables.

Data Limitations: No data were available on vehicle occupancy for trips to and from light industrial areas. The average was approximately 1.3 persons per vehicle for all industrial uses.

More information is needed concerning peak period directional distribution of traffic during shift changes as well as vehicle occupancy.

SUMMARY OF TRIP GENERATION RATES

Land Use/Building Type General Light Industrial ITE Land Use Code 110
Independent Variable—Trips per Acre

			Average Trip Rate	Maximum Rate	Minimum Rate	Correlation Coefficient	Number of Studies	Average Size of Independent Variable/Study
Average Weekday Vehicle Trip Ends			52.4	159.4	5.2		13	12.3
Peak Hour of Adjacent Street Traffic	A.M. Between 7 and 9	Enter	18.2	18.7	16.7		2	9.8
		Exit	3.3	3.3	3.3		2	9.8
		Total	11.4	34.4	1.6		10	11.5
	P.M. Between 4 and 6	Enter	6.9	7.3	5.4		2	9.8
		Exit	13.6	18.7	12.0		2	9.8
		Total	10.1	28.0	1.3		8	12.9
One Hour	A.M.	Enter						
		Exit						
		Total						
	P.M. Between 3:00 and 4:30	Enter	6.9	7.3	5.4		2	9.8
		Exit	13.3	18.7	11.8		3	7.6
		Total	11.4	31.2	1.3		12	11.1
Saturday Vehicle Trip Ends			25.2	43.5	4.7		3	9.0
Peak Hour of Generator		Enter						
		Exit						
		Total	5.4	7.1	4.0		2	9.2
Sunday Vehicle Trip Ends								
Peak Hour of Generator		Enter						
		Exit						
		Total						

Source Numbers 7, 9, 10, 11, 15, 17

ITE Technical Committee 6A-6—Trip Generation Rates
Date: 1975, Rev. 1979

Description: Industrial parks are areas containing a number of industrial or related facilities. They are characterized by a mix of manufacturing, service and warehouse facilities with a wide variation in the proportion of each type of use from one location to another. Many industrial parks contain highly diversified facilities—some with a large number of small businesses and others with one or two dominant industries.

The number of employees in industrial parks surveyed ranged from 88 to 5,300 with an average of 747. Gross square feet of floor area per employee averaged 510, or about two employees per 1,000 gross square feet of building area, and 18 employees per acre of developed land. Size of the industrial parks surveyed ranged from 1.6 to 115 acres with an average of approximately 40 acres.

Trip Characteristics: An analysis of correlation between average weekday vehicle trip ends and all measurable variables was made to determine the best variable for use in predicting vehicle trip ends. From the data assembled to date, number of employees has been found to have the highest correlation with average weekday vehicle trip ends. Gross square feet of floor area and total area occupied by the industrial park showed less correlation with average weekday trip ends, as shown in the table.

Since parking spaces are usually determined on the basis of the building size, it is recommended that parking not be used as a predictive variable for calculating trip ends.

On the average, industrial parks generate 3.6 weekday vehicle trip ends per employee. See the following tables for daily and peak hour trip generation rates.

Industrial park trips usually peak at the same time as the adjacent street traffic (7 to 9 A.M. and 4 to 6 P.M.), as indicated in the table.

Data Limitations: Caution should be exercised when using average trip generation rates found for industrial parks. The data showed wide inconsistencies (average weekday vehicle trip ends ranged from 1.4 to 8.8 per employee), believed to be due to differences in the mix of activities from one park to another.

It is recommended that traffic generation of industrial parks be forecast using rates for each type and amount of activity, i.e., manufacturing, office, warehouse, light industrial, etc. The combined result of these calculations should give a more realistic rate than the average indicated herein. It is not believed that additional data sources will improve validity of an average rate for all industrial parks.

Equations and Correlation Between Average Weekday Vehicle Trip Ends (AWDVTE) and the Independent Variables for Industrial Parks.

Equations and Independent Variables	*Correlation Coefficient (R)*
AWDVTE = 278.2 + 3.45 × Number of Employees	0.827
= 1103.1 + 4.178 × Thousands of Gross Square Feet	0.528
= 1712.0 + 24.45 × Number of Acres	0.376
Parking Spaces	0.799

SUMMARY OF TRIP GENERATION RATES

Land Use/Building Type Industrial Park ITE Land Use Code 130

Independent Variable—Trips per Acre

			Average Trip Rate	Maximum Rate	Minimum Rate	Correlation Coefficient	Number of Studies	Average Size of Independent Variable/Study
Average Weekday Vehicle Trip Ends			62.8	1272	14		41	40
Peak Hour of Adjacent Street Traffic	A.M. Between 7 and 9	Enter	10.1	18.4	7.9		7	34
		Exit	3.2	5.8	2.5		5	44
		Total	10.2	41.2	3.4		18	42
	P.M. Between 4 and 6	Enter	3.0	3.5	2.7		4	76
		Exit	9.4	12.9	6.9		4	76
		Total	10.9	59.4	3.2		18	47
Peak Hour of Generator	A.M.	Enter	8.1	21.2	3.1		8	40
		Exit	2.0	32.6	1.0		4	59
		Total	8.0	48.8	2.9		29	46
	P.M.	Enter	4.1	87.4	1.3		9	36
		Exit	8.5	9.2	5.6		3	78
		Total	8.5	59.4	2.1		29	46
Saturday Vehicle Trip Ends			41.1	564	12		10	30
Peak Hour of Generator		Enter	1.8	31.6	0.8		8	33
		Exit	3.3	31.6	0.6		3	57
		Total	4.8	6.0	4.6		2	94
Sunday Vehicle Trip Ends			10.0	99	0.9		10	30
Peak Hour of Generator		Enter	0.4	5.3	0.2		8	33
		Exit	0.4	5.3	0.2		3	57
		Total	1.0	2.8	0.7		2	94

Source Numbers 7, 10, 14, 68, 74, 85, 91, 100

ITE Technical Committee 6A-6—Trip Generation Rates

Date: 1975, 1979, Rev. 1982

820 – 828 — Shopping Center

Description: A shopping center is an integrated group of commercial establishments which is planned, developed, owned and managed as a unit. It is related to its market area in terms of size, location and type of store. It is provided with off-site parking facilities.*

Studies of over 3.25 different shopping centers were obtained for this analysis and included centers as small as 6,900 to as large as 1,600,000 gross square feet of leasable area. The centers studied are located throughout the United States and throughout urban areas and therefore reflect average conditions anywhere within the United States.

Some of the centers included nonmerchandising uses: office buildings, theatres, post offices, banks, health clubs and recreational facilities such as ice skating rinks.

Trip Characteristics: The calculated vehicle trip end rates based on 1,000 gross square feet exhibited a wide range in results for similar size centers. There are many probable reasons for this lack of correlation and range in trip generation rates:

- types of tenants
- method of marketing the center and tenants' merchandise
- density of the market area
- newness of a center in a relatively undeveloped market area
- size of center
- categorization of centers by type and size.

