STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

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R. SAMUEL HUNT III
SECRETARY

July 27, 1993

MEMORANDUM

TO: Mr. J. M. Lynch, P.E., State Traffic Engineer

FROM: Mr. R. Canales, P.E. Congestion Management Engineer

SUBJECT: Greensboro IVHS/Congestion Management Proposal

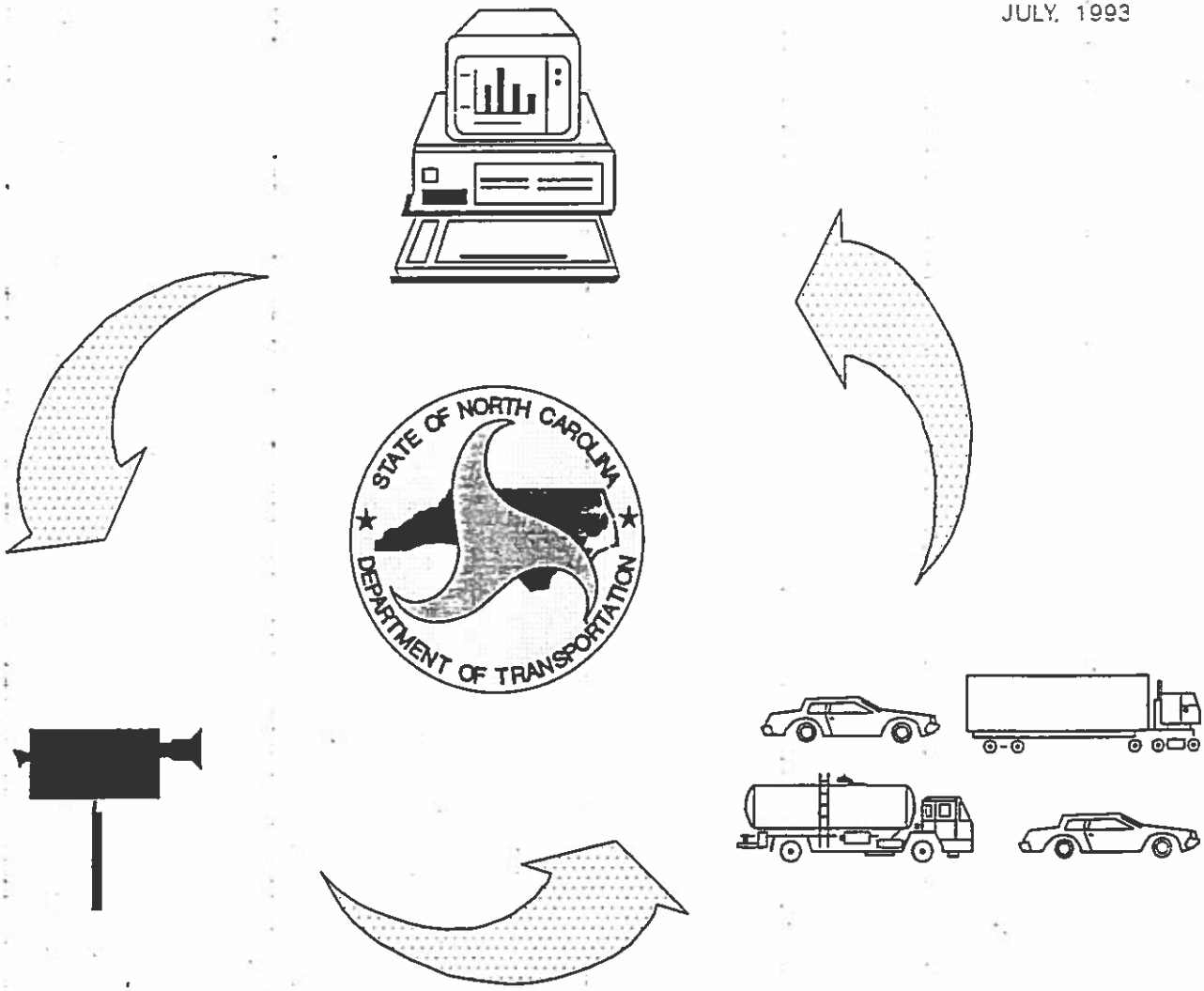
Attached, for your information, is a copy of the Congestion Management proposal for the I-40/I-85 IVHS Corridor in Greensboro. This document highlights specific IVHS improvements that are recommended in this area when funding becomes available. If there are any questions, please advise.

RC/VLL:vl
Attachment

cc: Mr. W. G. Marley, Jr., P.E., Att.
Mr. J. T. Peacock, Jr., P.E., Att.
Mr. D. W. Bailey, P.E., Att.
Mr. J. W. Watkins, P.E., Att.
Mr. T. A. Peoples, P.E., Att.
Mr. J. R. Atkins, GDOT, Att.
Mr. K. W. Ivey, P.E., FHWA, Att.
Mr. E. Y. Stafford, Att.
Mr. G. A. Fuller, Att.
Mr. G. C. Faulkner - Project File, Att.

GREENSBORO IVHS FEASIBILITY STUDY

JULY, 1993



EXECUTIVE SUMMARY

PURPOSE OF STUDY

The purpose of this proposal is to address the various congestion related issues associated with the I-40/85 Intelligent Vehicle/Highway System (IVHS) corridor in Greensboro. Due to high volumes of traffic, high accident rates, and insufficient geometrics, this corridor frequently experiences unacceptable congestion during peak hours.

The primary goals of this initiative are to improve the air quality and travel safety along this corridor. As peak period volumes increase, and the ability to accommodate these volumes decreases, a high concentration of pollutants are emitted to the area as a result of idling vehicles. This situation degrades the air quality of the area and increases the potential for accidents.

This IVHS Corridor is a critical segment of the only east-west interstate (I-40/85) in the central region of the state of North Carolina. The corridor links the Piedmont Triad (Greensboro, Winston-Salem, High Point, Burlington) region with the Triangle (Raleigh/Durham/Chapel Hill) region to the east and the Charlotte/Gastonia region to the southwest. It could be considered the "Main Street" of North Carolina, therefore it is imperative that this corridor remain relatively free from travel efficiency problems created by congestion.

In addition, the City of Greensboro, in coordination with the Greensboro Coliseum expansion, has proposed an IVHS initiative, which includes variable message signs and reversible lanes, to accommodate the expected increase in traffic volumes produced by event traffic in and around the coliseum area. This coliseum area is included in our area of study.

Finally, through a detailed traffic analysis, it has been determined that even with the completion of the entire Greensboro Thoroughfare Plan in the year 2015, traffic volumes within the IVHS Corridor will remain unacceptable for productive and efficient travel. Based on this information, congestion and incident management programs are proposed to assist this region with its travel efficiency problems into the 21st century.

PROPOSALS FOR IMPROVEMENT

Because of limited right of way and financial constraints, traditional methods of improvement (increased capacity by additional lanes) to the IVHS Corridor are not considered feasible. However, an Intelligent Vehicle/Highway System (IVHS) is a cost effective method of traffic management which is available to relieve congestion and increase the productivity and efficiency of the facility, thereby reducing the concentration of auto emissions along the corridor.

We propose the following diverse IVHS technologies and traffic management tools to help increase the productivity and efficiency of this facility: Variable Message Signs (VMS), traffic flow improvements, a Traffic Operations Center, Incident Management Signing, an Equipment Communications System, a coordinated signal system (i.e. Sydney Coordinated Adaptive Traffic System), and Video Surveillance (See Figure 1). The estimated cost of this first phase of our proposal is $18,151,000.00 including Preliminary and Construction Engineering and Mobilization estimates (See Figure 2).

Future improvements to this corridor could include ramp metering, High Occupancy Vehicle (HOV) lanes, additional traffic flow improvements, a vehicle detection system, expansion of the initial traffic management system, and Bus/Transit Pre-emption for signals and ramp meters. The cost has not yet been determined for these improvements.

This IVHS initiative is incorporated into the regional Incident Management Program for Active Control of Traffic (IMPACT) plan. The IMPACT proposal, which was developed by the Traffic Engineering Branch to initiate the utilization of multiple traffic management strategies, includes Greensboro, Winston-Salem, High Point, Burlington, and the smaller communities within the Piedmont Triad area.

FUNDING THE PROPOSED INITIATIVES

While there are many highway funding sources available, there are specific funds designated for improving the air quality in non-attainment areas. Among these specified funding programs is the Congestion Mitigation and Air Quality (CMAQ) program. The CMAQ program was created specifically to fund transportation projects which contribute to the attainment of the National Ambient Air Quality Standards (NAAQS). Guilford County is a designated ozone non-attainment area; therefore, according to the program provisions, it qualifies for CMAQ funding. It is our understanding that this proposal satisfies CMAQ eligibility and program requirements and presents a long-term mobility solution with immediate air quality benefits; therefore, we propose to use CMAQ funds in addition to any other available funds to make these necessary improvements.

