July 2009

Fast Lanes

GET THERE!

Charlotte Region ***Fast Lanes*** Study

FINAL REPORT

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1.0 INTRODUCTION

1.1 Purpose of Study

With increasing volumes of traffic using the Charlotte Region's road network, and given the persistent physical, financial and environmental constraints to the widening of major highways, an emphasis on serving travel demand through innovative use of existing or planned roadway capacity is ever more compelling. In 2004, the North Carolina Department of Transportation (NCDOT) began to use roadway capacity more efficiently by implementing high-occupancy vehicle (HOV) lanes along 10 miles of I-77 between Huntersville and Charlotte, which represents the first and only HOV facility in North Carolina. Based on public acceptance of this HOV facility, the Charlotte Department of Transportation (CDOT), NCDOT, the South Carolina Department of Transportation (SCDOT) and other agencies in the Charlotte region initiated an examination of existing and planned major highways throughout a 10-county region to identify where *Fast Lanes* – HOV, high-occupancy toll (HOT) or truck-only-toll (TOT) facilities – could improve roadway capacity.

Studies of similar *Fast Lanes* projects around the country showed that successful implementation requires a thorough analysis of the technical, financial and institutional feasibility of a managed lanes strategy. All three perspectives are important, and any missing perspective can preclude successful study outcomes. The study provided information for NCDOT, CDOT and other key stakeholders in the region so they could assess corridor performance against criteria established for all three feasibility perspectives.

1.2 Organization and Content

The study's final report includes the following:

- Chapter 2, Study Approach, describes the two-phase process used to identify corridors for potential managed lanes. This chapter includes the evaluation criteria used for corridor screening.

- Chapter 3, Results of Phase 1 and Phase 2 Analyses, summarizes the results of screening all of the corridors considered in the study. This chapter also includes the changes in person trip capacity and travel times along the corridors and segments which advanced into Phase 2.

- Chapter 4, Revenues and Costs, describes the annual revenues which could be generated by HOT lane implementation along the corridors studied in Phase 2 for two operating alternatives: 1) toll revenue maximization, and 2) minimization of aggregate travel time costs. This chapter summarizes estimated capital, operating and maintenance costs by corridor and segment to determine financial feasibility of individual *Fast Lanes* projects.

- Chapter 5, Next Steps, identifies what needs to be done by regional partners to advance the planning and design of *Fast Lanes* improvements. The Charlotte Region *Fast Lanes* Study represents the first stage in a series of technical, institutional and financial analyses that will successively implement the regional managed lanes network. Additional data and studies will be needed on a corridor-by-corridor basis to identify the physical attributes and operational characteristics of each priority *Fast Lanes* corridor.

Recommended phasing of improvements is intended to achieve the highest potential for early success and to minimize impacts and risk associated with *Fast Lanes* implementation.

1.3 Historical Context

In highly congested corridors where traditional strategies for improving mobility and roadway capacity cannot address unmet demand, specially-designated lanes are often implemented to more aggressively manage use of these lanes so as to improve roadway efficiency. This strategy provides a choice to motorists who otherwise would have to deal with traffic congestion. In the late 1960s, managed lanes began as restricted, often curbside lanes for buses on streets and a few expressways. By the mid-1970s, carpools and vanpools, usually with 3 or more persons, were allowed to use some dedicated lanes, which were termed HOV lanes. In the late-1980s, changes in federal policies allowed local governments to open HOV lanes to carpools with two or more persons. By the mid-1990s, congestion pricing was tested on several HOV lanes, and the term high occupancy toll (HOT) lane originated. There are currently over 2900 lane-miles of HOV or HOT lanes on freeways in North America plus a wide number of lanes primarily reserved for buses on arterials. Practically all HOV or HOT lanes are located in highly congested metropolitan areas where they provide a travel time advantage over adjacent lanes.

While the term "managed lanes" is often applied to a broad range of strategies targeted at ensuring "free flow" conditions along a portion of the roadway, the term has many locally accepted acronyms and evokes different meanings and connotations depending on location or individual project. There is presently no nationally recognized definition of managed lanes. The Federal Highway Administration (FHWA) offers the following definition:

> *"Managed lanes offer an enhanced operational condition within separated lanes, which result in outcomes such as greater efficiency, free-flow speeds or reduced congestion."*

In this study, lanes that allow HOV, HOT or other types of designated vehicles will be called managed lanes or *Fast Lanes* where appropriate in the context of the discussion; however, the terms HOV or HOT lanes may also be used.

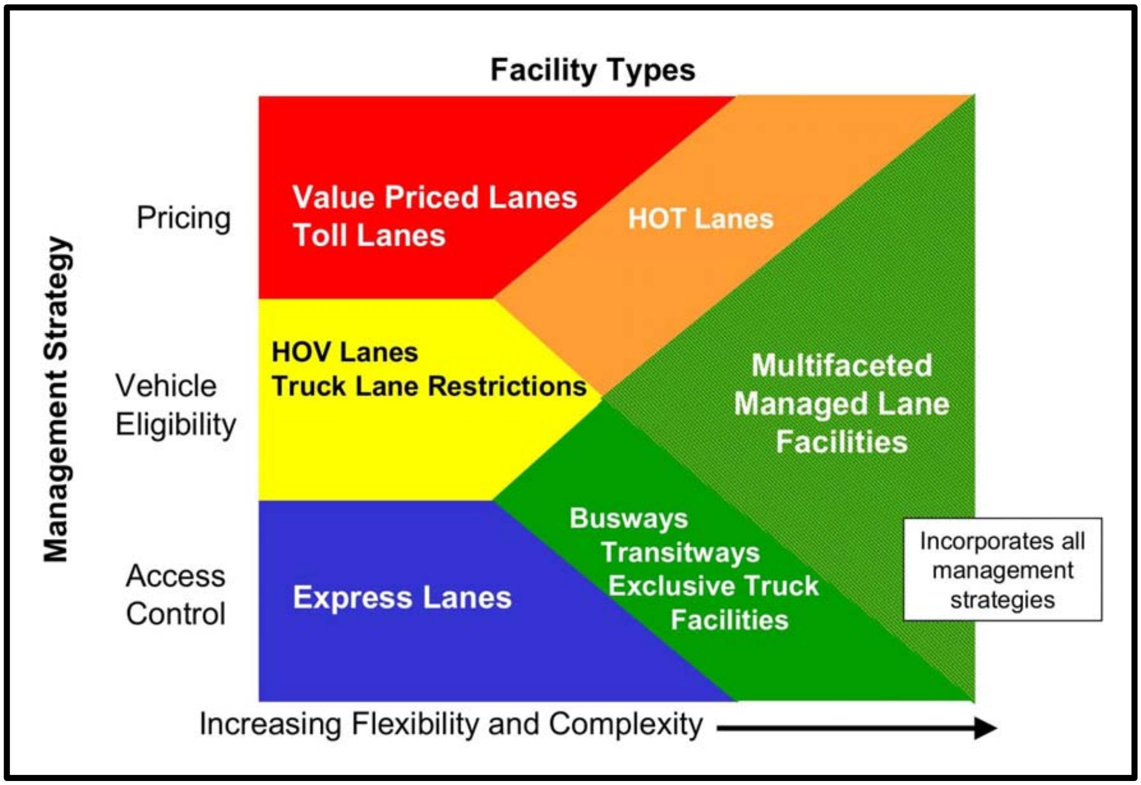
1.4 Managed Lanes Concepts

The following treatments could be considered managed lanes if they are designed and operated to provide an assured travel condition over adjacent lanes:

- HOV lanes
- HOT lanes
- TOT lanes
- Value priced lanes
- Express or special use lanes and roadways
- Bypass lanes, primarily for commercial vehicles

Figure 1-1 shows the entire menu of management options that exist under the umbrella of managed lanes.

Figure 1-1: Types of Managed Lanes



1.4.1 HOV Lanes

Most managed lanes over the past 30 years have been designated as HOV lanes with eligibility for carpools and vanpools. The following definition for HOV facilities explains the purpose of these managed lanes:

> *HOV Facility: A lane or roadway dedicated to the exclusive use of specific high-occupancy vehicles, including buses, carpools, vanpools or a combination thereof, for at least a portion of the day.*

By offering a reserved lane for multi-person vehicles, HOV lanes emphasize *person movement* rather than traditional *vehicle movement,* thus improving the roadway's ability to move more people in fewer vehicles (**Figure 1-2**). This approach only works when an assured level of service in the HOV lane is preserved and time savings that encourage mode shifts to transit, vanpooling and carpooling are realized. To provide this benefit, the dedicated lanes are managed at a vehicle flow rate that is below traditionally defined lane capacity so that the lane does not become congested. HOV facilities enable transportation agencies to better manage freeway capacity and offer an alternative to congestion. When operated and managed at a high level of service, HOV lanes save peak-period travel time over adjacent mixed-flow lanes and have a theoretical capacity to move substantially more commuters than general use lanes during peak demand periods when priority must be assigned to the highest and best use. During these periods, HOV lanes provide significant benefits to those choosing to ride a bus or travel in a vanpool or carpool.