The independent variable, 1,000 gross square feet of leasable building area, has not shown a good correlation for estimating trips but no other variable has been found to better describe a center and calculate trip generation rates. Therefore, it is used for all rate calculations for shopping centers.

As shown in Figure 2, the average weekday vehicle trip rates decrease as gross leasable area increases. The traditional categorization of regional, community and neighborhood centers was not used to express rates because the size of centers vary too much within each category which results in a wide variation in trip rates.

To obtain peak hour and weekday trip generation characteristics, the shopping centers were grouped into nine different size categories whose characteristics are summarized in the following trip generation tables.

The rates shown are averages within each size category. The average size center with each size category as related to the average rate is shown in the column labeled Average Size Independent Variable/Study.

The average rates can be estimated for centers of a different size from the average within a size category by interpolating between the average rates and average size center of two adjacent size categories.

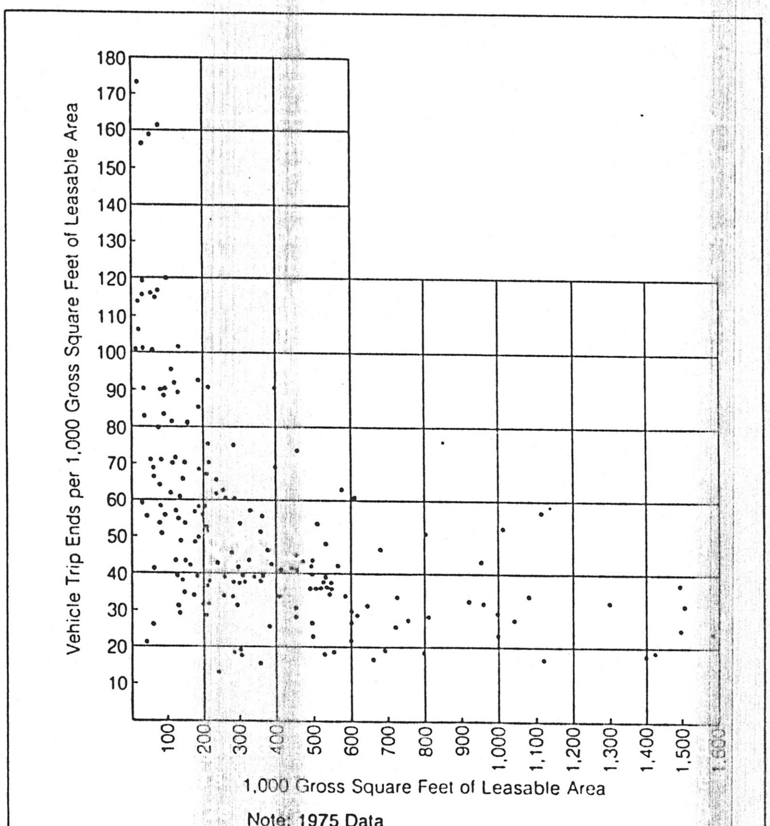


Figure 2.

*Urban Land Institute

Table 1. Correlations Between Average Weekday Vehicle Trip Ends and Gross Square Feet for Shopping Centers

Land Use	Correlation Coefficient (R)
820	0.491
821	0.226
822	0.299
823	0.128
824	0.204
825	−0.275
826	0.562
827	0.696
828	——— (Not enough data)

Limited research has been conducted to determine what portion of the driveway volumes is actually added to the adjacent street system and what portion is diverted from the passing stream of traffic. Slade and Gorove[1] found through interviews at one shopping center in Washington, D.C., between 4:30 and 6:00 P.M. that 35 percent of the trips were primary trips to the center. Forty percent of the trips were diverted from another route to shop and the remaining 25 percent of the trips came from the passing stream of traffic. For more information, see this article. Buttke[2] measured between 20 and 25 percent of the P.M. peak hour entering volume to a shopping center in Portland, Oregon, to be diverted from the passing stream of traffic.

A variation in trips to and from shopping centers occurs throughout the year. Table 2 indicates a generalized monthly variation in traffic entering and dollar sales at shopping centers in excess of 500,000 gross square feet of leasable area.

The data upon which Table 2 is based are limited but do show that trip ends are not directly related to dollar sales. During the midyear, people tend to make more trips per dollar sales, probably because more time is spent shopping for an item. Prior to holidays, and especially at Christmas, people spend more money in relation to vehicle trips to a center.

[1]Slade, Louis J. and Frederick E. Gorove, "Reductions in Estimates of Traffic Impacts of Regional Shopping Centers," *ITE Journal*, January 1981, Vol. 51, No. 1, pp. 16-18.
[2]Buttke, Carl H., Unpublished trip generation measurements, Portland, Oregon, 1975.

Data Limitations: A wide variation in calculated trip rates has resulted from the data obtained for the probable reasons indicated. More research is necessary in measuring shopping center trip generation to adjust the measurements to variations within the week and by month of the year. More peak-hour data by direction during average weekdays, weekends and during the peak days and months of the year are necessary. Additional statistical analyses should be made to develop usable generation equations which express the decreasing trend in rates as the centers increase in size.

Table 2. Monthly Variation in Traffic and Sales.

	Percent of Average Monthly Traffic Volume	Percent of Average Monthly Sales
January	70	80
February	60	65
March	100	85
April	90	80
May	110	95
June	110	92
July	103	90
August	100	115
September	95	95
October	115	102
November	105	110
December	150	200

Source: 1. Two Confidential Regional Shopping Centers in Washington, 1971, and One Shopping Center in California, 1965.
2. Cleveland, Donald E., and Edward A. Mueller, *Traffic Characteristics at Regional Shopping Centers.* New Haven, Connecticut: Bureau of Highway Traffic, Yale University, 1961.

Further research is necessary to determine if low generation rates for the new large shopping centers are a result of combined trip making through a greater number of shops at one destination or because the market area is not fully developed. It could also be a combination of these and other factors.

The described rates are driveway volumes of vehicles entering and leaving shopping centers. More research is necessary to determine what portion of the driveway volumes is made up of traffic that would have passed the site in any case while making a trip for another reason.