FOR FURTHER INFORMATION CONTACT:

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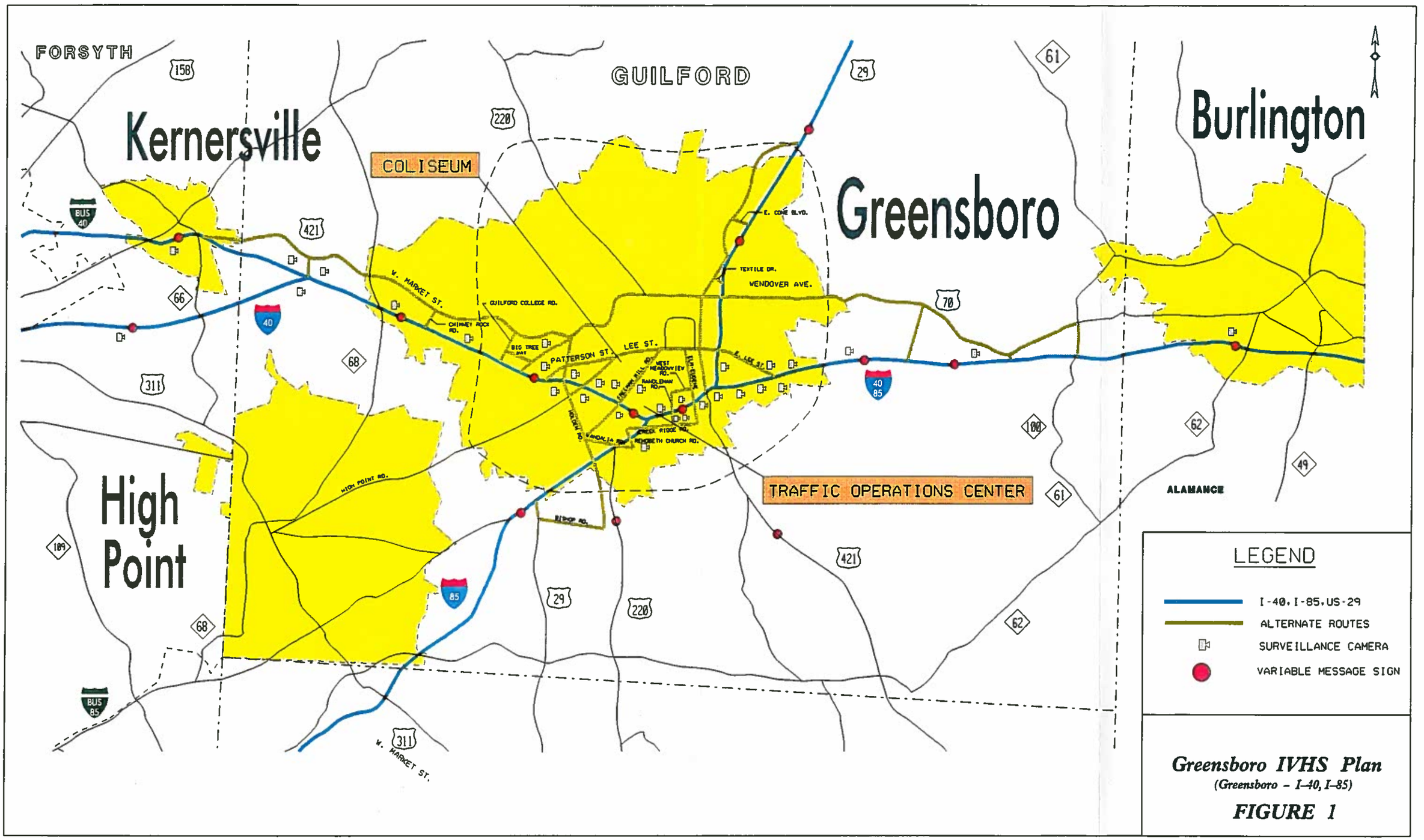
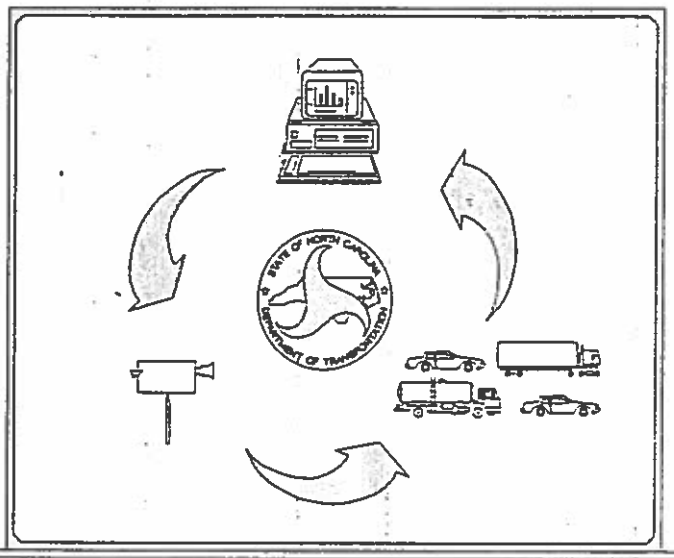


Greensboro IVHS Plan

(Greensboro – I-40, I-85)

FIGURE 1



GREENSBORO IVHS PHASE ONE COST ESTIMATE

VARIABLE MESSAGE SIGNING	$2,300,000.00
TRAFFIC FLOW IMPROVEMENTS	$4,700,000.00
TRAFFIC OPERATIONS CENTER	$2,000,000.00
INCIDENT MANAGEMENT SIGNING	$81,000.00
EQUIPMENT COMMUNICATIONS SYSTEM	$2,900,000.00
COORDINATED "SCATS" SIGNAL SYSTEM	$1,300,000.00
VIDEO SURVEILLANCE	$1,300,000.00
P.E. and CONSTRUCTION ENGINEERING	$2,990,000.00
MOBILIZATION	$580,000.00
TOTAL	$18,151,000.00

Figure 2

GREENSBORO
IVHS
FEASIBILITY STUDY

I-40/I-85 IVHS CORRIDOR

GUILFORD COUNTY

GREENSBORO

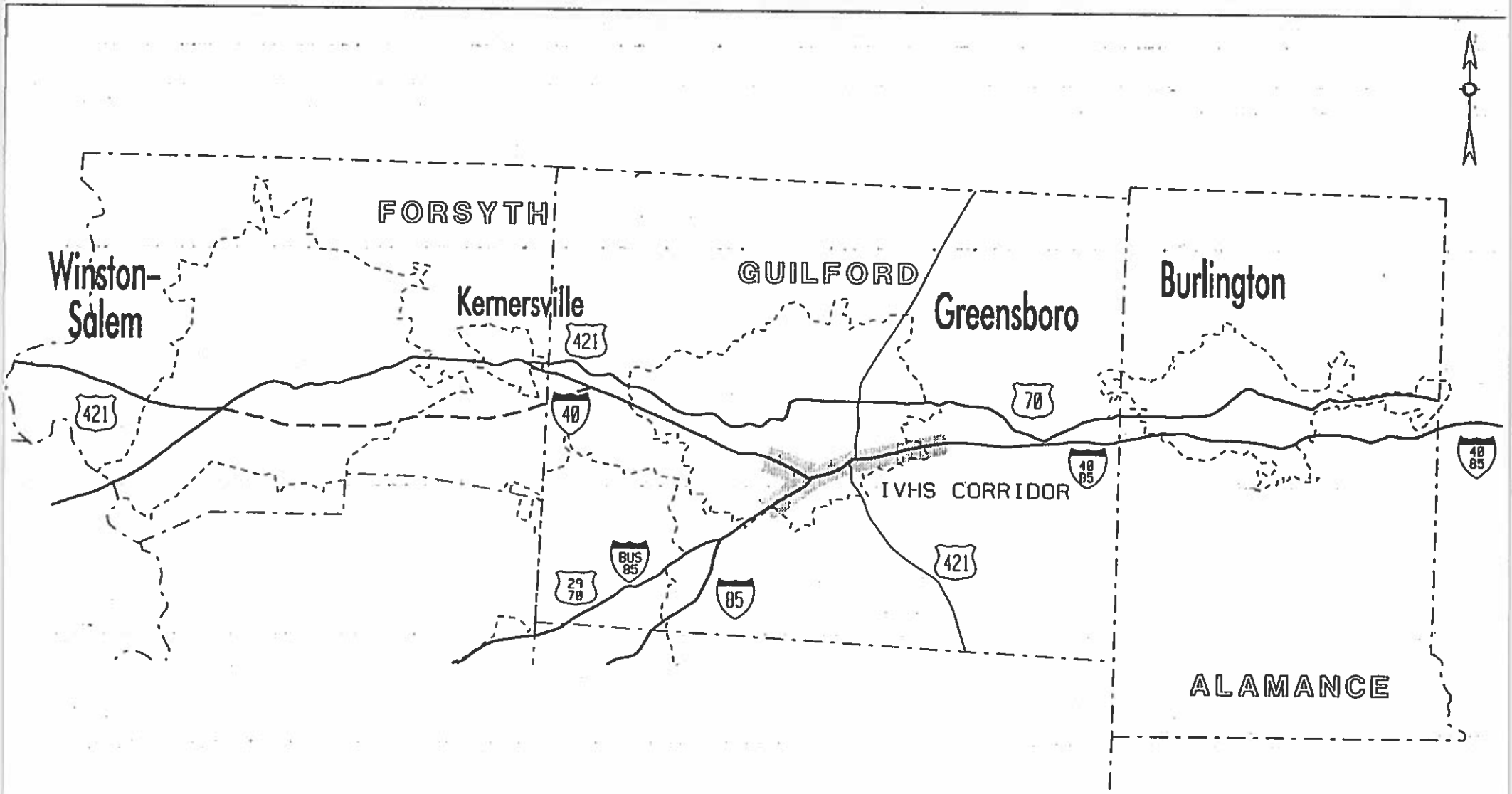
The Traffic Engineering and Safety Systems Branch of the North Carolina Department of Transportation developed this document in an attempt to address the problems associated with congestion management on major arterials located within Greensboro, a medium-sized urban region. This document was prepared by John Davenport, Valerie Lee, and Christa Atkins of the Congestion Management Section. Assistance was provided by Gary Faulkner, Anthony Wyatt, Craig Wilson - Design Review Squad, Mark Yalch and Robert Cauley -Signing Section, Julie Wilkins, P.E. - Construction Unit, Lane Hall and Paul Ingram - Division 7, Keith Pugh - City of Greensboro, Greg Fuller and Tom Parker - IVHS Section, and Doug Lane - Design Services Unit.