Figure 1-3 shows the cities in the United States where HOV lanes are in operation.

Figure 1-2: Example HOV Lane

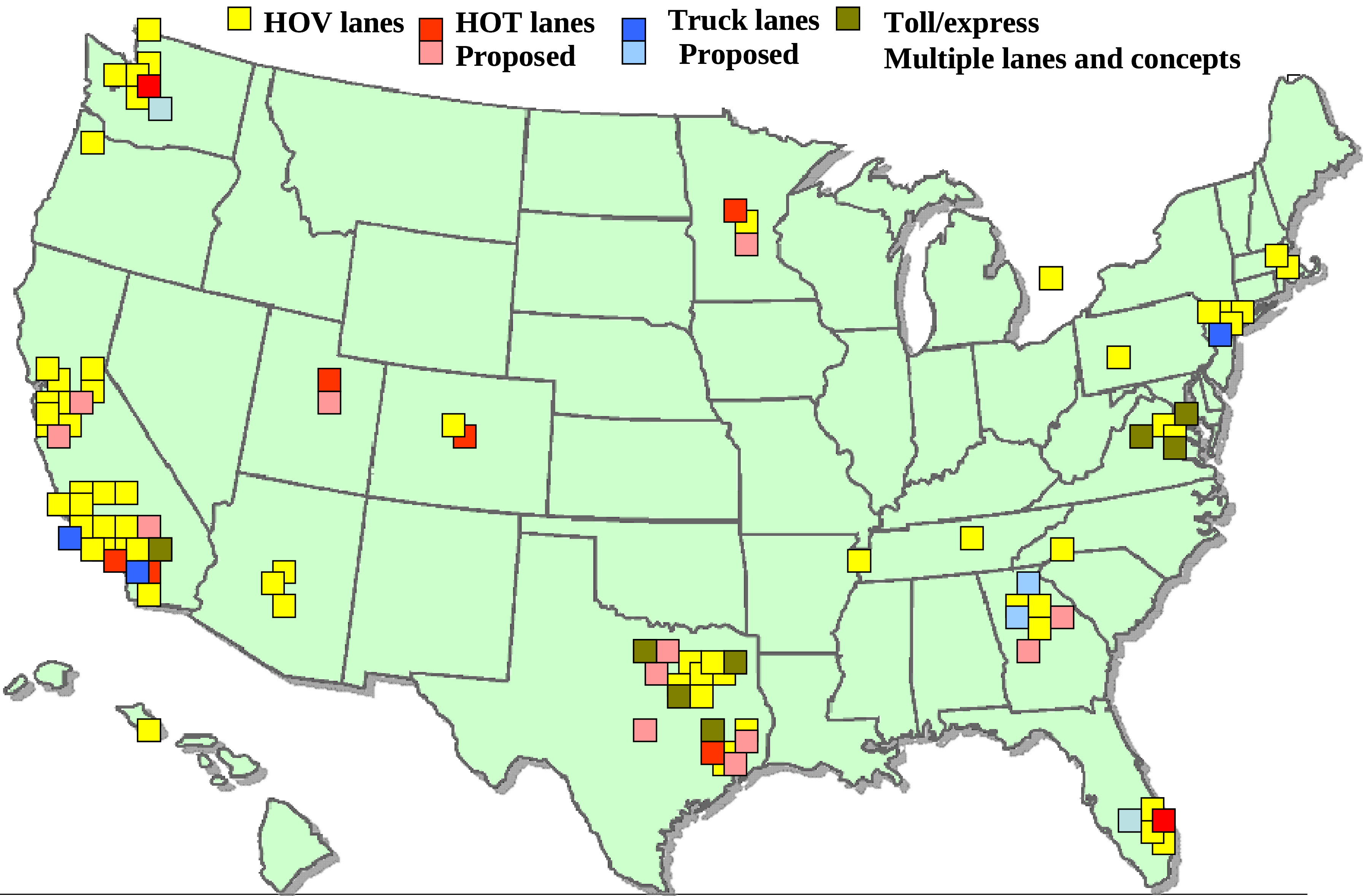
The primary tools used to manage HOV lane use are eligibility and access. Eligibility restricts lane use to vehicles with a minimum number of persons traveling in each vehicle. Access has sometimes been restricted to specific access or egress points in order to manage demand and promote better traffic flow.

HOV lanes make the most sense when:

- Adjacent general-purpose lanes are heavily congested during peak periods.
- Sufficient demand exists among transit and rideshare users to justify a dedicated lane.
- Travel benefits are enough to cause solo commuters to shift to transit or ridesharing.
- Resources are limited for expanding roadway capacity to meet future demand conventionally.

Analysis of HOV lanes has shown that they can have a positive impact on corridor transit and rideshare use. Various before/after studies have shown that about 40 percent of HOV users come from previous carpoolers who have shifted from adjacent lanes or other routes into the HOV lane (called “spatial shifts”); another 40 percent are newly formed carpools and vanpools and transit riders who previously drove alone (called “mode shifts”); and the balance were new trips in the corridor often created because the dedicated lane provided a superior way of commuting. These shifts in trips often changed the nature of lane use and commuting in the corridor.

Figure 1-3: Locations of Existing or Proposed Managed Lanes



1.4.2 HOT Lanes

While many HOV projects are adequately used, some are not, leaving space for others to use the lanes. In some instances HOV demand outpaces lane capacity, potentially requiring increasing minimum occupancies of three persons per vehicle. In both cases, adding pricing to an HOV lane, creating a HOT lane, can help regulate demand better by either permitting others to use the lane or pricing some out. HOT lanes are derived from the concept of congestion pricing, which recognizes that the value of travel-time savings will vary for trips at different times and places and that these trips have different values for different individuals. These different values of time carry a real and perceived value of time-savings at the particular moment for commuters. Depending upon that self-identified value of time, commuters may elect to purchase their way into an non-congested roadway (saving time) or choose to remain in the general-purpose lanes (saving money), thus providing a commute choice.

> *HOT Facility: An HOV lane or roadway in which electronic pricing is applied in conjunction with eligibility preference given to buses, vanpools and perhaps carpools to give others a travel option to use the lane. Others may include solo motorists or lower-occupancy carpools.*

The advent of electronic pricing started in the 1990s. In parallel with the growth in HOV lanes, improved technology quickly transformed the means by which tolls could be collected on toll roads worldwide. Electronic toll collection through the use of transponders located in the windshields of vehicles eliminated the need to stop and pay tolls through a conventional toll plaza.

HOT lanes offer one possible means of addressing mobility needs and helping ensure the long-term availability of HOT lanes for improved person movement. Transit buses and carpools are typically allowed to continue to use the HOT lanes for free. The toll value is set so that "free-flow" level of service for the lanes is not degraded, or the charge is maintained high enough to reflect parity with the prevailing transit fare in a corridor. **Figure 1-3** indicates where HOT lanes currently exist or are proposed.

HOT lanes make the most sense when:

- The HOV facility's adjacent general-purpose lanes are heavily congested during peak periods.
- Significant excess capacity exists on the HOV facility, even at its peak utilization, or significant excess capacity will be created by raising restrictions on HOV lanes that are overloaded.
- Resources are limited for either expanding roadway or transit capacity.
- The public is concerned by low utilization of the HOV lanes.

Figure 1-4: Example HOT Lane

1.4.3 TOT Lanes

TOT lanes offer the potential to apply the same benefits for commercial goods movement as are provided to commuters. While there have been various studies of truck-only lanes and roadways and more recent studies to charge tolls for trucks on these lanes, several operational and institutional issues have prevented such lanes from being implemented. These obstacles relate to the need to provide two directional lanes so that trucks can pass one another, because otherwise service capacity and operational benefits can be lost. There are also differences of opinions among transportation engineers about whether large volumes of trucks, transit and commuter flows can be mixed on such lanes and the intended level-of-service benefits to all can be preserved. Perhaps most difficult to resolve is the high cost of building dedicated truck lanes and the strong stance that trucking interests have taken against mandatory tolling if truck drivers were precluded from current highway lanes. Although this institutional barrier has prevented some potential projects from moving forward, **Figure 1-3** shows locations where TOT lanes exist or are proposed.