SUMMARY OF TRIP GENERATION RATES

Land Use/Building Type Shopping Center 400,000-499,999 G.S.F. ITE Land Use Code 825

Independent Variable—Trips per 1,000 Gross Square Feet of Leasable Area

			Average Trip Rate	Maximum Rate	Minimum Rate	Correlation Coefficient	Number of Studies	Average Size of Independent Variable/Study
Average Weekday Vehicle Trip Ends			49.7	102.0	27.2		16	441
Peak Hour of Adjacent Street Traffic	A.M. Between 7 and 9	Enter	0.3				1	473
		Exit	0.2				1	473
		Total	0.5				1	473
	P.M. Between 4 and 6	Enter	1.9				1	473
		Exit	1.9				1	473
		Total	4.9	7.2	3.8		4	454
Peak Hour of Generator	A.M.	Enter	2.0				1	454
		Exit	1.6				1	454
		Total	3.7	5.5	2.2		8	446
	P.M.	Enter	2.2				1	473
		Exit	2.1				1	473
		Total	4.9	7.2	3.9		8	446
Saturday Vehicle Trip Ends			61.4	94.4	42.0		6	449
Peak Hour of Generator		Enter	2.4				1	473
		Exit	2.8				1	473
		Total	5.2				1	473
Sunday Vehicle Trip Ends			10.2				1	473
Peak Hour of Generator		Enter	0.6				1	473
		Exit	0.8				1	473
		Total	1.4				1	473

Source Numbers 3, 13, 40, 49, 54, 78, 110

ITE Technical Committee 6A-6—Trip Generation Rates

Date: 1975, 1979, Rev. 1982

G.S.F. = Gross Square Feet of Leasable Area

Caution, limited sample size, use carefully.

SUMMARY OF TRIP GENERATION RATES

Land Use/Building Type Shopping Center 500,000-999,999 G.S.F. ITE Land Use Code 826
Independent Variable—Trips per 1,000 Gross Square Feet of Leasable Area

			Average Trip Rate	Maximum Rate	Minimum Rate	Correlation Coefficient	Number of Studies	Average Size of Independent Variable/Study
Average Weekday Vehicle Trip Ends			37.2	54.8	17.9		37	617
Peak Hour of Adjacent Street Traffic	A.M. Between 7 and 9	Enter	0.38	0.64	0.22		6	751
		Exit	0.23	0.44	0.07		6	751
		Total	0.61	1.08	0.30		6	751
	P.M. Between 4 and 6	Enter	1.59	1.99	1.18		7	757
		Exit	1.65	2.16	1.13		10	727
		Total	3.12	3.95	2.31		10	723
Peak Hour of Generator	A.M.	Enter	1.40	1.86	1.11		7	757
		Exit	1.35	1.95	0.82		12	710
		Total	2.54	3.24	1.95		6	751
	P.M.	Enter	1.68	2.06	1.36		7	757
		Exit	1.81	2.41	1.18		12	110
		Total	3.83	5.53	2.54		11	650
Saturday Vehicle Trip Ends			45.3	70.4	23.6		18	710
Peak Hour of Generator		Enter	2.30	3.66	1.04		7	757
		Exit	2.35	3.22	1.26		12	710
		Total	4.87	6.88	2.90		10	747
Sunday Vehicle Trip Ends			19.5	38.4	4.1		18	710
Peak Hour of Generator		Enter	0.81	1.81	0.20		7	757
		Exit	1.22	2.61	0.19		12	710
		Total	1.34	3.43	0.39		6	751

Source Numbers 1, 3, 5, 6, 13, 14, 18, 22, 26, 49, 54, 59, 60, 61, 64, 65, 72, 73, 77, 79, 99, 100, 110, 124

ITE Technical Committee 6A-6—Trip Generation Rates
Date: 1975, 1979, Rev. 1982

G.S.F. = Gross Square Feet of Leasable Area

SUMMARY OF TRIP GENERATION RATES

Land Use/Building Type Shopping Center 1,000,000-1,249,999 G.S.F. ITE Land Use Code 827

Independent Variable—Trips per 1,000 Gross Square Feet of Leasable Area

			Average Trip Rate	Maximum Rate	Minimum Rate	Correlation Coefficient	Number of Studies	Average Size of Independent Variable/Study
Average Weekday Vehicle Trip Ends			37.1	57.0	26.1		6	1076
Peak Hour of Adjacent Street Traffic	A.M. Between 7 and 9	Enter						
		Exit						
		Total						
	P.M. Between 4 and 6	Enter	1.4				1	1085
		Exit	1.9	2.8	1.3		3	1085
		Total						
Peak Hour of Generator	A.M.	Enter						
		Exit	1.5	2.2	0.8		3	1073
		Total						
	P.M.	Enter	3.0				1	1085
		Exit	1.9	2.0	1.7		2	1067
		Total	4.7				1	1085
Saturday Vehicle Trip Ends			39.2	46.5	32.1		2	1060
Peak Hour of Generator		Enter						
		Exit	2.1				1	1050
		Total	3.3				1	1071
Sunday Vehicle Trip Ends			22.8	30.3	15.3		2	1060
Peak Hour of Generator		Enter						
		Exit	1.8				1	1050
		Total						

Source Numbers 1, 18, 100, 124

ITE Technical Committee 6A-6—Trip Generation Rates

Date: 1975, 1979, Rev. 1982

G.S.F. = Gross Square Feet of Leasable Area

Caution, limited sample size, use carefully.

TECHNICAL MEMORANDUM NO. 3

LITTLEWORTH ROAD (N.H. ROUTE 9) CORRIDOR STUDY

APPENDIX D

TRAFFIC CAPACITY ANALYSES

****

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET.........ROUTE 9

NAME OF THE NORTH/SOUTH STREET.......ROUTE 155

AREA TYPE...........................OTHER

PEDESTRIAN WALKING SPEED............ 0 (feet/sec)

NAME OF THE ANALYST..................DRI

DATE OF THE ANALYSIS................5/18/88

TIME PERIOD ANALYZED................WKDY PM PK HR

OTHER INFORMATION:
EXISTING 1988 CONDITION

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	454	0	36	0
THRU	0	0	552	428
RIGHT	0	0	0	0
RTOR	0	0	0	0

(RTOR volume must be less than or equal to RIGHT turn volumes.)

NUMBER OF LANES PER DIRECTION INCLUDING TURN BAYS:
EASTBOUND = 1 WESTBOUND = 0 NORTHBOUND = 2 SOUTHBOUND = 1

	EB		WB		NB		SB	
LANE	TYPE	WIDTH	TYPE	WIDTH	TYPE	WIDTH	TYPE	WIDTH
1	LR	12.0	L	12.0	L	12.0	T	12.0
2		12.0	T	12.0	T	12.0		12.0
3		12.0	R	12.0		12.0		12.0
4		12.0		12.0		12.0		12.0
5		12.0		12.0		12.0		12.0
6		12.0		12.0		12.0		12.0

L - EXCLUSIVE LEFT LANE
LT - LEFT/THROUGH LANE
LR - LEFT/RIGHT ONLY LANE
LTR - LEFT THROUGH/RIGHT LANE
T - EXCLUSIVE THROUGH LANE
TR - THROUGH/RIGHT LANE
R - EXCLUSIVE RIGHT LANE