INTRODUCTION

Congestion has been a major concern for various highly urbanized regions across the United States. Today, traffic congestion is given greater emphasis in the non-traditional locations, such as, the midsized urban regions or North Carolina. Between 1969 and 1989 the total vehicle miles traveled across the nation increased by 98.5 percent while the total road miles increased by a mere 4.5 percent. As a result of the growth in automobile use drastically outpacing the expansion of the transportation network, disruptive levels of traffic congestion have been created. It is estimated that delays from congestion can amount up to $100 billion in annual productivity losses. Other negative effects include accident-related fatalities, increased air pollution, and inefficient fuel consumption.

The "Piedmont Triad" is defined as an area that includes the cities of Winston-Salem, Greensboro, High Point, and Burlington. An overview of this region is shown in Figure 3. This region is linked by two major interstate routes (I-40, I-85). Greensboro is the third largest city in North Carolina with a current population of nearly 200,000. The city grew nearly 18 percent during the period from 1980 to 1990. Greensboro has a very diversified business base ranging from textile manufacturing and electronic equipment industries to chemical and pharmaceutical production. Greensboro is classified as a non-attainment area for ozone concentration.

The section of freeway in Greensboro that carries both I-40 and I-85 was originally constructed as a bypass south of Greensboro in 1955. Between the completion date of 1955 and its first major reconstruction in 1967, this section of highway experienced excessive traffic accidents. Because of this, it earned the nickname "Death Valley". This section of I-40/85 will be referred to as the IVHS Corridor in this report. A major reconstruction of this facility in 1967 greatly improved both its capacity and safety temporarily. North Carolina has experienced significant growth in the past two decades, thus placing additional strain on this facility. The IVHS Corridor lies within the city limits of Greensboro and is a vital link in the corridor (I-40/85) which connects the state's three largest metropolitan areas (Raleigh/Durham, Greensboro/High Point/Winston-Salem, and Charlotte/Gastonia). This segment is also a part of the corridor which links Washington, DC with Atlanta, Georgia and other points to the south. The Greensboro area is now surrounded with commercial/industrial development on either side and will, with the completion of the proposed I-85 bypass in the year 2006, continue to be extremely essential to Greensboro, as well as North Carolina. Implementation of an effective congestion management program will be very beneficial to this location. For this reason, the primary focus will be to implement a total freeway management system for this area as soon as funds become available.



Piedmont Triad

Figure 3

BACKGROUND INFORMATION ON IVHS CORRIDOR

Characteristics of Existing Facility

The existing cross section of I-40/85 consists of three 12-foot lanes in each direction with various acceleration and deceleration lanes throughout its length. The outside shoulder width varies from four feet to ten feet with an inside shoulder of four feet. The existing right-of-way is 240 feet with full control of access throughout the study area. There are six mainline bridges, four cross street bridges, one railroad bridge, and one creek crossing bridge and five interchanges along the study corridor. The existing horizontal and vertical alignment is adequate to maintain a 60 mph design speed; however, the posted speed limit along the corridor is 55 mph.

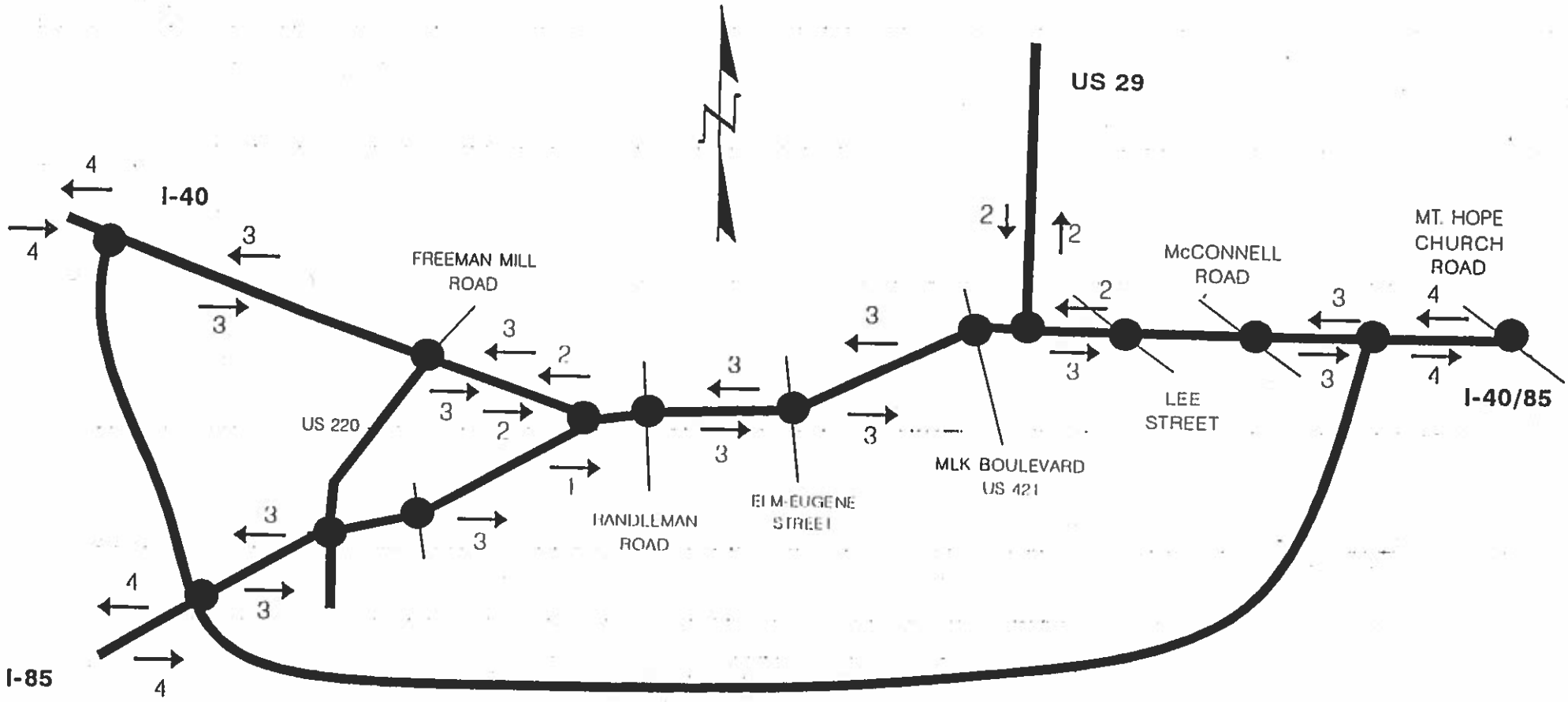
Scheduled And Active Projects in the Study Area

On the western end of the IVHS Corridor segment, I-40 is currently being widened to six lanes from the IVHS Corridor study area to the Forsyth County line under Transportation Improvement Program (TIP) projects U-60B and I-2201. Also under the U-60 A&B projects, US 220 is being extended from I-85 northward to connect with I-40. A full cloverleaf interchange including a semi-direct connection for northbound US 220 to eastbound I-40 traffic is planned at I-40. With the completion of this project, the IVHS Corridor will be linked to two six-lane freeways (I-40 and I-85) on the west side (See Figure 4). The completion of U-60B is expected to provide some relief for traffic travelling from northbound US 220 to westbound I-40 but will provide only marginal benefits for our study section.