For TOT lanes to work, they need a demand of about 800 trucks per hour (400 per lane for two lanes directionally) with common origin-destinations over a corridor or region. This volume may be considered in combination with other users if all users can be accommodated within a common design with suitable access.

TOT lanes make sense when:

- High volumes of trucks have common origins and destinations which will benefit from a limited access roadway.
- Potential to provide meaningful time and reliability benefits indicates truck toll lanes are cost effective and will generate revenue.
- There is political and institutional support to charge tolls on trucks, perhaps by mandating that all through trucks without local destinations use the TOT lanes.

1.4.4 Other Forms of Managed Lanes

While express lanes that assure a higher level of service through restrictions on access have been operated on various urban interstates in Chicago, St Louis, Seattle and other cities for many years, a broader application of dynamically managing express lanes through tolling, known as express toll lanes (ETL), is planned for a number of areas, as shown by

Figure 1-3. In 2008, operations along I-10 (Katy Freeway) in Houston changed from a single reversible HOT lane in the median to dual managed lanes in each direction along a 12-mile segment. Transit buses and 3+ HOVs travel for free along this portion of I-10. In this context, the Katy project is intended to cover the added construction, operation and maintenance costs, and it is owned by the local toll road authority. **Figure 1-5** shows the Katy Freeway before the express lanes were opened to traffic.

Other active traffic management strategies that are applied in Europe and could be employed on managed lanes to improve travel speeds or reliability include dynamic speed controls and temporary travel on emergency breakdown shoulders at traffic bottlenecks. This wide array of emerging management tools is just now being studied in a select number of cities.

Other forms of managed lanes may make sense when:

- General-purpose lanes are heavily congested during peak periods.
- There is not enough HOV demand to justify preferential treatment, but enough commute demand and travel benefits to justify a managed lane.
- Resources are limited for expanding the roadway.

Figure 1-5: Katy Freeway Express Toll Lanes

1.5 Goals and Objectives for Managed Lanes

Typically, goals for implementing managed lanes include, but are not limited to:

- Maintaining mobility
- Improving roadway operation efficiency, safety and reliability
- Promoting transit and ridesharing
- Improving safety
- Providing travel options to meet user needs, such as “time-sensitive” travel, and
- Generating revenue to offset capital and operating expenses
- Improving air quality

Objectives for managed lanes can be region and/or corridor specific:

- Increasing person-moving capacity of the roadway
- Promoting transit and ridesharing mode split
- Optimizing vehicle-carrying capacity
- Promoting travel time savings, reliability, or efficiency for selected travel modes
- Promoting air quality by increasing ridesharing and transit as part of a conformity plan
- Increasing funding opportunities for new mobility improvements
- Enhancing existing transit investments and services in the region/corridor
- Providing a greater choice in serving multi-modal needs (people, goods, services)
- Improving the movement of commerce (goods and services movements)
- Supporting community land use and development goals, particularly to major areas of employment

Fundamental to these goals and objectives is an implicit set of conditions that should exist for managed lanes to be considered viable. These conditions include the following:

- A recurring congestion problem with traffic operating at level of service D or worse within a corridor or region for a significant period of time each weekday
- A significant backlog of unmet travel demand, and/or lack of available resources (right-of-way, funding, regional consensus or environmental issues) to address capacity deficiencies in a more conventional means through adding roadway or transit capacity
- An interest and ability to minimally increase roadway capacity by managing its use to specific dedicated purposes to ensure that a high level of service can be provided as an alternative to recurring congestion

Ultimately, the goals and objectives that are set for a corridor improvement or managed lanes project should dictate the operational strategies which are employed.

1.6 Strategies for Managing Lane Use

Common lane management strategies used to regulate demand fall into three broad categories:

- Eligibility
- Access
- Pricing

While these strategies are applied in other traffic management applications and may offer benefits, they have specific relevance to actively managing lane demand in this context. A wide variety of emerging projects is likely to expand the application of these strategies. Each strategy described more fully below can be applied and implemented individually or in combination, depending on the unique travel demand conditions associated with each project setting.

1.6.1 Eligibility

Restricting a dedicated lane to specific users will limit demand. Use restrictions on HOV lanes typically have taken the form of eligibility requirements based on the requisite minimum number of people traveling in a vehicle (**Figure 1-6**). Over the years, restrictions on HOV lanes have evolved to include several other occupancy-exempt vehicle classes (e.g., motorcycles, inherently low emission vehicles (ILEVs) or hybrid vehicles, emergency vehicles, deadheading buses, paratransit vehicles, etc.). Other examples include designated bus-only or truck/freight-only roadway facilities. Eligibility restrictions can be in effect 24 hours or vary by time of day or day of the week. A managed lane using a variable eligibility strategy may restrict use to HOVs with a minimum of three or more occupants during the peak commute hours, and relax restrictions to include lower occupancy vehicles and occupancy-exempt vehicles or other users during off-periods or weekends. If the eligibility rules are made unusually complicated, signing requirements can become confusing and cumbersome.

Figure 1-6: Example Eligibility Restriction

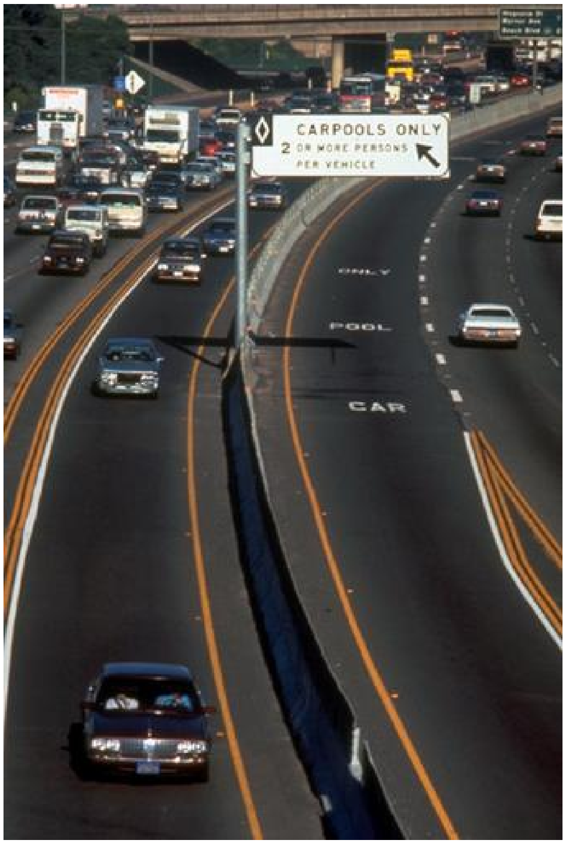
1.6.2 Access

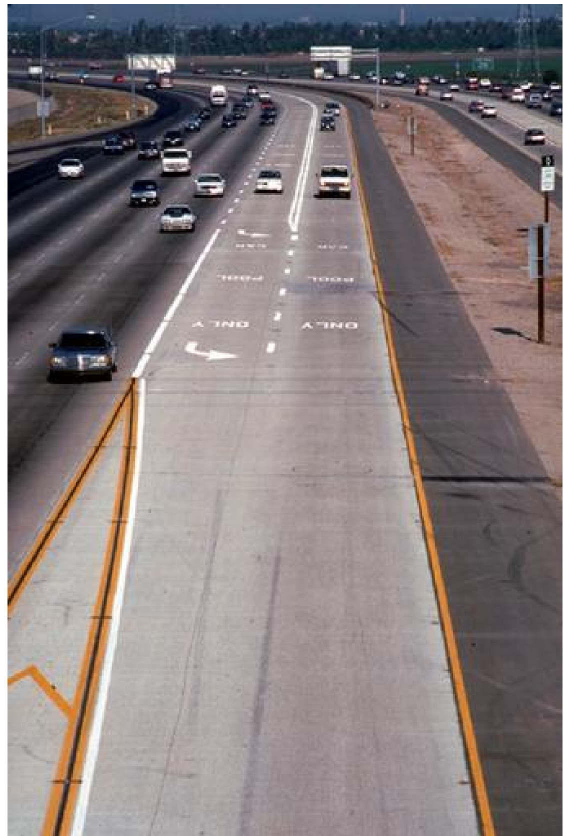
Limiting access has traditionally been applied to HOV and express lanes as a means of regulating entry and exit movements (**Figure 1-7**). Restricting access helps to ensure that the lanes do not become overloaded, regardless of the level of demand they generate. Access restrictions may also help alleviate specific traffic bottlenecks where short-distance trips cause a lane to exceed its capacity.