ADJUSTMENT FACTORS

	GRADE (%)	HEAVY VEH. (%)	ADJACENT PKG Y/N	(Nm)	BUSES (Nb)	PHF
EASTBOUND	0.00	4.00	N	0	0	0.85
WESTBOUND	0.00	3.00	N	0	0	0.85
NORTHBOUND	0.00	3.00	N	0	0	0.85
SOUTHBOUND	0.00	3.00	N	0	0	0.85

Nm = number of parking manouvers/hr; Nb = number of buses stopping/h

	CONFLICTING PEDS (peds/hour)	PEDESTRIAN BUTTON (Y/N)	(min T)	ARRIVAL TYP
EASTBOUND	0	N	17.0	3
WESTBOUND	0	N	17.0	3
NORTHBOUND	0	N	9.6	3
SOUTHBOUND	0	N	9.6	3

min T = minimum green time for pedestrians

SIGNAL SETTINGS - OPERATIONAL ANALYSIS

ACTUATED   LOST TIME/PHASE = 3.0   CYCLE LENGTH = 75.0

EAST/WEST PHASING

	PHASE-1	PHASE-2	PHASE-3	PHASE-4
EASTBOUND				
LEFT	X			
THRU	X			
RIGHT	X			
PEDS				
WESTBOUND				
LEFT	X			
THRU	X			
RIGHT	X			
PEDS				
NORTHBOUND RT				
SOUTHBOUND RT				
GREEN	30.0	0.0	0.0	0.0
YELLOW + ALL RED	5.0	0.0	0.0	0.0

NORTH/SOUTH PHASING

	PHASE-1	PHASE-2	PHASE-3	PHASE-4
NORTHBOUND				
LEFT	X			
THRU	X	X		
RIGHT	X	X		
PEDS				
SOUTHBOUND				
LEFT		X		
THRU		X		
RIGHT		X		
PEDS				
EASTBOUND RT				
WESTBOUND RT				
GREEN	5.0	30.0	0.0	0.0
YELLOW + ALL RED	0.0	5.0	0.0	0.0

VOLUME ADJUSTMENT WORKSHEET

	MVT. VOL.	PHF	ADJ. VOL.	LANE GRP.	LANE GRP. VOL.	NO. LN	LANE UTIL. FACT.	GROWTH FACT.	ADJ. GRP. VOL.	PROP LT
EB										
LT	454	0.85						1.000		
TH	0	0.85	0	LR	534	1	1.000	1.000	534	1.00
RT	0	0.85						1.000		
WB										
LT	0	0.85						1.000		
TH	0	0.85						1.000		
RT	0	0.85						1.000		
NB										
LT	36	0.85	42	L	42	1	1.000	1.000	42	1.00
TH	552	0.85	649	T	649	1	1.000	1.000	649	0.00
RT	0	0.85						1.000		
SB										
LT	0	0.85						1.000		
TH	429	0.85	504	T	504	1	1.000	1.000	504	0.00
RT	0	0.85						1.000		

* Denotes a Defacto Left Turn Lane Group

SATURATION FLOW ADJUSTMENT WORKSHEET

	IDEAL SAT. FLOW	NO. LNS	f W	f HV	f G	f p	f BB	f A	f RT	f LT	ADJ. SAT. FLOW
EB											
LR	1800	1	1.000	0.980	1.000	1.000	1.000	1.000	1.000	0.765	1349
WB											
NB											
L	1800	1	1.000	0.985	1.000	1.000	1.000	1.000	1.000	0.950	1684
T	1800	1	1.000	0.985	1.000	1.000	1.000	1.000	1.000	1.000	1773
SB											
T	1800	1	1.000	0.985	1.000	1.000	1.000	1.000	1.000	1.000	1773

CAPACITY ANALYSIS WORKSHEET

	ADJ. FLOW RATE (v)	ADJ. SAT. FLOW RATE (s)	FLOW RATIO (v/s)	GREEN RATIO (g/C)	LANE GROUP CAPACITY (c)	v/c RATI
EB						
LR	534	1349	0.396	0.427	576	0.92
WB						
NB						
L	42	1684	0.025	0.027	45	0.94
T	649	1773	0.366	0.493	875	0.74
SB						
T	504	1773	0.284	0.427	756	0.66

Cycle Length, C = 75.0 sec.
Lost Time Per Cycle, L = 6.0 sec.

Sum (v/s) critical = 0.762
X critical = 0.828

	v/c RATIO	g/C RATIO	CYCLE LEN.	DELAY d 1	LANE GROUP CAP.	DELAY d 2	PROG. FACT.	LANE GRP. DELAY	LANE GRP. LOS	DELAY BY APP.	LOS BY APP.
EB											
LR	0.928	0.427	75.0	15.5	576	15.4	0.85	26.3	D	26.3	D
WB											
NB											
L	0.943	0.027	75.0	27.7	45	80.8	1.00	108.5	F	17.8	C
T	0.742	0.493	75.0	11.5	875	2.4	0.85	11.7	B		
SB											
T	0.666	0.427	75.0	13.1	754	1.6	0.85	12.5	B	12.5	B

Intersection Delay = 18.9 (sec/veh) Intersection LOS = C

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET.........ROUTE 9

NAME OF THE NORTH/SOUTH STREET.......ROUTE 155

AREA TYPE............................OTHER

PEDESTRIAN WALKING SPEED............. 0 (feet/sec)

NAME OF THE ANALYST..................DRI

DATE OF THE ANALYSIS.................5/18/88

TIME PERIOD ANALYZED.................WKDY PM PK HR

OTHER INFORMATION:
PROJECTED 2008 CONDITION - EXISTING ZONING - NO INTERCHANGE

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	1245	33	91	241
THRU	155	130	729	600
RIGHT	155	163	91	0
RTOR	0	0	0	0

(RTOR volume must be less than or equal to RIGHT turn volumes.)

NUMBER OF LANES PER DIRECTION INCLUDING TURN BAYS:
EASTBOUND = 3 WESTBOUND = 3 NORTHBOUND = 3 SOUTHBOUND = 3

	EB		WB		NB		SB	
LANE	TYPE	WIDTH	TYPE	WIDTH	TYPE	WIDTH	TYPE	WIDTH
1	L	12.0	L	12.0	L	12.0	L	12.0
2	L	12.0	T	12.0	T	12.0	T	12.0
3	TR	12.0	R	12.0	TR	12.0	TR	12.0
4		12.0		12.0		12.0		12.0
5		12.0		12.0		12.0		12.0
6		12.0		12.0		12.0		12.0

L - EXCLUSIVE LEFT LANE
LT - LEFT/THROUGH LANE
LR - LEFT/RIGHT ONLY LANE
LTR - LEFT/THROUGH/RIGHT LANE
T - EXCLUSIVE THROUGH LANE
TR - THROUGH/RIGHT LANE
R - EXCLUSIVE RIGHT LANE

ADJUSTMENT FACTORS

	GRADE (%)	HEAVY VEH. (%)	ADJACENT PKG Y/N	(Nm)	BUSES (Nb)	PHF
EASTBOUND	0.00	2.00	N	0	0	0.90
WESTBOUND	0.00	2.00	N	0	0	0.90
NORTHBOUND	0.00	2.00	N	0	0	0.90
SOUTHBOUND	0.00	2.00	N	0	0	0.90

Nm = number of parking maneuvers/hr; Nb = number of buses stopping.