On the eastern end of the project, I-40/85 is currently being widened to six lanes from US 29 to McConnell Road under TIP Project I-303E. From McConnell Road eastward to Hillsborough, I-40/85 will be eight lanes. The proposed I-85 bypass (I-2402) is proposed to intersect existing I-40/85 near McConnell Road. Approaching from the east, I-40/85 will taper from four lanes in each direction to only three after passing this point. After the I-303E project is completed, five westbound freeway lanes, three lanes from I-40/85 and two lanes from US 29 will dispense into the IVHS Corridor (See Figure 4).

The I-85 bypass is proposed to loop south of the city of Greensboro and connect back to existing I-85 near Groometown Road. Eventually, this bypass is proposed to encircle the city of Greensboro. Upon completion, this facility would carry vehicles around the city to bypass local traffic travelling on existing I-40/85. Construction of this highway is proposed to begin in the year 1997 and continue for several years.

In addition to construction projects, there are other proposed improvement projects along the study corridor. TIP Project I-2714, which involves improving the signing through the corridor, is currently under construction. This project should alleviate some of the confusion that presently exists, however it will not address other operational concerns. This project is scheduled to be complete in 1993. TIP Project I-2702, a pavement rehabilitation and resurfacing project, is currently scheduled for February 1994 letting.



I-40/85 BYPASS (PROPOSED)

PROPOSED LANE CONFIGURATION GREENSBORO AREA

FIGURE 4

RECOMMENDED IMPROVEMENTS

The goal of a successful Congestion Management Program is to minimize the impact of non-recurring and recurring congestion on existing travelling conditions. Alleviating congested conditions will assist with preserving life, improving travel efficiency and air quality, and protecting private property. Variable message signing, traffic flow improvements, a traffic operations center, an equipment communications system, a coordinated signal system (SCATS), video surveillance, and an incident management plan are recommended technical improvements to assist with minimizing the congested conditions on the IVHS Corridor. Ramp metering, vehicle detection, and High Occupancy Vehicle (HOV) lanes are future improvements to be considered.

All of the recommended improvements were coordinated with the City of Greensboro's expansion plan for the Greensboro Coliseum. The RBA Group was hired to conduct a study of this coliseum area and provide recommendations. The recommendations consisted of reversible lanes and variable message signs. The reversible lanes are expected to be operational by October 1993.

Variable Message Signing

The Greensboro Variable Message Sign (VMS) Project is one of the initial stages in implementing the Greensboro Congestion Management Program. The use of VMS is one proven method to provide traffic information and possible directions to motorists during incidents. There will be stationary signs at key locations initially proposed for this congestion management program.

The Greensboro Incident Management Design Committee, comprised of representatives from the North Carolina Department of Transportation, Federal Highway Administration, and City of Greensboro, established alternate route plans for incidents occurring on Interstates I-85 and I-40, and US Highways US 220 and US 29. This core group will be expanded to become the Interagency Incident Management Team which includes representatives from various emergency response agencies (ie. Fire, Hazardous Material Unit (HAZMAT), Highway Patrol, Emergency Medical Service, City and County Police). The NCDOT Signing Unit has prepared an initial VMS location plan based on the routing plan and input from the IMT and the RBA Group, a consulting firm involved with the Greensboro Coliseum Traffic Management Project. This plan proposes fourteen VMS sites in the Greensboro Incident Management Area shown on the attached Area map (Figure 1). These signs will be used primarily to inform motorists of abnormal traffic conditions and hazards, and, if necessary, divert them onto the planned alternative routes to ease congestion and reduce the excessive fuel consumption and air pollution caused by traffic delays. The VMS system will also be instrumental in controlling event traffic at the Greensboro Coliseum, which will increase the normal traffic volumes on I-40 between the Patterson Street and Freeman Mill Road exits by as many as 8000 vehicles per event.

The variable message sign system will be controlled by a central computer located initially at the Greensboro Division Office until the Greensboro Traffic Operations Center is constructed. The system will initially be interconnected using a cellular phone or radio communication link. This will eventually be replaced by a dedicated fiber optic cable link that will provide access to the

signs as well as to other components of the Greensboro Area IVHS system (closed-circuit cameras, ramp metering, vehicle detectors, etc.). The cellular link may be used as a backup. The Greensboro Coliseum will have on-site limited access to designated signs to control event traffic; however, the NCDOT will have override capability.

The total estimated cost for all signing components is $2.3 million.

Proposed Traffic Flow Improvements

Based on data obtained from the City of Greensboro, NCDOT Division 7, the Congestion Management staff and the Estimating Section of Design Services, the following traffic flow (geometrical) improvements are recommended to reduce air quality and congestion. Figure 2 summarizes the estimates of the proposed geometric improvements inclusive of the final pavement markings and lane configurations. The total estimated cost of all of these improvements is $4.7 million.

IMPROVEMENT 1

Extend the Randleman Road westbound on-ramp to I-40 to tie into the three-lane section of I-40 westbound proposed under the U-60B project. No additional right-of-way will be necessary for this improvement. This proposed geometric improvement will increase the merge level of service (LOS) of this ramp from a LOS D to a LOS A. It will also coincide with a proposed VMS that will be used to direct traffic away from congested areas along westbound I-40. This improvement has an estimated cost of $140,000 excluding the variable message sign.

IMPROVEMENT 2

Add a fourth lane to the eastbound lanes of I-40/85 from east of the CSX Railroad bridge to the US 29 northbound off-ramp. This widening will take place in the existing grass median. A barrier wall will be constructed in the median from where the existing wall now terminates east of the CSX bridge to the point where the proposed barrier wall of the I-303E project is proposed to terminate. The entire median will be paved. This improvement will coincide with a proposed VMS and will provide an exclusive lane for traffic, directed to use US 29 northbound, to bypass queued vehicles on I-40/85 in the event of an accident. With this lane addition, a two lane off-ramp can also be developed to better serve the heavy US 29 northbound movement. This is a high accident area, and these improvements will improve its safety; therefore, reducing accidents, delay, and improving air quality.

A subsequent improvement in the level of service through this section could be expected. Furthermore, a hazardous maintenance condition would also be eliminated.

Because there will be new pavement provided on the westbound side of I-40/85 in the same general area, it is suggested that the two westbound lanes be shifted onto the new pavement to provide room to extend the Martin Luther King Drive (US 421) on-ramp acceleration lane. The lengthening of this acceleration lane will coincide with the possible metering of this ramp. A possible HOV bypass lane could be built on this ramp in the future to function with the ramp meter. The US 29 southbound merge will be tapered into one lane and function as a lane addition. These recommendations will provide operational and safety improvements, therefore reducing congestion related accidents and pollution. No additional right-of-way is required for these improvements. These geometric improvements are estimated to cost $1,170,000.

IMPROVEMENT 3

Under U-60B, the proposed eastbound I-40 section approaching the IVHS Corridor will have three through lanes and one auxiliary lane. The leftmost through lane will terminate just before the I-85 overpass bridge and the auxiliary lane will taper onto the existing ramp to I-85 southbound. This will leave only two through lanes leading to the IVHS Corridor. It is proposed that this leftmost lane be extended over the I-85 overpass and taper at the left hand Randleman Road exit. This improvement will not require any additional right-of-way and will coincide with intersection and signal improvements along Randleman Road.

This improvement will increase the capacity of the intersection; therefore, reducing delay, which will in turn reduce auto emissions. Also, the level of service in this area can be expected to improve from a LOS E/F to a LOS C. The cost of this improvement, including the I-85 overpass structure widening and excluding the signal improvements is estimated to be $2.5 million.

IMPROVEMENT 4

Add dual left turn lanes to the Randleman Road exit ramps serving I-40/85 westbound and I-85 northbound and the Elm-Eugene Street exit ramp serving I-40/85 westbound. Better signing should also be provided in the Randleman Road interchange area. These improvements would increase the efficiency of the signals on Randleman Road and Elm-Eugene Street, therefore reducing delay and fuel consumption, as well as provide more storage space on the ramps to prevent traffic from stacking onto the freeway. In addition, wherever possible, the radii at all of these ramp terminals should be improved to better handle large trucks. The level of service for these ramps, when analyzed independently would improve from a LOS C to a LOS B. No additional right-of-way is necessary for these improvements. The estimated costs of these geometrical improvements is $140,000, $140,000, and $165,000 per ramp respectively.