As an example, HOV access restrictions are applied on most lane treatments in the Los Angeles area where demand on all HOV lanes is high. Access is also restricted in various multi-lane facilities and on reversible freeway facilities where positive separation between opposing flow is required. On some roadways like the New Jersey Turnpike, access is managed or metered between separate, parallel roadways, thereby giving preferential service to one of the two roadways during incidents. Access can be restricted under normal conditions 1) by metering demand at entrance ramps via the use of traffic signals or gates, 2) by limiting access at specific ramps to selected users like HOVs (e.g., I-5 Seattle downtown ramps) or 3) by limiting the number of entrance and exit ramps so that free-flow is ensured (e.g., I-5 Seattle, I-94 Chicago and I-15 San Diego). In several areas, such as Chicago and Seattle, this latter application is sometimes referred to as *express lanes*, and the lanes are open to all traffic at an enhanced level of service. Once traffic enters the express lanes, vehicles can typically travel at unimpeded speeds to downstream exits.

Some express lanes like those in Seattle and New Jersey also include HOV priority ramps or connect to HOV lanes on either end or on other routes.

Figure 1-7: Example Access Treatments





Express lanes, reversible lanes and dual express/local roadway systems are examples of facilities where access can be managed either dynamically and/or by design.

1.6.3 Congestion Pricing

The introduction of electronic toll collection (ETC) has allowed this technology to become increasingly practical and inexpensive in regulating demand (**Figure 1-8**). Congestion pricing can help maximize the use of available pavement, while continuing to prioritize operation for selected users such as HOVs. The introduction of pricing offers an opportunity to manage a dedicated lane by allowing others to use the lane as capacity allows.

Figure 1-8: Electronic Toll Technology Applied to Managed Lanes

Pricing can be a crude or fine-tuned tool. If fixed pricing is applied, it simplifies the message to users but limits the ability to regulate demand in peak periods. Dynamically varying pricing in accordance to demand is a better solution, but makes communicating the price to users potentially harder. This application is often called congestion, demand-based, or value pricing. Value pricing involves charging a fee or toll to travel on a lane or roadway which varies according to time of day (peak/off-peak) and day of week or by the level of congestion on the managed lane or adjacent lanes. While value pricing has potential in many different contexts, the primary purpose in this application is to varying the pricing so that the lane does not become congested. Higher tolls are usually charged when congestion is heaviest and delay is at its worst, while lower tolls or free access may be provided to some or all users during periods of low demand. Pricing is applied to better balance demand to lane capacity and can encourage some peak period users to shift their trip to lower demand periods. Pricing can give preference to selected user groups, as has been demonstrated on several HOV lanes, so that lower occupancy vehicles pay a higher price than higher occupancy vehicles. Pricing is implemented using electronic toll tag readers, and typically all vehicles that are priced are required to have a toll tag to use the facility.

Pricing has been implemented in a limited number of areas on existing HOV lanes. Value pricing may permit all vehicles or only a select user group to access the managed lanes. Revenue generated from value pricing typically covers the operation, enforcement and administrative costs associated with toll collection and may also cover other expenditures such as capital costs associated with construction. Enforcement of toll evasion may be automated if electronic toll tags are employed and all users are treated equally, or enforcement may be more complicated if pricing preferences are applied to selected users (i.e., single occupants are tolled and HOVs are free), thereby requiring increased on-site law enforcement presence as is the case for monitoring HOV occupancy requirements.

2.0 STUDY APPROACH

Studies of similar *Fast Lanes* projects around the country indicate that successful implementation requires a thorough analysis of the technical, financial and institutional feasibility of a managed lanes strategy. All three perspectives are important, and any missing perspective can preclude successful study outcomes. The study approach involved a two-tiered process in which study corridors were screened in the first phase, followed in Phase 2 by a more detailed evaluation of those corridors which showed the most promise for managed lanes feasibility. Throughout the *Fast Lanes* analysis, a technical team provided useful input on study results and recommendations. In addition, one-on-one conversations were held with 15 individuals to document key stakeholder perceptions and concerns regarding a system of managed lanes in the Charlotte region.

In order to increase local awareness of managed lanes and to review national experience with their application, a one-day workshop was held early in Phase 1 of the study. The workshop included representatives of all regional agency study sponsors and provided an opportunity to discuss and define screening criteria and assumptions being used. At the conclusion of Phase 1, a second daylong workshop was conducted to review the results of the screening. This session allowed representatives of sponsoring agencies to learn the latest developments in managed lanes implementation and to thoroughly review the analysis results from the study's first phase.

In addition to the technical team, educational workshops, and stakeholder interviews, the following public outreach activities were used to educate citizens in the Charlotte region about managed lanes strategies:

- Using the name *Fast Lanes* for the study so it would be more understandable and recognizable to citizens. The name was incorporated in a study logo and tagline which takes advantage of the region's prominence in auto racing.
- Establishing a study website (www.fastlanes.org) for disseminating information about study progress.
- Printing and distributing a "business card" with managed lanes examples, reasons for considering them in Charlotte, study contacts and a web site address.
- Making presentations to Metropolitan Planning Organizations, Rural Planning Organizations, local elected officials and other groups to discuss the study's purpose and findings.
- Creating a video (produced by the City of Charlotte) for use on public television, at meetings and on the website to explain the benefits and potential use of managed lanes.

2.1 Regional Technical Team

The Regional Technical Team consisted of representatives of the following agencies:

- Charlotte Department of Transportation
- North Carolina Department of Transportation
- South Carolina Department of Transportation
- Mecklenburg-Union Metropolitan Planning Organization
- Gaston Urban Area Metropolitan Planning Organization

- Rock Hill-Fort Mill Area Transportation Study
- Cabarrus-Rowan Metropolitan Planning Organization
- Rocky River Rural Planning Organization
- Lake Norman Rural Planning Organization
- Town of Mooresville
- Charlotte Area Transit System
- North Carolina Turnpike Authority

The technical team met throughout the study to review progress, discuss preliminary recommendations, and provide input. Technical team members also served as project liaisons to their respective agencies or governments.

2.2 Stakeholder Interviews

A key component of the Public Involvement Program for the Charlotte Region *Fast Lanes* Study consisted of identifying stakeholders who could help clarify the region's mobility and congestion management issues, opportunities and deficiencies. One-on-one stakeholder interviews were conducted with a small group of business, environmental and public leaders in the region to surface issues, opportunities, and concerns and how the management of freeway lanes could improve travel options. The intent of these interviews was to ensure that the study recommendations would be sensitive to the vision of, and adequately address issues raised by, area stakeholders.

These interviews were used to:

- Document perceptions of transportation conditions occurring on individual corridors, and each person's use of freeways or expressways when making local, regional, and intrastate trips.
- Gather initial feedback on managed lane options.
- Gather attitudes and expectations including a query for opinions on lanes managed by access, eligibility, pricing, or a combination thereof.
- Document how the proposed study process would address stakeholder concerns.

Interviewees were selected because of:

- Representation of a specific geographic region in the study area
- Knowledge or responsibility regarding a specific mode or environmental, social, or community issue
- Stature in the community
- Ability to reflect a representative range of opinions and interests