	CONFLICTING PEDS (peds/hour)	PEDESTRIAN BUTTON (Y/N)	(min T)	ARRIVAL T
EASTBOUND	0	N	17.0	3
WESTBOUND	0	N	17.0	3
NORTHBOUND	0	N	9.6	3
SOUTHBOUND	0	N	9.6	3

min T = minimum green time for pedestrians

ACTUATED LOST TIME/PHASE = 3.0 CYCLE LENGTH = 107.0

EAST/WEST PHASING

	PHASE-1	PHASE-2	PHASE-3	PHASE-4
EASTBOUND				
LEFT	X			
THRU	X			
RIGHT	X			
PEDS				
WESTBOUND				
LEFT		X		
THRU		X		
RIGHT		X		
PEDS				
NORTHBOUND RT				
SOUTHBOUND RT				
GREEN	40.0	7.0	0.0	0.0
YELLOW + ALL RED	5.0	5.0	0.0	0.0

NORTH/SOUTH PHASING

	PHASE-1	PHASE-2	PHASE-3	PHASE-4
NORTHBOUND				
LEFT	X			
THRU		X		
RIGHT		X		
PEDS				
SOUTHBOUND				
LEFT	X			
THRU		X		
RIGHT		X		
PEDS				
EASTBOUND RT				
WESTBOUND RT	X			
GREEN	15.0	30.0	0.0	0.0
YELLOW + ALL RED	0.0	5.0	0.0	0.0

		MVT. VOL.	PHF	ADJ. VOL.	LANE GRP.	LANE GRP. VOL.	NO. LN	LANE UTIL. FACT.	GROWTH FACT.	ADJ. GRP. VOL.	PROP LT	F
EB												
	LT	1245	0.90	1383	L	1383	2	1.050	1.000	1453	1.00	0
	TH	155	0.90	172	TR	344	1	1.000	1.000	344	0.00	0
	RT	155	0.90						1.000			
WB												
	LT	33	0.90	37	L	37	1	1.000	1.000	37	1.00	0
	TH	130	0.90	144	T	144	1	1.000	1.000	144	0.00	0
	RT	163	0.90	181	R	181	1	1.000	1.000	181	0.00	1
NB												
	LT	91	0.90	101	L	101	1	1.000	1.000	101	1.00	0
	TH	729	0.90	810	TR	911	2	1.050	1.000	957	0.00	0
	RT	91	0.90						1.000			
SB												
	LT	241	0.90	268	L	268	1	1.000	1.000	268	1.00	0
	TH	600	0.90	667	TR	667	2	1.050	1.000	700	0.00	0
	RT	0	0.90						1.000			

* Denotes a Defacto Left Turn Lane Group

SATURATION FLOW ADJUSTMENT WORKSHEET

	IDEAL SAT. FLOW	NO. LNS	f_W	f_{HV}	f_G	f_p	f_{BB}	f_A	f_{RT}	f_{LT}	ADJ. SAT. FLOW
EB											
L	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.920	3279
TR	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	0.925	1.000	1648
WB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
T	1800	1	1.000	0.970	1.000	1.000	1.000	1.000	1.000	1.000	1782
R	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	0.850	1.000	1515
NB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
TR	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	0.983	1.000	3505
SB											
L	1800	1	1.000	0.970	1.000	1.000	1.000	1.000	1.000	0.950	1693
TR	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	1.000	1.000	3564

CAPACITY ANALYSIS WORKSHEET

	ADJ. FLOW RATE (v)	ADJ. SAT. FLOW RATE (s)	FLOW RATIO (v/s)	GREEN RATIO (g/C)	LANE GROUP CAPACITY (c)	v/c RATIO
EB						
L	1453	3279	0.443	0.393	1287	1.129
TR	344	1648	0.209	0.393	647	0.532
WB						
L	37	1693	0.022	0.084	142	0.258
T	144	1782	0.081	0.084	150	0.954
R	181	1515	0.120	0.196	297	0.609
NB						
L	101	1693	0.060	0.112	190	0.533
TR	957	3505	0.273	0.299	1048	0.913
SB						
L	268	1693	0.158	0.112	190	1.410
TR	700	3564	0.196	0.299	1066	0.657

Cycle Length, C = 107.0 sec. Sum (v/s) critical = 0.994
Lost Time Per Cycle, L = 12.0 sec. X critical = 1.119

LEVEL-OF-SERVICE WORKSHEET

	v/c RATIO	g/C RATIO	CYCLE LEN.	DELAY d 1	LANE GROUP CAP.	DELAY d 2	PROG. FACT.	LANE GRP. DELAY	LANE GRP. LOS	DELAY BY APP.	LOS BY APP.
EB											
L	1.129	0.393	107.0	26.9	1287	66.8	1.00	93.8	F	79.0	F
TR	0.532	0.393	107.0	19.0	647	0.7	0.85	16.7	C		
WB											
L	.0.258	0.084	107.0	34.9	142	0.2	1.00	35.1	D	45.5	E
T	0.964	0.084	107.0	37.1	150	46.0	0.85	70.7	F		
R	0.609	0.196	107.0	29.8	297	2.6	0.85	27.5	D		
NB											
L	0.533	0.112	107.0	34.1	190	2.2	1.00	36.3	D	31.2	D
TR	0.913	0.299	107.0	27.5	1048	8.6	0.85	30.6	D		
SB											
L	1.416	0.112	107.0	*	190	*	1.00	*	*	*	*
TR	0.657	0.299	107.0	24.9	1066	1.0	0.85	22.0	C		

Intersection Delay = * (sec/veh)   Intersection LOS = *

* Delay and LOS not meaningful when any v/c is greater than 1.2

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IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET.........ROUTE 9

NAME OF THE NORTH/SOUTH STREET.......ROUTE 155

AREA TYPE............................OTHER

PEDESTRIAN WALKING SPEED............ 0 (feet/sec)

NAME OF THE ANALYST..................DRI

DATE OF THE ANALYSIS.................5/18/88

TIME PERIOD ANALYZED.................WKDY PM PK HR

OTHER INFORMATION:
PROJECTED 2008 CONDITION - WITH REZONING - NO INTERCHANGE

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	2392	46	116	241
THRU	299	233	928	800
RIGHT	299	187	116	0
RTOR	0	0	0	0

(RTOR volume must be less than or equal to RIGHT turn volumes.)