The existing JJ Drive, which ties into the Randleman Road ramp at eastbound I-40/85 (making it a two way ramp), should either be closed or have access restricted to right-in/right-out movements.

IMPROVEMENT 5

Extend the westbound I-40/85 auxiliary lane serving Randleman Road and Elm-Eugene Street through the gore area of the Randleman Road exit ramp to tie into the four-lane section under the Randleman Road overpass. With properly coordinated VMS signing, this improvement will help alleviate some of the present congestion at the westbound I-40/southbound I-85 split. It is estimated that the segment level of service would improve from a LOS F to a LOS D. No additional right-of-way is needed for this proposal. The cost of construction is estimated to be $450,000.

Traffic Operations Center

A Traffic Operations Center is essential to providing an effective congestion management plan. It will control all incoming information and determine an appropriate course of action for traffic management, incidents, or other roadway conditions that are needed by motorists in the area. For this reason, it is proposed that a new building designed specifically to accommodate these systems be constructed. Initial estimates indicate that approximately 3,000 square feet will be adequate to serve the needs of the electronic equipment of the IVHS Corridor. Consideration should be given to the need for an auditorium at the center for visitors, the inter-agency incident management team, training needs, and the media. Since the location of the control center is proposed in the right-of-way of westbound I-40, purchasing land will not be necessary. Therefore the approximate cost for construction of the traffic operations center, adding electronics and equipment, and providing operational software is $2,000,000.

Equipment Communication System

A Communication system is the central link which permits communication from the field devices such as loop detectors, VMS and video cameras. The estimate for its main components including conduit, junction boxes, and fiber optics is approximately $2.9 million for the entire corridor.

Coordinated Signal System

The traffic signals along the alternate routes must be coordinated by a central computer to enable the most efficient use of all roads in the corridor. The Sydney Coordinated Adaptive Traffic System (SCATS) is a central computer based traffic signal network. SCATS operates in real-time, automatically adjusting signal timings in response to measured variations in traffic demand. The system is fully adaptive to actual street conditions and requires no precalculation or continual update of signal timing plans. New values of system cycle length, phase split, and offset are calculated automatically, providing an infinite range of timing plans. As the demand continues to increase, the SCATS system will allow the cycle length to adjust until the demand stabilizes.

When an incident occurs along one of the corridors, the alternate routes will experience a sudden change in traffic volumes. SCATS has the flexibility to respond to both continuous fluctuations and unpredictable increases in traffic demands.

The implementation of a fully responsive system like SCATS along the alternate routes will eliminate the need for continuous monitoring by an operator to make manual timing adjustments during an incident. During normal operation, SCATS will provide extended green times along the alternate route, thereby improving overall transportation performance, safety, and fuel efficiency. While SCATS will not create additional capacity, it will provide a significant device to fully utilize the available capacity along the alternate routes. The estimated total cost of the SCATS Implementation is $1.3 million.

Video Surveillance

Onsite video cameras will give personnel the ability to visualize, first hand, the impact of traffic incidents on the IVHS Corridor, or alternate routes. It will allow instant verification of specific locations of problems and efficiently initiate an appropriate response. Cameras will be placed at critical intervals along the corridor and at all interchanges. It is estimated it will cost $1.3 million to install video camera equipment along the IVHS Corridor.

Proposed Incident Management Plan

The purpose of Greensboro's Incident Management Plan is to develop an efficiently operating inter-agency incident management team for Greensboro's freeway system that would be responsible for taking appropriate action in the event of a system blocking incident that would reduce the efficiency of the corridor. In case of a lane blockage, incident or scheduled event, motorists can be directed to use prearranged alternate routes to help mitigate the impact of the incident. In addition, with recurring congestion, motorists can be informed that delays should be expected. This would assist in the diversion of some traffic to arterial roads, reducing congestion on the freeway and the concentration of vehicle emissions. After careful evaluation and analysis, Lee Street (NC 6), Wendover Avenue (US 70), and US 421 were selected as alternate routes for the I-40/85 corridor. These routes will require only minor geometric and signal revisions to make them suitable for alternative detour routes.

A major part of the proposed incident management plan will be the implementation of the Motorist Assistance Patrol (MAP). The MAP Program utilizes specially equipped NCDOT vehicles to provide services to stranded motorists, surveillance and detection for incident response agencies, and traffic control at incident scenes. The MAP for the Greensboro IVHS Corridor is in the early stages of implementation.

It is likely that an effectively coordinated incident management program, even in regions that already respond to non-recurring congestion, will improve highway travel efficiency and will reduce the expenditures necessary for future incident response. Estimates for this incident management program are being developed by the incident management task force.

Ramp Metering

Ramp metering can effectively control the discharge of traffic from the ramp onto the freeway as desired. In the event of an incident downstream, ramp metering would restrict access to the impacted facility at ramps upstream from the incident. This system will further control the access of vehicles after the incident is cleared to allow the impacted facility time to recover to its normal traffic flow. During normal traffic conditions, ramp metering would regulate the stream of vehicles entering the facility to avoid exceeding maximum capacity.

Ramp metering has been suggested as an option to reduce congestion at ramp merge areas. A study to determine the feasibility of ramp metering in the Greensboro IVHS Corridor is currently being conducted by a consulting firm. The study is expected to be complete in December 1993.

Vehicle Detection

To effectively monitor the traffic conditions (speed, volume, etc.) of the facility at any given time of the day will require an elaborate system of loop detectors (or an equivalent system) and the associated equipment for each travel lane. Many of the other systems described within this proposal will depend directly on information received from a field detection system. Furthermore, these detectors can deliver instantaneous traffic data for evaluation purposes. Also, the Traffic Engineering Safety Systems Branch is exploring the possibility of placing loop detectors on the off ramps along the corridor to detect queing traffic that could possibly cause congested conditions on the freeway. Installation of this system would be $700,000 for the entire facility or $150,000 for the IVHS Corridor.

HOV Lanes

As a result of heavy commuter traffic, the possibility of adding High Occupancy Vehicle (HOV) lanes to the corridor was considered. This would require adding one lane in each direction between Randleman Road and US 29. These lanes would only be designated as HOV during the peak hours and would be restricted to vehicles that had two or more passengers. This lane addition would require the replacement of the CSX rail bridge and the Elm-Eugene Street overpass. A structure carrying I-40/85 over Buffalo Creek would have to be widened in addition to purchasing some right of way. The estimated cost of this recommendation is $32 million.

BENEFITS OF PROPOSED IMPROVEMENTS

IVHS devices will provide technology-based approaches to enhance the overall effectiveness of the nation's surface transportation system. NCDOT recommends the implementation of several technologies along the I-40/85 IVHS Corridor in Greensboro to improve the existing congested conditions. These technologies include the use of variable message signing, traffic flow improvements, a traffic operations center, incident management signing, a coordinated (SCATS) signal system, video surveillance, and an incident management plan. Future consideration will be given to ramp metering and HOV lanes. The ultimate goal is to have a complete system offering maximum freeway video surveillance and control. These recommended IVHS devices will increase the mobility of the corridor, therefore improving the air quality and overall efficiency.

Variable Message Signs

The primary function of variable message signs is to warn motorists of unusual circumstances such as incidents, work zones, or special events that change the normal roadway operating conditions. In addition to providing valuable real-time information to the motorists, they also build highway agency credibility and promote public support for proposed transportation projects in the area. The proper use of these variable message signs results in altering the traffic demands. By altering the traffic demands, there will be a reduction in congestion, delay, fuel consumption, and vehicle emissions. Traffic safety is improved by making drivers aware of downstream congestion, giving them enough warning to take an alternate route and reduce the magnitude of the downstream congestion.

It is difficult to quantify the benefits of providing real-time information to the public. A study was conducted in Dallas, Texas to provide an indication of the effectiveness of providing information to motorists for special events. The purpose of these studies was to determine the amount of diversion that occurred from the main freeway route to the event. There was an alternate route that intersected the freeway approximately five miles upstream from the event. The results showed that the variable message signs greatly influenced diversion to the alternate route. It was estimated that up to 85 percent of the event traffic diverted to the alternate route as a result of the advance warning. This demonstrates that it is extremely valuable to provide real-time information to motorists.

Traffic Flow Improvements

Improving the geometric design of a facility with minimal costs can be a very beneficial option for increasing capacity and decreasing congestion. Increasing the length of acceleration lanes, improving sight distances, improving signing, restriping existing pavement and adding new pavement on existing right-of-way are ways to improve the design of a facility. These minor improvements allow the motorist to effectively utilize the existing facility.