2.3 Study Corridors

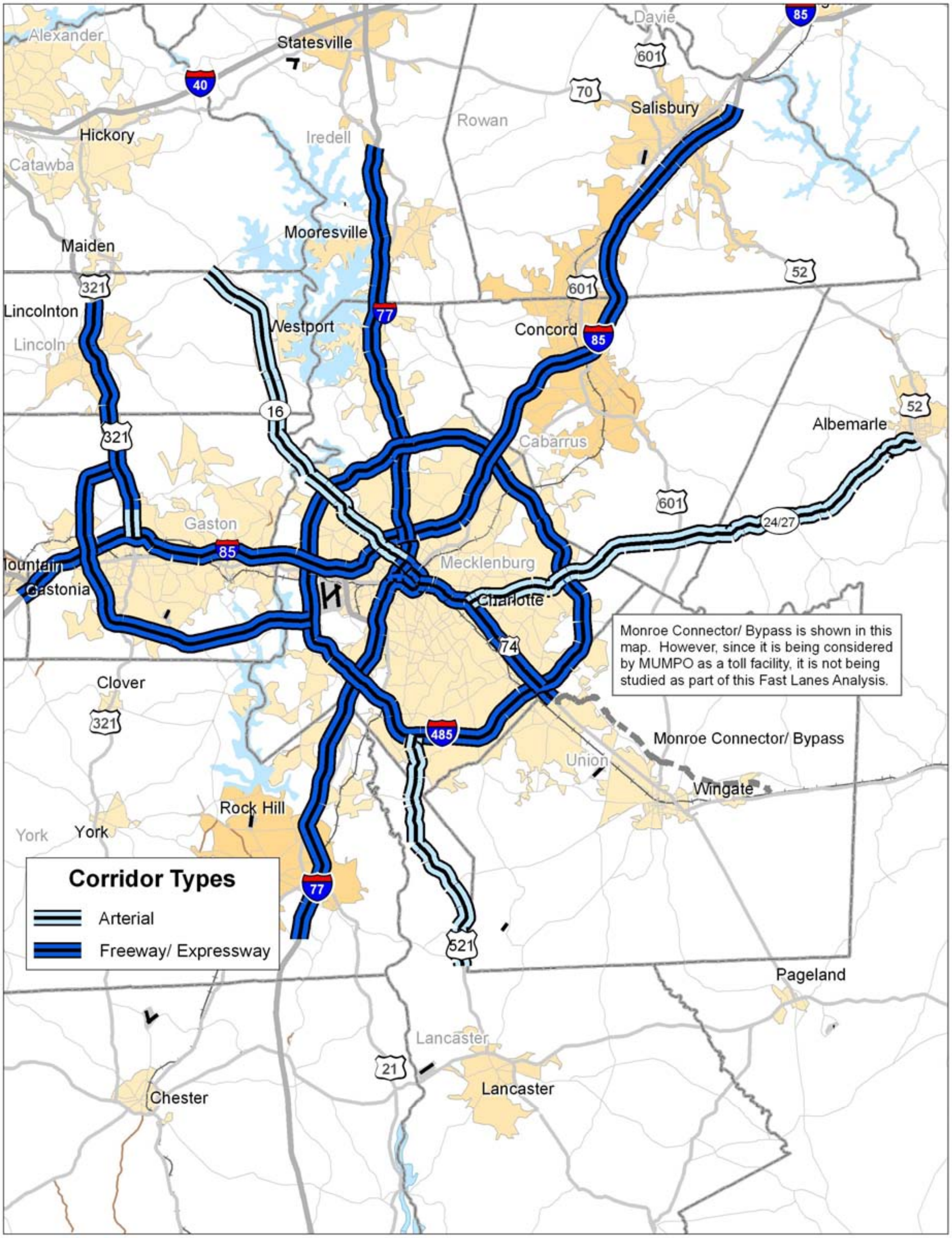
The major study corridors evaluated during the Regional *Fast Lanes* Study are listed in **Table 2-1** and are mapped in **Figure 2-1**.

There were twelve primary corridors, totaling approximately 334 miles, included in the first phase of this study. Some corridors were further subdivided to facilitate the evaluation process. The majority of the miles (77 percent) are freeways/expressways while NC-16, NC-24/27, and US-521 operate as arterials (see **Figure 2-1**). The map also shows roadways that are planned for the future, such as US-321 Bypass and Garden Parkway in Gaston County and the northeast section of I-485 (between I-77 North and I-85 North). Based on the adopted Long Range Transportation Plans, these future roadways are assumed to be built before 2030. The proposed Monroe Connector/Bypass in Union County was not included in this analysis of managed lanes because it has already been approved by the Mecklenburg-Union Metropolitan Planning Organization (MUMPO) to operate exclusively as a toll road and is being planned and designed by the North Carolina Turnpike Authority (NCTA).

Table 2-1: Phase 1 List of Study Corridors

Corridor	Location / Description	Length (Miles)
US-521	Between SC-5 in Lancaster County, SC and I-485 south near Ballantyne/ Pineville area.	18.1
NC-24/27	Between US-74 in Charlotte and US-52 in Albemarle	35.6
Garden Parkway	Starting at I-85 and US-321 Bypass, heading south (around Gastonia) and east towards Charlotte, terminating at I-485 near Charlotte/Douglas International Airport.	20.0
US-321Bypass	Between US-321 and I-85 northwest of Gastonia.	7.4
US-321	Starting at I-85 (Exit 17) in Gastonia and going north and terminating at Lincoln/ Catawba County line.	17.5
NC-16 north	Starting at Lincoln/Catawba County line at NC-150 and going southeast toward Charlotte; terminating at I-277/ I-77 interchange.	27.5
US-74 east	Between I-277 loop in Charlotte and I-485 southeast.	13.1
I-85 south	Between US-74 (Exit 10) and I-77 (Exit 38) in Charlotte.	28.3
I-85 north	Starting at I-77 (Exit 38) in Charlotte, heading northeast through Cabarrus County and terminating near Long Ferry Road (Exit 81) in Rowan County.	41.8
I-77 south	Between Chester/ York County, SC (Exit 73) and I-85 in Charlotte	31.5
I-77 north	Between I-85 in Charlotte (including existing HOV lanes) and US-21/NC-115 (Exit 42) in Iredell County.	27.8
I-485	Includes the entire loop around Charlotte in Mecklenburg County.	65.4
	Total	**334.0**

Figure 2-1: Phase 1 Study Corridors



2.4 Analysis of *Fast Lane* and Highway Performance

The short-term and long-term feasibility of managed lanes in the Charlotte region was analyzed by relying on the Metrolina travel demand model, which is used in developing long-range transportation plans for jurisdictions in the region. Two horizon years were selected for this study – 2013 for the short-term analysis and 2030 for long-range analysis.

2.4.1 Phase 1 Screening Process

In the first phase of the study, the corridors and individual corridor segments were screened for their feasibility for managed lanes by applying criteria and thresholds that typically define effectiveness for *Fast Lanes* strategies. The purpose of the screening criteria was to identify corridor fatal flaws before proceeding into more detailed evaluations.

The screening criteria are based on guidance from several reference sources including the American Association of State Highway and Transportation Officials (AASHTO) *Guide for High Occupancy Vehicle Facilities*, National Cooperative Highway Research Program (NCHRP) 414 *HOV Systems Manual* and *HOV Facilities Planning, Operation and Design Guide* by Parsons Brinckerhoff. HOT lane guidelines are found in the Federal Highway Administration (FHWA) *HOT Lane Guide*. The selected screening criteria respond to regional mobility goals by using the following performance measures:

- Congestion levels along a corridor or at isolated bottlenecks (required for any *Fast Lane* option)
- Travel patterns (responds to HOV, HOT or truck potential)
- Vehicle demand for HOV, HOT or truck options (responds to overall potential for effectiveness using different types of vehicle eligibility)
- Patronage demand for transit and rideshare services (responds to person-carrying potential for an HOV lane)
- Tolling potential (responds to HOT lane potential)
- Physical ability to add *Fast Lanes*, or conversely, to borrow or convert existing lanes based on current or future operations

Table 2-2 provides a summary of the screening criteria used during Phase 1 of this study, and **Figure 2-2** illustrates the overall screening process.

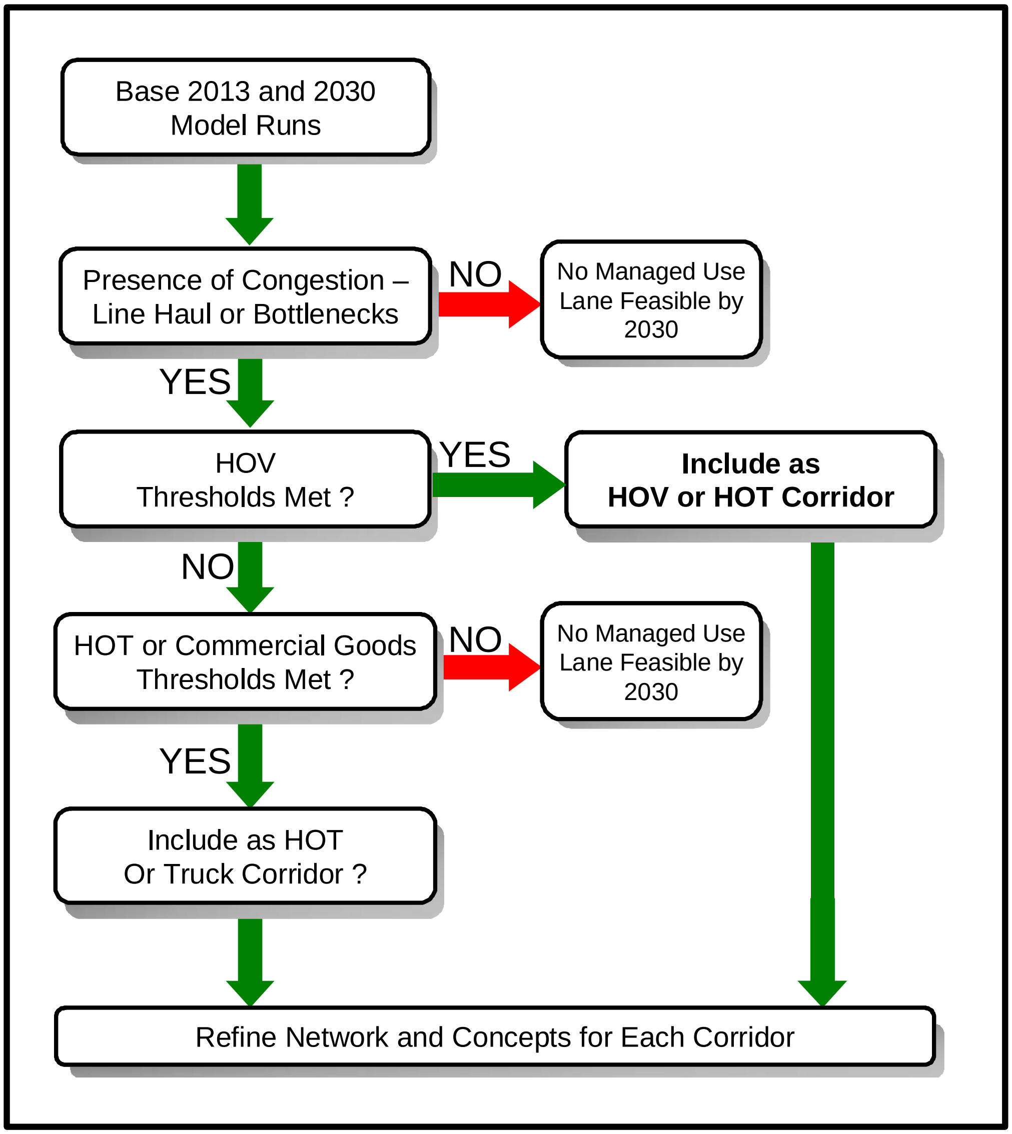
Table 2-2: Phase 1 Corridor Screening Criteria