INTERSECTION GEOMETRY Pa[illegible]

NUMBER OF LANES PER DIRECTION INCLUDING TURN BAYS:
EASTBOUND = 3 WESTBOUND = 3 NORTHBOUND = 3 SOUTHBOUND = 3

LANE	EB TYPE	EB WIDTH	WB TYPE	WB WIDTH	NB TYPE	NB WIDTH	SB TYPE	SB WIDTH
1	L	12.0	L	12.0	L	12.0	L	12.0
2	L	12.0	T	12.0	T	12.0	T	12.0
3	TR	12.0	R	12.0	TR	12.0	TR	12.0
4		12.0		12.0		12.0		12.0
5		12.0		12.0		12.0		12.0
6		12.0		12.0		12.0		12.0

L - EXCLUSIVE LEFT LANE
LT - LEFT/THROUGH LANE
LR - LEFT/RIGHT ONLY LANE
LTR - LEFT/THROUGH/RIGHT LANE
T - EXCLUSIVE THROUGH LANE
TR - THROUGH/RIGHT LANE
R - EXCLUSIVE RIGHT LANE

ADJUSTMENT FACTORS

	GRADE (%)	HEAVY VEH. (%)	ADJACENT PKG Y/N	(Nm)	BUSES (Nb)	PHF
EASTBOUND	0.00	2.00	N	0	0	0.90
WESTBOUND	0.00	2.00	N	0	0	0.90
NORTHBOUND	0.00	2.00	N	0	0	0.90
SOUTHBOUND	0.00	2.00	N	0	0	0.90

Nm = number of parking maneuvers/hr; Nb = number of buses stopping

	CONFLICTING PEDS (peds/hour)	PEDESTRIAN BUTTON (Y/N)	(min T)	ARRIVAL T
EASTBOUND	0	N	17.0	3
WESTBOUND	0	N	17.0	3
NORTHBOUND	0	N	9.6	3
SOUTHBOUND	0	N	9.6	3

min T = minimum green time for pedestrians

SIGNAL SETTINGS - OPERATIONAL ANALYSIS

ACTUATED LOST TIME/PHASE = 3.0 CYCLE LENGTH = 107.0

EAST/WEST PHASING

	PHASE-1	PHASE-2	PHASE-3	PHASE-4
EASTBOUND				
LEFT	X			
THRU	X			
RIGHT	X			
PEDS				
WESTBOUND				
LEFT		X		
THRU		X		
RIGHT		X		
PEDS				
NORTHBOUND RT				
SOUTHBOUND RT				
GREEN	40.0	7.0	0.0	0.0
YELLOW + ALL RED	5.0	5.0	0.0	0.0

NORTH/SOUTH PHASING

	PHASE-1	PHASE-2	PHASE-3	PHASE-4
NORTHBOUND				
LEFT	X			
THRU		X		
RIGHT		X		
PEDS				
SOUTHBOUND				
LEFT	X			
THRU		X		
RIGHT		X		
PEDS				
EASTBOUND RT				
WESTBOUND RT	X			
GREEN	15.0	30.0	0.0	0.0
YELLOW + ALL RED	0.0	5.0	0.0	0.0

VOLUME ADJUSTMENT WORKSHEET

		MVT. VOL.	PHF	ADJ. VOL.	LANE GRP.	LANE GRP. VOL.	NO. LN	LANE UTIL. FACT.	GROWTH FACT.	ADJ. GRP. VOL.	PROP LT	PI
EB												
	LT	2392	0.90	2658	L	2658	2	1.050	1.000	2791	1.00	0.
	TH	299	0.90	332	TR	664	1	1.000	1.000	664	0.00	0
	RT	299	0.90						1.000			
WB												
	LT	46	0.90	51	L	51	1	1.000	1.000	51	1.00	0.
	TH	233	0.90	259	T	259	1	1.000	1.000	259	0.00	0
	RT	187	0.90	208	R	208	1	1.000	1.000	208	0.00	1.
NB												
	LT	116	0.90	129	L	129	1	1.000	1.000	129	1.00	0.
	TH	928	0.90	1031	TR	1160	2	1.050	1.000	1218	0.00	0.
	RT	116	0.90						1.000			
SB												
	LT	241	0.90	268	L	268	1	1.000	1.000	268	1.00	0.
	TH	800	0.90	889	TR	889	2	1.050	1.000	933	0.00	0
	RT	0	0.90						1.000			

* Denotes a Defacto Left Turn Lane Group

SATURATION FLOW ADJUSTMENT WORKSHEET

	IDEAL SAT. FLOW	NO. LNS	f W	f HV	f G	f p	f BB	f A	f RT	f LT	ADJ. SAT. FLOW
EB											
L	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.920	3279
TR	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	0.925	1.000	1648
WB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
T	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	1.000	1782
R	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	0.850	1.000	1515
NB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
TR	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	0.983	1.000	3505
SB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
TR	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	1.000	1.000	3564

CAPACITY ANALYSIS WORKSHEET

	ADJ. FLOW RATE (v)	ADJ. SAT. FLOW RATE (s)	FLOW RATIO (v/s)	GREEN RATIO (g/C)	LANE GROUP CAPACITY (c)	v/c RATIO
EB						
L	2791	3279	0.851	0.393	1287	2.168
TR	664	1648	0.403	0.393	647	1.027
WB						
L	51	1693	0.030	0.084	142	0.359
T	259	1782	0.145	0.084	150	1.727
R	208	1515	0.137	0.196	297	0.699
NB						
L	129	1693	0.076	0.112	190	0.679
TR	1218	3505	0.348	0.299	1048	1.162
SB						
L	268	1693	0.158	0.112	190	1.410
TR	933	3564	0.262	0.299	1066	0.876

Cycle Length, C = 107.0 sec. Sum (v/s) critical = 1.502
Lost Time Per Cycle, L = 12.0 sec. X critical = 1.692

	v/c RATIO	g/C RATIO	CYCLE LEN.	DELAY d 1	LANE GROUP CAP.	DELAY d 2	PROG. FACT.	LANE GRP. DELAY	LANE GRP. LOS	DELAY BY APP.	LOS BY APP.
EB											
L	2.168	0.393	107.0	*	1287	*	1.00	*	*	*	*
TR	1.027	0.393	107.0	25.1	647	34.4	0.85	50.6	E		
WB											
L	0.359	0.084	107.0	35.2	142	0.7	1.00	35.9	D	*	*
T	1.727	0.084	107.0	*	150	*	0.85	*	*		
R	0.699	0.196	107.0	30.4	297	4.8	0.85	30.0	D		
NB											
L	0.679	0.112	107.0	34.7	190	6.3	1.00	41.0	E	94.2	F
TR	1.162	0.299	107.0	30.6	1048	86.9	0.85	99.9	F		
SB											
L	1.410	0.112	107.0	*	190	*	1.00	*	*	*	*
TR	0.876	0.299	107.0	27.1	1066	5.9	0.85	28.1	D		

Intersection Delay = * (sec/veh)   Intersection LOS = *

* Delay and LOS not meaningful when any v/c is greater than 1.2

IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET.........ROUTE 9

NAME OF THE NORTH/SOUTH STREET.......ROUTE 155

AREA TYPE............................OTHER

PEDESTRIAN WALKING SPEED............. 0 (feet/sec)

NAME OF THE ANALYST..................DRI

DATE OF THE ANALYSIS.................5/18/88

TIME PERIOD ANALYZED.................WKDY PM PK HR

OTHER INFORMATION:
PROJECTED 2008 CONDITION - EXISTING ZONING - NEW INTERCHANGE

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	294	33	91	241
THRU	155	130	729	600
RIGHT	155	163	91	0
RTOR	0	0	0	0

(RTOR volume must be less than or equal to RIGHT turn volumes.)