Temporarily restriping one or both shoulders of a freeway to be used as travel lanes during peak periods in peak directions, can increase the capacity as much as 30 percent on a congested freeway. Low cost improvements such as this have the potential of returning a benefit-to-cost ratio of up to 7:1 depending on the type of improvement.

It is difficult to fully quantify the benefits of making minor improvements to the geometric design of a facility, but this method of congestion management is referenced often in several congestion management documents such as "A Toolbox for Alleviating Traffic Congestion" by the Institute of Transportation Engineers (ITE) as an effective way to reduce congestion.

Traffic Operations Center

The Traffic Operations Center is an essential link in the congestion/incident management chain. It ties all of the other IVHS components of the system to a central command center where information can be received, processed, and distributed to the motorists. The benefits of this are far numerable. Incidents can be responded to quickly and efficiently and the driver can receive real-time information concerning travelling conditions. The over-all benefit of this is that congestion is reduced, therefore reducing auto emissions, the number and severity of accidents, and driver frustration.

Incident Management Signing

When an incident occurs on the major routes, incident management signs will be used to direct vehicles to the designated alternate routes. The use of alternate routes to alleviate congestion can be very beneficial to the motorist and municipality. Designating parallel alternate routes to freeway facilities gives the driver alternatives to utilizing the freeway for short trips or commuting. In addition, it gives official routes to detour traffic onto in the event of a major accident or occurrence. These routes can also be used to bypass congested areas. The benefits of alternate routes cannot be quantified exclusively because alternate routes are usually used in conjunction with other congestion/incident management devices such as variable message signing, vehicle detection, and video surveillance.

Coordinated Signal System

An extensive system of signals coordinated with a centralized computer network has been used in Australia for several years. This signal system, called the Sydney Coordinated Adaptive Traffic System (SCATS), provides significant benefits compared to a traditional signal network. Studies in Australia show that because of SCATS' ability to efficiently process traffic, a 7% reduction in auto emissions, 12% reduction in fuel consumption, and 20% reduction in delay can be expected from its application. The United States anticipates this technology to be a vital part of its congestion management system in the future.

Video Surveillance

Video surveillance combines several areas of IVHS technology to provide relief from recurrent and nonrecurrent congestion. This type of system may include, but is not limited to, one or more of the following components: variable message signing, electronic surveillance, closed circuit television surveillance, ramp controls, motorists information displays, traffic signal control, preferential HOV treatments, and incident management systems. The benefits of video surveillance includes reduced travel-times, improved travel reliability, reduced fuel consumption and vehicle emissions, reduced accidents, increased driver satisfaction, increased capacity, and less maintenance of the facility.

There are several video surveillance systems in operation, construction, design, or planning throughout the United States. Detroit, Michigan has a system which includes electronic surveillance, closed circuit television, variable message signs, ramp metering, and motorist-aid telephones that has been in operation since the 1960's. Michigan State University conducted a study which indicated that the system provides positive benefits to the area. Speeds along the facility were increased by eight percent while 14 percent more traffic was accommodated. In addition, accidents were reduced by 50 percent, and injury accidents were reduced by 71 percent.

Illinois also has an extensive video surveillance system which encompasses a six-county regions in the Chicago area for a total of 118 miles. This system includes electronic surveillance, ramp controls, variable message signs, highway advisory radio, emergency traffic patrol, a communication center, and cellular telephone communications. This system has reduced peak-period traffic congestion by 60 percent and accidents by 18 percent.

A video surveillance system that incorporates all of the available IVHS components will provide maximum results in reducing congestion, fuel consumption, vehicle air pollutant emissions and road user costs. If it is not feasible to provide all of these components at one time, it can still be beneficial to the system to add individual components when possible. While this is not as effective as providing the entire system, several of the IVHS technologies will provide substantial benefits.

Incident Management Plan

An incident management plan can be as simple as a motorist assistance patrol or as complex as combining a motorist assistance patrol with variable message signing, electronic surveillance, closed circuit television surveillance, interagency communication, highway advisory radio, and detour routing - all linked to a traffic control center. The primary goal of a freeway incident management plan is to safely remove an incident from a roadway in order to minimize delay to other motorists. This is important because closure of one lane on a three lane section can reduce the capacity of the freeway up to 50 percent. An incident of any magnitude can cause unacceptable levels of congestion, which can lead to secondary accidents.

The Institute of Transportation Engineers (ITE) estimate that an incident management plan can reduce congestion by about 30 percent and can cut incident duration by an average of ten minutes. The estimated benefit to cost ratio for implementing this system is 4:1. An active incident management plan can reduce congestion and delay while improving safety and capacity. Several cities around the United States have active incident management systems that have been successfully operating for several years.

The Illinois Department of Transportation began a motorist assistance patrol named the Emergency Traffic Patrol (ETP) in 1961. This patrol covers 135 miles of freeway continuously. They process all incoming incident reports as well as alert other agencies who need to assist with the incident. The ETP assisted over 100,000 motorists in 1988. It is estimated that the ETP has reduced the time needed to clear major incidents in half as a result of their training and available equipment. They are generally able to detect and respond to an incident that blocks a travel lane in about five minutes. This quick response time is essential to minimize delay and secondary impacts while improving driving conditions.

San Antonio, Texas has an area wide motorist assistance patrol. Accident data was collected prior to the start of the patrol and during its implementation. The results indicated that 160 secondary accidents were prevented by the assertive efforts of the motorist assistance patrol, resulting in an accident cost savings of $1,600,000 (1979 dollars) for one year. The expenses for that same year were $226,100, which results in approximately a 5:1 benefit to cost ratio. This does not consider any delay cost reductions that may be incurred by the motorists. It is obvious that the motorist assistance patrol was a worthwhile investment for San Antonio.

Ramp Metering

Ramp metering has been proven to be an effective method of decreasing congestion in Southern California since 1968. Ramp metering utilizes a traffic signal to control the flow of traffic merging onto the freeway. The rate at which traffic is permitted to enter the freeway is determined by either pretimed intervals or the volume of traffic on the ramp or mainline. The benefits of ramp metering include increased traffic flow rate, increased freeway speeds, and a reduction in the number and severity of accidents at ramp merge areas.

The Washington Department of Transportation began metering the freeway network of Seattle in 1968. This system was expanded in 1973, 1979, and to its present state in 1981. Since ramp metering began, travel times have decreased or remained stable while traffic demands in the region have increased 49 percent. The accident rate for the system experienced a 38 to 62 percent decrease depending on location and time of day.

The Colorado Department of Highways installed ramp metering on a portion of I-25 in Denver as a demonstration project in 1981. This project was an immediate success. The stop-and-go conditions that existed before the ramp metering project were eliminated. There was a 58 percent increase in freeway speed and a 37 percent reduction in travel times. Public reaction to the new system was very

positive. Because of this success, this system was expanded in 1984 and 1988 to include most of the freeway network.

HOV Lanes

The purpose of constructing HOV lanes along an existing freeway is to maximize the people-moving capacity of a facility. This concept of HOV lanes encourages motorists to share rides to work and other destinations and shift from single occupancy vehicles. HOV lanes have a much higher occupancy rate than general purpose lanes. The rates range from 5.79 passengers per vehicle on the I-5 FLOW System (Seattle) to 46.15 passengers per vehicle on the I-495 Contraflow Bus Lane (N.Y.). Studies show that the benefit-to-cost ratio can be as high as 6:1 for adding HOV lanes to a freeway.

NEED FOR IMPROVEMENTS IN THE SURROUNDING AREA

Major Cities

One of North Carolina's most important facilities is the I-40/I-85 freeway. It is the only east/west connector for three major cities in the state. These cities include Winston Salem to the west, High Point to the southwest, and Burlington to the east. Due to the diverse manufacturing industries and the significant population growth in these cities, the implementation of a congestion management plan can be a valuable means to alleviate the effects of the projected traffic growth on the existing roadways.

Winston Salem

With a population of nearly 165,000, Winston-Salem is the fourth largest city in the state. The city has grown 8.8 percent over the last ten years. There is a broad range of industry in Winston-Salem including tobacco, fabrics and knitted wear, air conditioning equipment, furniture, and dairy products. With the completion of the new I-40 section in the city and the accident history of Business 40, interest in a congestion management program including these corridors has grown. Although traffic volumes along Business 40 have decreased considerably, it is projected that traffic will oversaturate this corridor in five to ten years.

High Point

High Point has a population of nearly 70,000 and is the seventh largest city in the state. The city has grown 9.7 percent from 1980 to 1990. High Point's current industries include manufacturing trucking equipment, furniture, and textiles. Also, an existing distribution center that currently serves Polo, Ralph Lauren, and Capital Records is being expanded. The I-85 corridor passes through this city carrying approximately 35,000 vehicles per day with 10 percent of these being heavy trucks.