Screening No.	Criteria	Threshold(s) to be Met	Parameters	Source
Presence of Congestion				
1.A	Line- haul	Freeways: Volume/capacity (V/C) greater than 1.0 and average speeds below 30 mph in the peak period. Arterials: V/C greater than 1.0 and average speeds below 20 mph in the peak period.	Travel speeds Volume/capacity ratio	Regional model output based on existing and proposed roadways for 2013 and 2030
1.B	Bottlenecks (less than 0.5 miles)	V/C below 1.0 Speeds below 20 mph	Travel speeds Volume/capacity ratio	Regional model output for 2013 and 2030.
HOV Demand				
2.A	Travel Patterns	Freeway corridors: Average trip distances of 5 miles or more. Arterial corridors: Average trip distances of 3 miles or more.	Vehicle volumes Threshold is either met or not met for each defined corridor or combination of corridors for a defined commute-shed.	Regional model select link data for 2030. Not applied to connecting route segments in core of region.
2.B	Person Moving Demand	Parity or greater when compared to general purpose lane person movement in same corridor, on a per-lane basis, assuming 2000 persons/general purpose lane.	Person moving demand basis for vehicles must be capped based on a maximum per-lane flow rate of 1650 passenger car equivalents (PCEs) per hour for freeways and 900 PCEs per hour on arterials. Threshold is either met or not met.	Carpool forecasts from model (2030 only) Vehicle occupancy surveys from 2007 Transit patronage estimates where number of carpools is below thresholds.
2.C	Vehicle Demand	HOV Freeway: 600 PCEs/hour minimum HOV Arterial: 200 PCEs/hour minimum	Vehicle demand determined for peak period. Maximum volume is 1650 PCEs/lane Criteria is met or not met.	HOV demand from regional model for 2013 and 2030. Confirm through national sketch planning techniques for select corridors.

Table 2-2 (Continued): Phase 1 Corridor Screening Criteria

Screening No.	Criteria	Threshold(s) to be Met	Parameters	Source
HOT or TOT Demand				
3.A	Travel Patterns	Freeway corridors: Average trip distances of 5 miles or more for commuters or large trucks. Arterial corridors: Average trip distances of 3 miles or more.	Vehicle volumes Threshold is either met or not met for each defined corridor Not applied to connecting route segments in core of region.	Regional model link data for 2030
3.B	Vehicle Demand (2013 and 2030)	HOT Freeway: 1000 PCEs/hour minimum HOT Arterial: 400 PCEs/hour minimum Commercial movement demand 400 large trucks directionally/hour x two lanes= 800 trucks/hour Common origins/destinations > 5 miles using corridor	Vehicle demand must be capped based at a maximum per-lane flow rate of 1650 PCEs per hour for freeways and 900 passenger car equivalents per hour on arterials. Criteria is met or not met for each vehicle group	Demand from regional model for 2013 and 2030
3.C	Revenue Potential	Forecast revenue (gross) for screening stage	Rapid toll optimization model results based on regional travel forecasts per corridor	Regional model Toll optimization model for 2013 and 2030
Physical Attributes				
4.A	Physical Feasibility-Add a lane	Space to add a managed lane (typically 16 ft per direction)	ROW and roadway characteristics for each corridor	Aerials As-built plans Project plans implemented by 2030
4.B	Physical Feasibility-Convert a lane	Ability to convert or borrow an existing lane or shoulder for a peak hour or direction (reversible lanes), without more than one degradation in LOS for traffic in the remaining lanes; no spillover traffic onto other routes.	Resulting volumes cannot exceed 2000 vph for conversion, or reductions in lane, shoulder widths acceptable.	ADT/lane in peak hours for 2013 and 2030 Current observed LOS on existing corridors

Figure 2-2: Phase 1 Screening Process



2.4.2 Phase 2 Analysis of *Fast Lanes* Mobility Improvements

In the study's second phase, the corridors which advanced for more detailed analysis were evaluated to determine the differences in person and vehicle throughputs with the added *Fast Lanes*. The differences in travel times for motorists using general-purpose and managed lanes were also estimated using output from the Metrolina travel demand model.

The results of both the Phase 1 and 2 analyses are summarized in the following chapter.

3.0 RESULTS OF ANALYSES

This chapter contains two sections. The first section summarizes the results of the Phase 1 screening analysis and identifies the corridors and corridor segments which advanced to Phase 2 of the study. The second section of this chapter describes the results of the more detailed analysis for those roadways carried over into the study's second phase.

3.1 Phase 1 Screening Analysis

The results of the Phase 1 screening analysis were used to recommend corridors and corridor segments that merited detailed analysis in Phase 2 of the study. **Table 3-2** summarizes the screening criteria findings for the original candidate corridors. Results of the corridor screening are illustrated in **Figure 3-1**. Corridors and individual segments that passed the Phase 1 screening for more detailed study in Phase 2 were separated into two groups:

- Pass to Phase 2 – included corridors and segments that ranked high on the screening criteria and were deemed to be excellent candidates for further consideration in Phase 2.
- Pass Conditionally – included corridors and segments that were found in this phase to be marginal unless certain assumptions were changed. The most common basis for conditional passing included constrained physical attributes that could not be overcome without significant design exceptions. The partnering agencies serving on the RTT provided input on the potential for success of these corridors and the likelihood that physical attributes could be acceptably addressed in the more detailed Phase 2 of the study.

3.1.1 Recommended for Phase 2 Evaluation

The following corridors and segments met the screening criteria and were recommended for detailed study during Phase 2:

- I-77 North between Center City Charlotte and Iredell County – the majority of the corridor met the congestion, HOV demand, and physical attributes criteria. This corridor is also a logical extension of the existing I-77 HOV lanes, which are experiencing increased use during peak travel periods.
- I-85 North in Cabarrus County, northeast of I-485 – met congestion, HOV demand, and physical threshold criteria.
- US-74 East between Center City Charlotte and I-485 – met congestion, HOV demand, and physical threshold criteria. There are already bus-only lanes for part of this corridor which could be analyzed for conversion to *Fast Lanes*.
- Future I-485 in northeast Charlotte, between I-85 and I-77 – although traffic forecasts do not fare well against the congestion and HOV demand criteria, the segment was recommended to advance to Phase 2 because it is a strategic link between two radials with high demand, is a yet-to-be-implemented facility with the potential to accommodate *Fast Lanes*, has adequate right-of-way, and connects two major freeways (I-77 and I-85) in a growing area.

- I-485 between Arrowood Road and US-521 – passed the congestion threshold and met HOV demand and physical attribute threshold criteria, especially the section between I-77 South and US-521, which is currently being considered for widening.