NUMBER OF LANES PER DIRECTION INCLUDING TURN BAYS:
EASTBOUND = 3 WESTBOUND = 3 NORTHBOUND = 3 SOUTHBOUND = 3

	EB		WB		NB		SB	
LANE	TYPE	WIDTH	TYPE	WIDTH	TYPE	WIDTH	TYPE	WIDTH
1	L	12.0	L	12.0	L	12.0	L	12.0
2	LT	12.0	T	12.0	T	12.0	T	12.0
3	R	12.0	R	12.0	TR	12.0	TR	12.0
4		12.0		12.0		12.0		12.0
5		12.0		12.0		12.0		12.0
6		12.0		12.0		12.0		12.0

L - EXCLUSIVE LEFT LANE
LT - LEFT/THROUGH LANE
LR - LEFT/RIGHT ONLY LANE
LTR - LEFT/THROUGH/RIGHT LANE
T - EXCLUSIVE THROUGH LANE
TR - THROUGH/RIGHT LANE
R - EXCLUSIVE RIGHT LANE

ADJUSTMENT FACTORS

	GRADE (%)	HEAVY VEH. (%)	ADJACENT PKG Y/N	(Nm)	BUSES (Nb)	PHF
EASTBOUND	0.00	2.00	N	0	0	0.90
WESTBOUND	0.00	2.00	N	0	0	0.90
NORTHBOUND	0.00	2.00	N	0	0	0.90
SOUTHBOUND	0.00	2.00	N	0	0	0.90

Nm = number of parking maneuvers/hr; Nb = number of buses stopping/

	CONFLICTING PEDS (peds/hour)	PEDESTRIAN BUTTON (Y/N)	(min T)	ARRIVAL TY
EASTBOUND	0	N	17.0	3
WESTBOUND	0	N	17.0	3
NORTHBOUND	0	N	9.6	3
SOUTHBOUND	0	N	9.6	3

min T = minimum green time for pedestrians

SATURATION FLOW ADJUSTMENT WORKSHEET

	IDEAL SAT. FLOW	NO. LNS	f W	f HV	f G	f P	f BB	f A	f RT	f LT	ADJ. SAT. FLOW
EB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
LT	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.984	1754
R	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	0.850	1.000	1515
WB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
T	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	1.000	1782
R	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	0.850	1.000	1515
NB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
TR	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	0.983	1.000	3505
SB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
TR	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	1.000	1.000	3564

CAPACITY ANALYSIS WORKSHEET

	ADJ. FLOW RATE (v)	ADJ. SAT. FLOW RATE (s)	FLOW RATIO (v/s)	GREEN RATIO (g/C)	LANE GROUP CAPACITY (c)	v/c RATIO
EB						
L	245	1693	0.145	0.263	445	0.551
LT	254	1754	0.145	0.263	461	0.551
R	172	1515	0.114	0.434	658	0.26
WB						
L	37	1693	0.022	0.121	205	0.17
T	144	1782	0.081	0.121	216	0.66
R	181	1515	0.120	0.293	444	0.40
NB						
L	101	1693	0.060	0.172	291	0.348
TR	957	3505	0.273	0.323	1133	0.844
SB						
L	268	1693	0.158	0.172	291	0.921
TR	700	3564	0.196	0.323	1152	0.60

Cycle Length, C = 99.0 sec. Sum (v/s) critical = 0.695
Lost Time Per Cycle, L = 12.0 sec. X critical = 0.791

LEVEL-OF-SERVICE WORKSHEET

	v/c RATIO	g/C RATIO	CYCLE LEN.	DELAY d 1	LANE GROUP CAP.	DELAY d 2	PROG. FACT.	LANE GRP. DELAY	LANE GRP. LOS	DELAY BY APP.	LOS BY APP.
EB											
L	0.551	0.263	99.0	23.9	445	1.1	1.00	25.0	D	20.2	C
LT	0.551	0.263	99.0	23.9	461	1.1	0.85	21.3	C		
R	0.262	0.434	99.0	13.6	658	0.1	0.85	11.6	B		
WB											
L	0.179	0.121	99.0	29.7	205	0.0	1.00	29.7	D	24.7	C
T	0.669	0.121	99.0	31.6	216	5.2	0.85	31.3	D		
R	0.408	0.293	99.0	21.4	444	0.4	0.85	18.5	C		
NB											
L	0.348	0.172	99.0	27.4	291	0.3	1.00	27.8	D	24.1	C
TR	0.844	0.323	99.0	23.7	1133	4.3	0.85	23.8	C		
SB											
L	0.921	0.172	99.0	30.7	291	23.4	1.00	54.1	E	28.6	D
TR	0.608	0.323	99.0	21.4	1152	0.7	0.85	18.8	C		

Intersection Delay = 24.7 (sec/veh) Intersection LOS = C

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IDENTIFYING INFORMATION

NAME OF THE EAST/WEST STREET.........ROUTE 9

NAME OF THE NORTH/SOUTH STREET.......ROUTE 155

AREA TYPE............................OTHER

PEDESTRIAN WALKING SPEED............ 0 (feet/sec)

NAME OF THE ANALYST..................DRI

DATE OF THE ANALYSIS.................5/18/88

TIME PERIOD ANALYZED.................WKDY PM PK HR

OTHER INFORMATION:
PROJECTED 2008 CONDITION - WITH REZONING - NEW INTERCHANGE

TRAFFIC VOLUMES

	EB	WB	NB	SB
LEFT	439	46	116	241
THRU	299	233	928	800
RIGHT	299	187	116	0
RTOR	0	0	0	0

(RTOR volume must be less than or equal to RIGHT turn volumes.)