Burlington

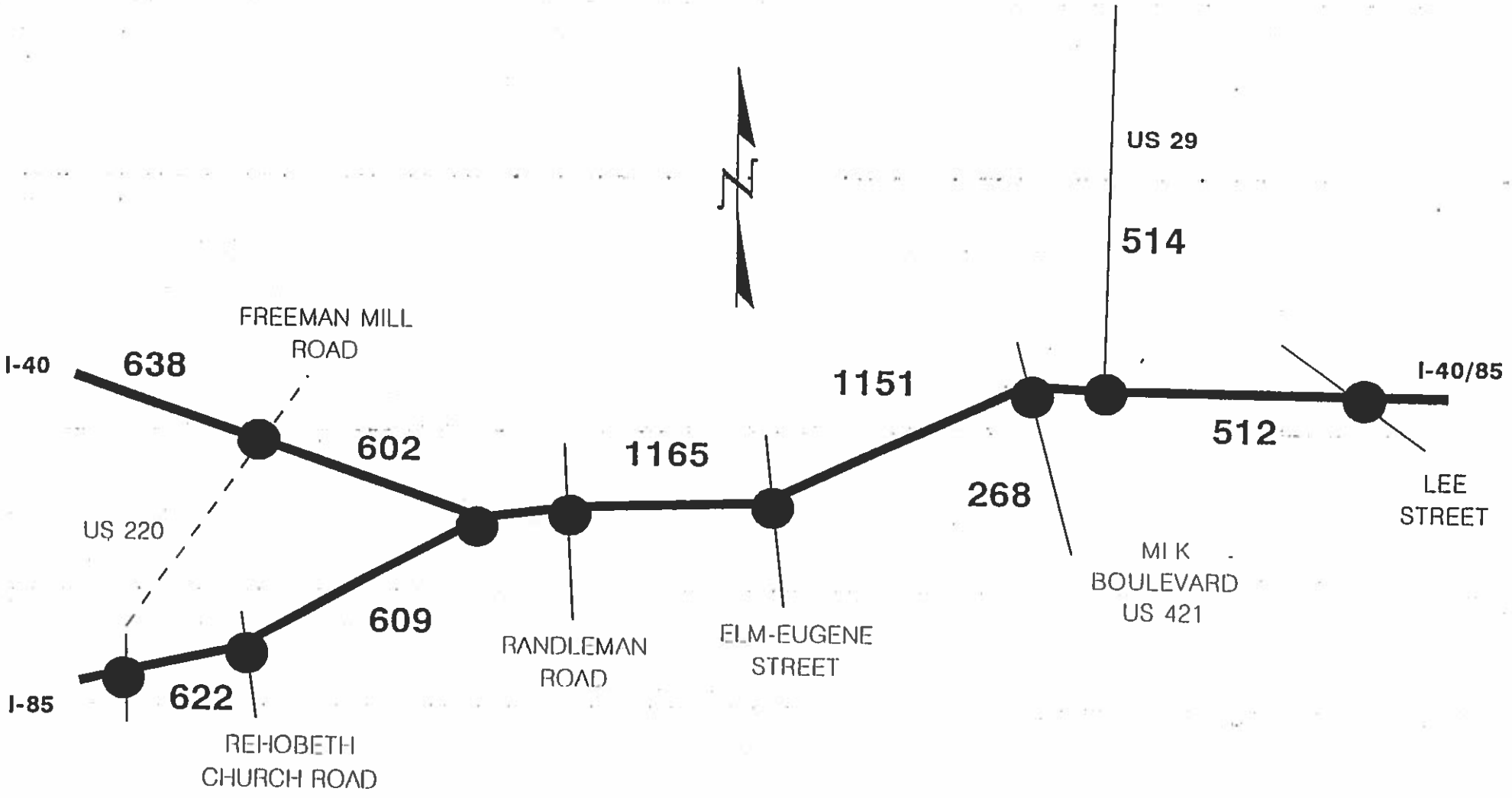
There are approximately 40,000 people living in the city of Burlington making it the fourteenth largest city in the state. Burlington has experienced a 5.8 percent growth rate over the last ten years. The current industries include electronic equipment, chemicals, furniture, and textiles. Similar to Greensboro, the I-40/85 corridor passes through the city carrying approximately 55,000 vehicles a day with over 20 percent of these being heavy trucks. Although this section of interstate is currently being widened to four lanes in each direction, it is projected that it will be operating at full capacity by its design year (2010).

TRAFFIC VOLUMES

Current 1991 traffic count data indicates that the IVHS Corridor is carrying between 115,100 to 116,500 vehicles per day with approximately 20 percent of these vehicles being heavy vehicles (Figure 5). This corridor now operates at a level of service "F" for both the AM and PM peaks, particularly at ramp merges and diverges. The areas presently experiencing poor operational LOS are as follows:

(1) Ramp from northbound I-85 to Randleman Road currently experiences queues that extend into the freeway thus causing delays during peak hours.
(2) Ramp from westbound I-40/85 to Elm-Eugene Street currently experiences queues that extend into the freeway thus causing delays during peak hours.
(3) Southbound US 29 - northbound Ramp from US 421 -I-40/85 merge becomes a major congestion problem routinely during the PM peak periods as four lanes of traffic merge into three lanes.
(4) Ramp from eastbound I-40/85 to Martin Luther King Drive experiences peak period stacking which greatly impacts the mainline traffic flow.
(5) Weaving at major junctions (I-40/85 split and merge on the west end of the corridor, and the I-40/85 -US 29 -US 421 split and merge on the east end) is of considerable concern, from a safety perspective.

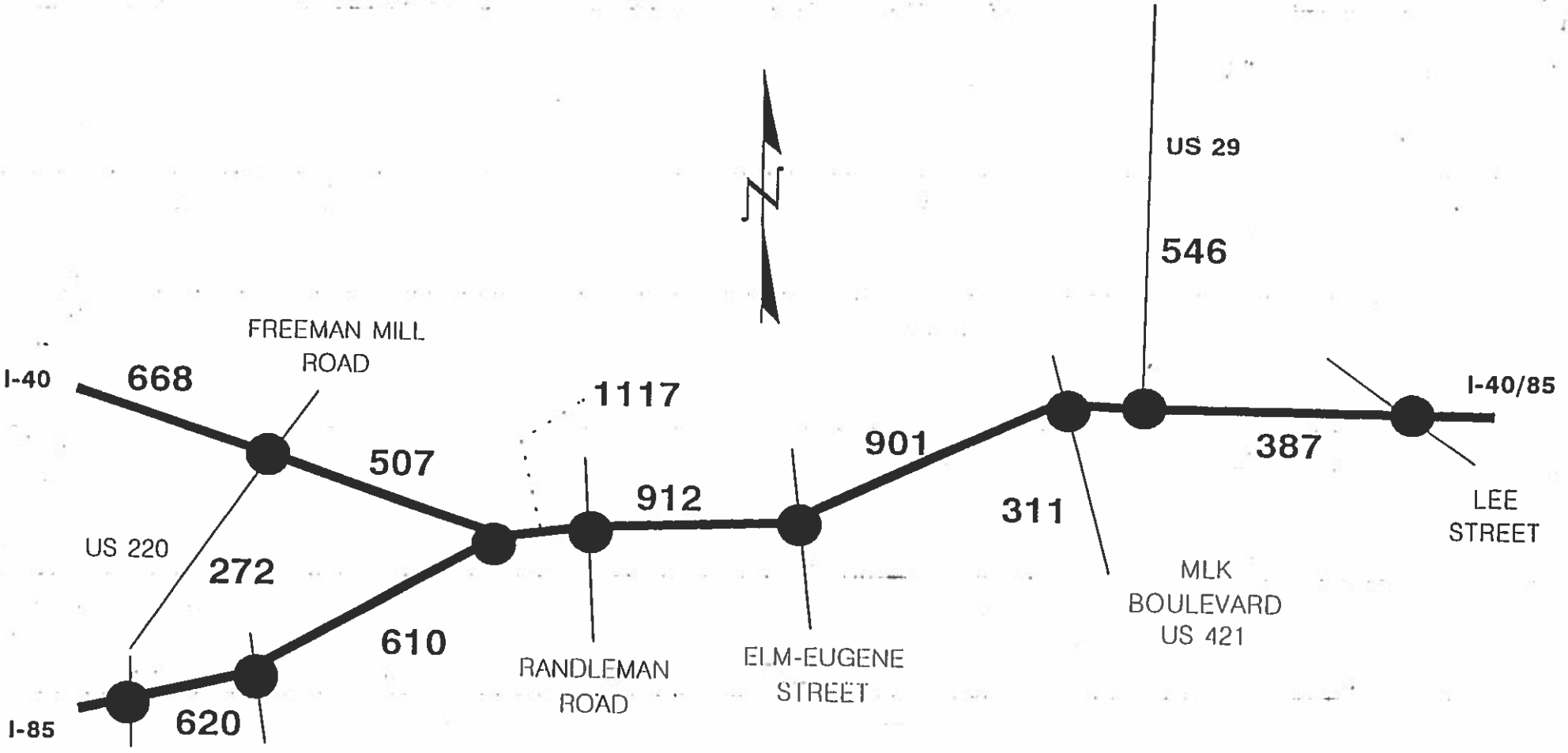
Without the proposed I-85 bypass scheduled to be constructed in the year 1999, traffic volumes are expected to rise to between 130,000 and 140,000 vehicles per day by the year 1996. It is projected that by this time, the impacts of congestion on the community street network will be evident. Using the best case scenario, which includes the complete construction of the Outer Loop (including the I-85 bypass), and all interstate traffic assigned to the bypass, 2015 volumes are still projected to be between 91,000 and 111,000 (Figure 6). By the same year, ramp volumes are projected to nearly double. Given this data, it is evident that without some type of operational improvement, this facility will continue to be a source of undesirable congestion and deteriorating air quality.