3.1.2 Conditionally Passing Phase 1 Screening Criteria

Although some corridors did not meet some of the screening criteria, they were deemed to have potential for managed lanes despite their weaknesses. Successful implementation of *Fast Lanes* in these corridors will require major improvements and/or will be dependent on other factors that will be analyzed further in Phase 2 of the study. The RTT approved the following segments for Phase 2 analysis on a conditional basis:

- I-85 from I-485 to Gastonia due to the limited ability to add a lane without narrowing other lanes and taking over inside shoulders.
- I-77 from Center City Charlotte to south of I-485 – although this corridor has the highest traffic volume and meets the congestion criteria, there is limited right-of-way and major improvements would require reconstruction of existing I-77. However, this corridor could be considered as a continuation of the existing I-77 HOV facility. Without reconstruction of this freeway, this segment could develop into a bottleneck diminishing gains from other *Fast Lanes* projects.
- I-77 South – segment north of Gold Hill Road has a 70/30 split in the AM peak direction (inbound) and could be considered for a reversible lane operation by borrowing one outbound lane. During the PM peak period, an inbound I-77 lane would be borrowed.
- NC-16 North (Brookshire Boulevard) between I-77 and Rozzelles Ferry Road – due to a limited number of median breaks and signalized intersections from I-77 to I-85 and for reversible operation between North Hoskins Road and Rozzelles Ferry Road because there is a 70/30 AM peak split inbound with 920 vehicles per hour outbound which could be accommodated by one lane.
- I-485 between US-521 and US-74 due to congestion that is likely to grow and become critical beyond the short-term planning horizon. A very short segment of US-521 south of I-485 was retained to facilitate access to this portion of the Charlotte Outer Loop.

3.1.3 Corridors Not Passing Phase 1 Screening Criteria

The following corridors were not recommended for further study during Phase 2:

- US-321 in Lincoln and Gaston Counties – did not pass the presence of congestion and HOV demand criteria.
- Future US-321 Bypass – did not pass the congestion and HOV demand criteria.
- Future Garden Parkway – did not pass the congestion and HOV demand criteria for inclusion of managed lanes. However, the NCTA is studying this roadway as a potential toll facility.
- NC-16 – sections in Lincoln County and sections in Gaston County north of Killian Road did not pass the congestion and HOV demand criteria.
- I-85 North in Rowan County – did not pass due to a combination of criteria, especially HOV demand and marginal level of projected congestion.

- NC-24/27 from US-74 toward Cabarrus and Stanly Counties – did not pass the physical attribute criteria. Although sections of this corridor are projected to be congested, uncontrolled access and right-of-way issues would make it difficult to implement a successful *Fast Lanes* project.
- US-521 – sections in Lancaster County and the southern portion of US-521 near the Ballantyne area did not pass the HOV demand and physical attribute criteria.
- I-77 South in York County – segment south of Gold Hill Road did not meet the HOV demand criteria, and the directional split does not justify reversible lanes.
- I-485 East between I-85 North and US-74 – did not pass the HOV demand criteria.
- I-485 West and Northwest between I-77 North and Arrowood Road – did not pass the HOV demand criteria.
- I-277 (Brookshire and Belk Freeways) – although this freeway passed the congestion and HOV demand criteria, it was not recommended for Phase 2 due to the physical limitations of the freeway-to freeway interchanges. However, recognizing the importance of this freeway, improvements to I-277 should be studied subsequently in conjunction with *Fast Lanes* implementation on I-77, NC-16 or US-74 near Center City Charlotte.

Although the corridors listed above were not recommended for study in Phase 2 based on the criteria required for successful implementation of a *Fast Lanes* project, they could benefit from other types of improvements. The following matrix (**Table 3-1**) provides guidance on the types of improvements that could be applied along these corridors. More information also is available from these two publications:

- ***Freeway Management and Operations Handbook***, FHWA Report No.: FHWA-OP-04-003 EDL No.: 13875 http://www.ops.fhwa.dot.gov/freewaymgmt/publications/frwy_mgmt_handbook
- ***A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility,*** ITE Informational Report/Traffic Congestion/Transportation Demand Management http://www.ite.org/M&O/congestion.asp

Table 3-1: Potential Other Recommendations

Corridors → Types of Improvement	US-321	US-521	NC-24/27	NC-16
Intersection Improvement	X		X	X
Signal upgrades	X		X	
Signal Coordination			X	X
Interchange upgrade	X			
Grade separation	X		X	X
Safety improvements		X		
Transit improvements			X	X
ITS improvement			X	
Active traffic management		X	X	X
Bottleneck removal	X			
Access management		X	X	X

3.1.4 Additional Corridors Recommended by the RTT for Phase 2

Although the following corridors were not proposed initially to pass through to Phase 2, the RTT recommended further analysis of:

- I-85 North to Exit 68 in Rowan County – This four-lane segment of I-85 will be widened at the same time as the section of the interstate just south in Cabarrus County. Because I-85 north of Exit 68 has already been widened to eight lanes, the RTT recommended that the portion in Rowan County which has not been widened be analyzed for managed lanes.
- I-485 between I-85 and Arrowood Road – The potential for expanded freight movements along this section of I-485 near Charlotte-Douglas International Airport prompted the RTT's interest in retaining this segment of the Charlotte Outer Loop for further study of managed lanes feasibility.

Figure 3-1 illustrates the corridors advancing to Phase 2, representing about 158 miles of freeways and expressways.

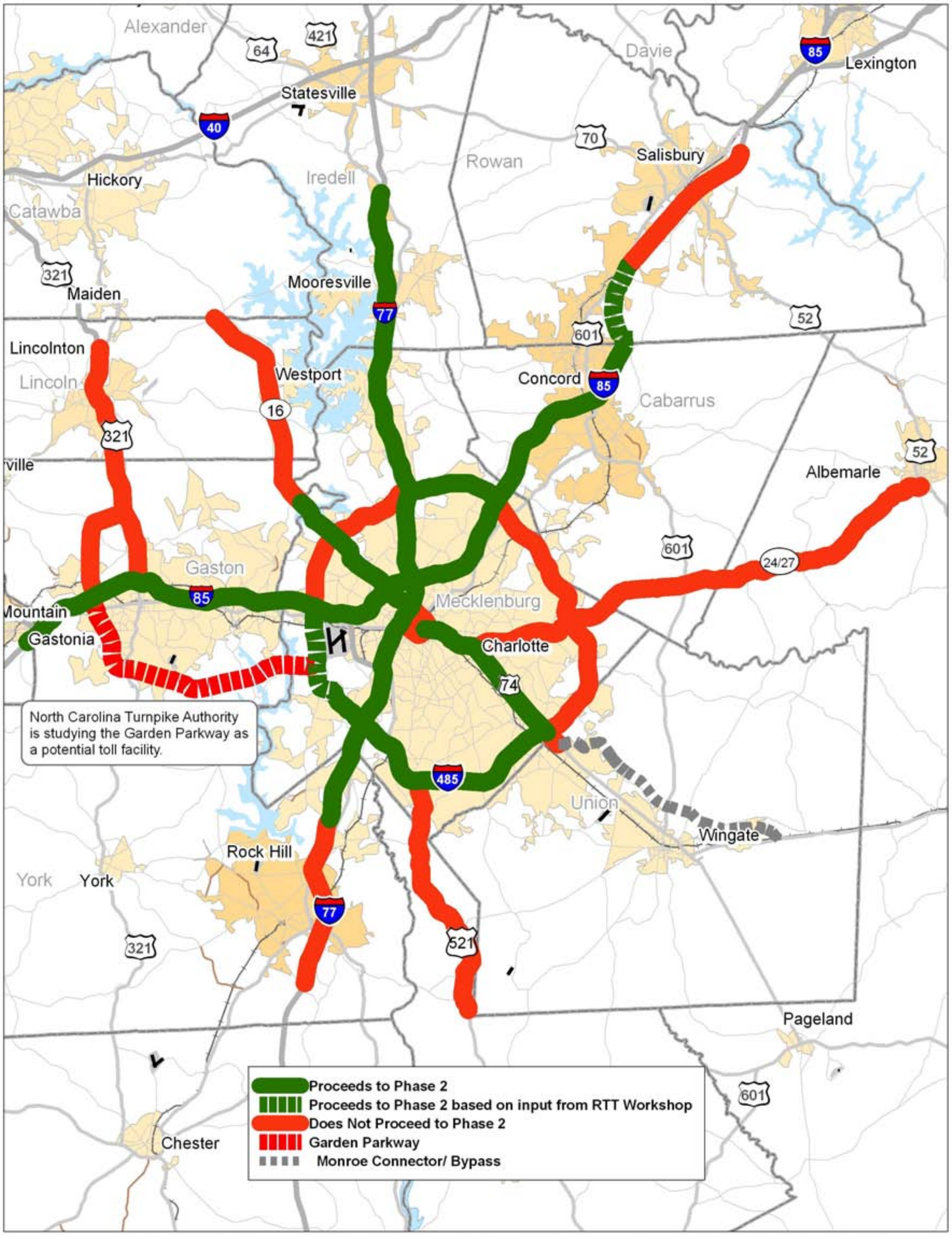
Table 3-2: Summary of Corridor Screening Results