INTERSECTION GEOMETRY Pa

NUMBER OF LANES PER DIRECTION INCLUDING TURN BAYS:
EASTBOUND = 3 WESTBOUND = 3 NORTHBOUND = 3 SOUTHBOUND = 3

	EB		WB		NB		SB	
LANE	TYPE	WIDTH	TYPE	WIDTH	TYPE	WIDTH	TYPE	WIDTH
1	L	12.0	L	12.0	L	12.0	L	12.0
2	LT	12.0	T	12.0	T	12.0	T	12.0
3	R	12.0	R	12.0	TR	12.0	TR	12.0
4		12.0		12.0		12.0		12.0
5		12.0		12.0		12.0		12.0
6		12.0		12.0		12.0		12.0

L - EXCLUSIVE LEFT LANE
LT - LEFT/THROUGH LANE
LR - LEFT/RIGHT ONLY LANE
LTR - LEFT/THROUGH/RIGHT LANE
T - EXCLUSIVE THROUGH LANE
TR - THROUGH/RIGHT LANE
R - EXCLUSIVE RIGHT LANE

ADJUSTMENT FACTORS

	GRADE (%)	HEAVY VEH. (%)	ADJACENT PKG Y/N	(Nm)	BUSES (Nb)	PHF
EASTBOUND	0.00	2.00	N	0	0	0.90
WESTBOUND	0.00	2.00	N	0	0	0.90
NORTHBOUND	0.00	2.00	N	0	0	0.90
SOUTHBOUND	0.00	2.00	N	0	0	0.90

Nm = number of parking maneuvers/hr; Nb = number of buses stopping

	CONFLICTING PEDS (peds/hour)	PEDESTRIAN BUTTON (Y/N)	(min T)	ARRIVAL T
EASTBOUND	0	N	17.0	3
WESTBOUND	0	N	17.0	3
NORTHBOUND	0	N	9.6	3
SOUTHBOUND	0	N	9.6	3

min T = minimum green time for pedestrians

SIGNAL SETTINGS - OPERATIONAL ANALYSIS

ACTUATED LOST TIME/PHASE = 3.0 CYCLE LENGTH = 104.0

EAST/WEST PHASING

	PHASE-1	PHASE-2	PHASE-3	PHASE-4
EASTBOUND				
LEFT	X			
THRU	X			
RIGHT	X			
PEDS				
WESTBOUND				
LEFT		X		
THRU		X		
RIGHT		X		
PEDS				
NORTHBOUND RT				
SOUTHBOUND RT				
GREEN	22.0	12.0	0.0	0.0
YELLOW + ALL RED	5.0	5.0	0.0	0.0

NORTH/SOUTH PHASING

	PHASE-1	PHASE-2	PHASE-3	PHASE-4
NORTHBOUND				
LEFT	X			
THRU		X		
RIGHT		X		
PEDS				
SOUTHBOUND				
LEFT	X			
THRU		X		
RIGHT		X		
PEDS				
EASTBOUND RT	X			
WESTBOUND RT	X			
GREEN	20.0	35.0	0.0	0.0
YELLOW + ALL RED	0.0	5.0	0.0	0.0

VOLUME ADJUSTMENT WORKSHEET

	MVT. VOL.	PHF	ADJ. VOL.	LANE GRP.	LANE GRP. VOL.	NO. LN	LANE UTIL. FACT.	GROWTH FACT.	ADJ. GRP. VOL.	PROP LT	F
EB											
LT	439	0.90	488	L	390	1	1.000	1.000	390	1.00	0
TH	299	0.90	332	LT	430	1	1.000	1.000	430	0.23	0
RT	299	0.90	332	R	332	1	1.000	1.000	332	0.00	1
WB											
LT	46	0.90	51	L	51	1	1.000	1.000	51	1.00	0
TH	233	0.90	259	T	259	1	1.000	1.000	259	0.00	0
RT	187	0.90	208	R	208	1	1.000	1.000	208	0.00	1
NB											
LT	116	0.90	129	L	129	1	1.000	1.000	129	1.00	0
TH	928	0.90	1031	TR	1160	2	1.050	1.000	1218	0.00	0
RT	116	0.90						1.000			
SB											
LT	241	0.90	268	L	268	1	1.000	1.000	268	1.00	0
TH	800	0.90	889	TR	889	2	1.050	1.000	933	0.00	0
RT	0	0.90						1.000			

* Denotes a Defacto Left Turn Lane Group

SATURATION FLOW ADJUSTMENT WORKSHEET

	IDEAL SAT. FLOW	NO. LNS	f W	f HV	f G	f P	f BB	f A	f RT	f LT	ADJ. SAT. FLOW
EB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
LT	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.989	1762
R	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	0.850	1.000	1515
WB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
T	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	1.000	1782
R	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	0.850	1.000	1515
NB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
TR	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	0.983	1.000	3505
SB											
L	1800	1	1.000	0.990	1.000	1.000	1.000	1.000	1.000	0.950	1693
TR	1800	2	1.000	0.990	1.000	1.000	1.000	1.000	1.000	1.000	3564

CAPACITY ANALYSIS WORKSHEET

	ADJ. FLOW RATE (v)	ADJ. SAT. FLOW RATE (s)	FLOW RATIO (v/s)	GREEN RATIO (g/C)	LANE GROUP CAPACITY (c)	v RA
EB						
L	390	1693	0.231	0.231	391	0.
LT	430	1762	0.244	0.231	407	1.
R	332	1515	0.219	0.394	597	0.
WB						
L	51	1693	0.030	0.135	228	0.
T	257	1782	0.145	0.135	240	1.
R	208	1515	0.137	0.298	451	0.
NB						
L	129	1693	0.076	0.163	277	0.
TR	1218	3505	0.348	0.356	1247	0.
SB						
L	268	1693	0.158	0.163	277	0.
TR	933	3564	0.262	0.356	1268	0.

Cycle Length, C = 104.0 sec.
Lost Time Per Cycle, L = 12.0 sec.

Sum (v/s) critical = 0.895
X critical = 1.012

LEVEL-OF-SERVICE WORKSHEET

	v/c RATIO	g/C RATIO	CYCLE LEN.	DELAY d 1	LANE GROUP CAP.	DELAY d 2	PROG. FACT.	LANE GRP. DELAY	LANE GRP. LOS	DELAY BY APP.	LOS BY APP.
EB											
L	0.999	0.231	104.0	30.4	391	34.7	1.00	65.1	F	53.1	E
LT	1.057	0.231	104.0	30.9	407	51.9	0.85	70.4	F		
R	0.556	0.394	104.0	18.6	597	0.9	0.85	16.5	C		
WB											
L	0.224	0.135	104.0	30.5	228	0.1	1.00	30.6	D	56.4	E
T	1.079	0.135	104.0	34.6	240	72.3	0.85	90.9	F		
R	0.460	0.298	104.0	22.6	451	0.5	0.85	19.6	C		
NB											
L	0.466	0.163	104.0	29.9	277	0.9	1.00	30.9	D	33.9	D
TR	0.977	0.356	104.0	25.1	1247	15.1	0.85	34.2	D		
SB											
L	0.968	0.163	104.0	32.9	277	33.4	1.00	66.3	F	30.5	D
TR	0.736	0.356	104.0	22.2	1268	1.6	0.85	20.2	C		

Intersection Delay = 40.9 (sec/veh)   Intersection LOS = E