1991 AVERAGE DAILY TRAFFIC VOLUMES

(IN HUNDREDS)

FIGURE 5



*THESE VOLUMES ASSUME COMPLETION OF GREENSBORO'S THOROUGHFARE PLAN INCLUDING I-40/85 SIGNED TO URBAN LOOP

2015 PROJECTED AVERAGE DAILY TRAFFIC VOLUMES

(IN HUNDREDS)

FIGURE 6

ACCIDENT ANALYSIS

In order to locate the safety problems along this corridor, an accident report for the entire length of the corridor (2.6 miles) was provided by the Accident Studies section of the Traffic Engineering Branch. The report was divided into two sections (east and west) with the division line being the Elm-Eugene Street bridge. The accident report is compiled from data collected during a three year period between October 31, 1989 and November 1, 1992.

The report indicates that the eastern section of the corridor experienced an accident rate of 159.07 accidents per 100 million vehicle-miles (acc/100mvm) which is 22 percent higher than the statewide average of 130.20 acc/100mvm for urban interstates. The western section experienced a rate of 268.88 acc/100mvm which is more than double the statewide average. The facility experienced nearly 800 accidents over this period, with approximately 30% occurring during the weekday peak hours of 4:00pm to 7:00pm (Figure 7). Approximately 45 percent of these accidents were rearend accidents caused by slowing or stopping vehicles, with another 30 percent being sideswipe or angle type. This data indicates that weaving around slow moving traffic to avoid congestion causes a high percentage of the traffic accidents. The total cost of injury and property damage that occurred during this period is estimated to be 8.5 million dollars. This cost excludes lost productivity, fuel consumption, and accidents outside of the study area caused by queing traffic. There were two fatalities that occurred during this period. Sixty-six percent (66%) of the vehicles involved in the accidents were passenger vehicles or vans, and twenty-five percent were heavy trucks. Most of the accidents occurred at major merge and diverge areas.

With the implementation of the proposed Greensboro IVHS management plan, the number of potential secondary accidents will be reduced by minimum response time to incidents. Improving traffic flow along the corridor will reduce the number of slowing and/or stopping vehicles; therefore, lowering the total accident rate.

CLOSING

There are studies that suggest that a significant amount of the day to day congestion on existing highways is not simply a result of the traffic volumes utilizing the facility. As much as 60 percent of all freeway congestion is suggested to be a result of accidents, disabled vehicles, or similar incidents. It is estimated that an efficient incident management system could have monetary benefits that exceed the actual cost by 17 to 1. Calculations show that the closure of a single lane on I-40/85 for only one hour during peak traveling times can cost motorists $50,000. Furthermore, an effective congestion management program to handle routine traffic congestion can have monetary benefits to motorists that exceed actual cost by a ratio of 9 to 1. If implemented, the proposed system can have a significant impact on improving the safety and reducing travel time on I-40/85 and intersecting routes on a daily basis. It will work to actively address traffic congestion through physical systems described herein, and will use various devices to provide traffic information and roadway conditions to the motorist. This type of "on the spot" information along with the knowledge of possible alternative means of travel shall give the public the greatest level of flexibility to address their travel needs.

HOURLY SUMMARY OF ACCIDENTS

IVHS CORRIDOR

Data Taken From 11/89 - 11/92

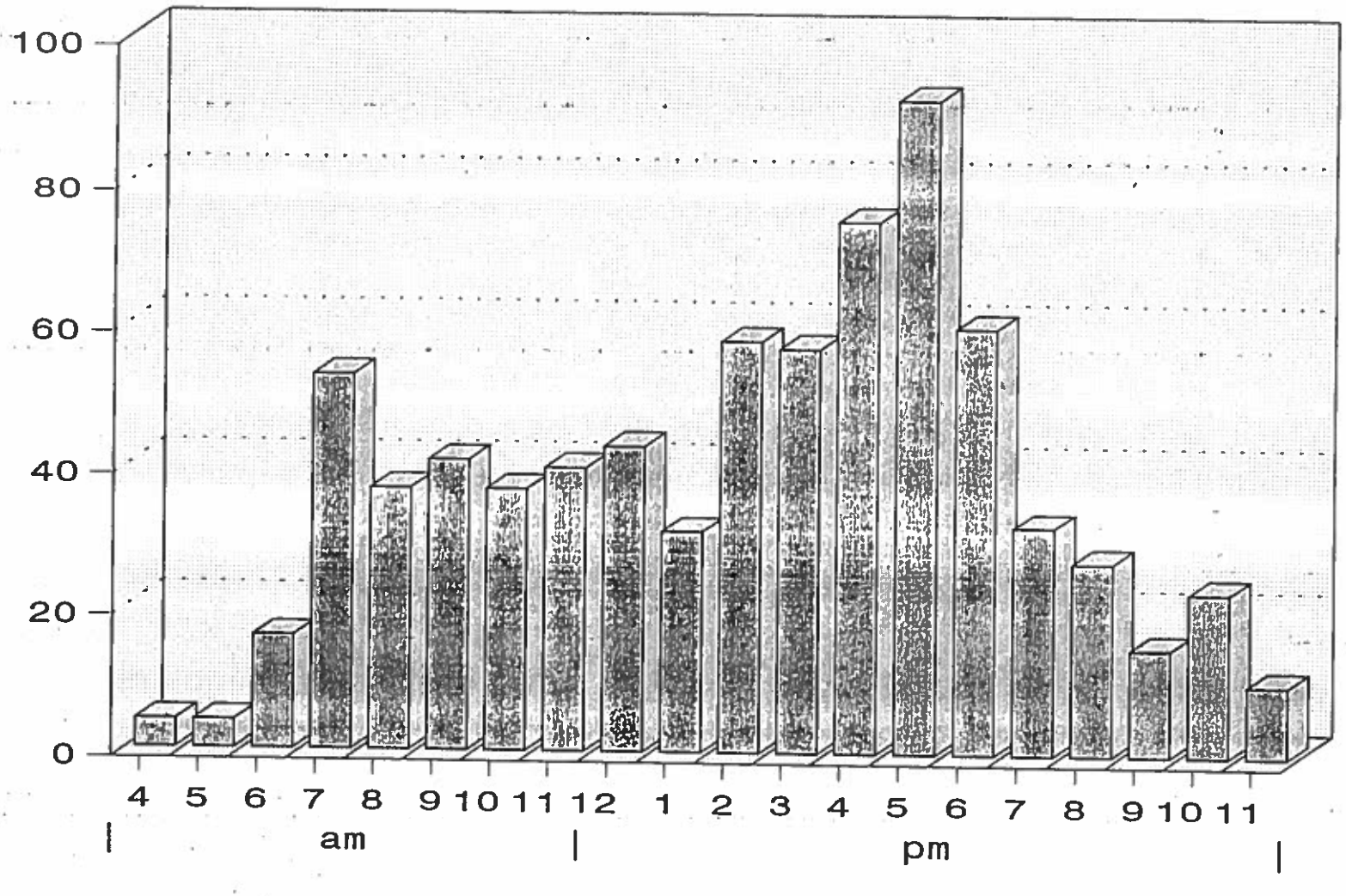


Figure 7

These proposals are not a cure-all for Greensboro's traffic problems, but they do offer greater flexibility to the existing street network. Better management of traffic flow, can reduce congestion therefore reducing the negative environmental affects associated with congested conditions. Furthermore, initial evaluations indicate that the majority of these proposals would qualify for Congestion Mitigation and Air Quality (CMAQ) funds or any other available funding.