					HOV Demand											
			Congestion		Person		Vehicle		HOT Demand			Truck Demand		Space	Connectivity	
Segment Desription	From	TO	AM	PM	AM	PM	AM	PM	AM	PM	Toll	AM	PM	Available	Needs	Revenue
I-277 (Brookshire)	I-77	US-74 east	Average	Average	Best	Best	Best	Best	Above average	Above average	Best	Fail	Fail	Fail	Average	Best
I-277 (John Belk)	US-74 east	I-77	Average	Below average	Best	Best	Average	Average	Average	Above average	Best	Fail	Fail	Fail	Average	Average
I-485 south	I-77	US-521	Average	Average	Best	Best	Below average	Below average	Average	Above average	Above average	Fail	Fail	Above average	Best	Fail
I-485 south	US-521	US-74 east	Below average	Average	Fail	Above average	Fail	Fail	Fail	Average	Below average	Fail	Fail	Above average	Average	Fail
I-485 east	US-74 east	NC-24/27	Below average	Below average	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Above average	Average	Fail
I-485 east	NC-24/27	I-85	Fail	Below average	Below average	Above average	Fail	Fail	Fail	Average	Fail	Fail	Fail	Above average	Best	Fail
I-485 northwest	NC-16 north	I-77	Below average	Below average	Fail	Below average	Fail	Fail	Fail	Fail	Below average	Average	Average	Above average	Average	Fail
I-485 northwest	I-85	NC-16 north	Below average	Average	Fail	Average	Fail	Fail	Fail	Below average	Below average	Average	Average	Above average	Average	Fail
I-485 west	I-85	Garden Parkway	Fail	Average	Fail	Average	Fail	Fail	Fail	Fail	Fail	Fail	Average	Above average	Fail	Fail
I-485 west	Garden Parkway	I-77	Below average	Average	Fail	Best	Fail	Below average	Fail	Below average	Below average	Fail	Fail	Above average	Fail	Fail
I-77 south, York Co	Exit 73, SC	Exit 90 (US-21)	Average	Average	Best	Best	Below average	Average	Average	Above average	Fail	Average	Average	Below average	Fail	Average
I-77 south	Exit 90 (US-21)	Exit 4 (Nations Ford)	Above average	Average	Best	Best	Best	Best	Above average	Above average	Average	Best	Best	Average	Average	Average
I-77 south	Exit 4 (Nations Ford)	I-277(Brookshire)	Average	Average	Best	Best	Average	Best	Above average	Above average	Average	Best	Best	Fail	Best	Average
I-77 existing HOV	I-277(Brookshire)	I-485 north	Above average	Above average	Best	Best	Average	Above average	Above average	Above average	Average	Fail	Fail	Fail	Best	Above average
I-77 north, Meck Co	I-485 north	Meck/ Iredell CL	Above average	Above average	Best	Best	Average	Above average	Above average	Above average	Above average	Average	Average	Best	Best	Above average
I-77 north, Iredell Co	Meck/ Iredell CL	US-21/I-77	Average	Average	Above average	Best	Below average	Average	Below average	Average	Average	Average	Average	Average	Average	Above average
I-85 south, west Gastonia	Cleveland/ Gaston CL	Exit 17 (US-321)	Above average	Average	Best	Above average	Below average	Below average	Above average	Average	Best	Average	Best	Above average	Below average	Above average
I-85 south, east Gastonia	Exit 17 (US-321)	Exit 27 (NC-273)	Above average	Average	Best	Best	Average	Average	Best	Above average	Best	Best	Best	Above average	Average	Above average
I-85 south, outside I-485	Exit 27 (NC-273)	I-485 west	Above average	Average	Best	Best	Above average	Above average	Best	Best	Best	Best	Best	Above average	Above average	Above average
I-85 south	I-485 west	I-77	Average	Average	Best	Best	Below average	Below average	Average	Average	Above average	Best	Best	Below average	Best	Above average
I-85 north	I-77	I-485 east	Average	Average	Best	Best	Below average	Average	Average	Above average	Below average	Best	Best	Average	Best	Average
I-85 north, outside I-485	I-485 east	Exit 49 (Speedway Blvd)	Average	Average	Best	Best	Average	Average	Above average	Above average	Average	Best	Best	Above average	Above average	Average
I-85 north, Cabarrus Co	Exit 49 (Speedway Blvd)	Cabarrus/ Rowan CL	Above average	Average	Best	Best	Average	Average	Average	Above average	Below average	Best	Best	Above average	Average	Average
I-85 north, Rowan Co	Cabarrus/ Rowan CL	Exit 81, Long Ferry Rd	Below average	Below average	Above average	Above average	Fail	Below average	Fail	Below average	Fail	Best	Best	Above average	Fail	Average
US-321 north	US-321 Bypass/ US-321	US-321 Business	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Above average	Fail	Fail
US-74 east	I-277	Albemarle Rd	Average	Average	Best	Best	Above average	Above average	Above average	Above average	Best	Fail	Fail	Average	Average	Above average
US-74 east	Albemarle Rd	I-485 southeast	Above average	Above average	Best	Best	Average	Above average	Above average	Above average	Above average	Fail	Fail	Fail	Below average	Above average
NC-16 north	Lincoln/Catawba CL	Killian Rd	Below average	Fail	Below average	Average	Fail	Fail	Fail	Below average	Below average	Fail	Fail	Average	Fail	Below average
NC-16 north, outside I-485	Killian Rd	I-485 northwest	Above average	Average	Best	Best	Average	Average	Above average	Above average	Average	Fail	Fail	Average	Average	Below average
NC-16 north, inside I-485	I-485 northwest	I-277 (Brookshire)	Above average	Above average	Best	Best	Best	Best	Best	Best	Above average	Fail	Fail	Average	Best	Below average
NC-24/27	US-74 east	I-485 east	Above average	Best	Best	Best	Best	Best	Above average	Best	Best	Fail	Fail	Fail	Average	Below average
NC-24/27	I-485 east	Cabarrus/ Stanly CL	Above average	Average	Best	Best	Average	Average	Above average	Above average	Average	Fail	Fail	Fail	Below average	Below average
NC-24/27, Stanly Co	Cabarrus/ Stanly CL	US-52, Albemarle	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Best	Fail	Below average
US-321 south	US-321 Bypass/ US-321	I-85	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail
US-521, Lancaster Co	SC-5, SC	SC/NC state line	Below average	Below average	Above average	Above average	Fail	Below average	Average	Average	Average	Fail	Fail	Below average	Average	Below average
US-521, Meck Co	SC/NC state line	I-485 south	Above average	Average	Best	Best	Above average	Best	Above average	Best	Above average	Fail	Fail	Fail	Above average	Below average
US-321 Bypass	US-321	I-85 south	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Fail	Best	Fail	Fail
Gpkwy - south Gastonia	I-85 south	I-485 southwest	Fail	Below average	Fail	Fail	Fail	Fail	Fail	Fail	Above average	Fail	Fail	Best	Fail	Fail
I-485 northeast	I-77	I-85	Below average	Average	Fail	Below average	Fail	Fail	Fail	Fail	Below average	Average	Best	Best	Fail	Fail

Legend: = Fail, = Below average, = Average, =Above average, = Best

Highlight indicates that the segment is not being considered for Phase 2 at this point.

Figure 3-1: Final Phase 1 Screening Recommendations



3.2 Phase 2 Results of Analysis

The following three performance measures were used to compare the results of the analysis of conditions projected for 2030: 1) illustrative trip time savings for managed lane users, 2) the levels of congestion in the general purpose and managed lanes along the limited access highways, and 3) mobility, representing the number of vehicle and person trips in a corridor with and without managed lanes.

The analysis was based on the level of service (travel time, congestion, and mobility) projected for the critical peak hour. Inbound travel (coming toward Center City Charlotte) is the critical direction during the morning peak hour and outbound travel (traffic leaving Center City Charlotte) is the critical direction during the afternoon peak hour.

This analysis assumed the roadway improvements recommended in the long range transportation plans for the region. The planned improvements directly impacting the level of service along the study corridors/segments by 2020 are:

- I-77 north widened to six lanes between I-485 and Langtree Road,
- I-77 south widened to ten lanes between I-277 in Center City Charlotte and Nations Ford Road and eight lanes between Nations Ford Road and the North Carolina/South Carolina State Line,
- Completion of the final segment of I-485 between I-77 North and I-85 North,
- I-85 north widened to eight lanes between Speedway Boulevard and Exit 68,
- US-74 would be an expressway with six lanes and a busway from Center City Charlotte east to I-485, and
- I-485 south between I-77 south and US-74 east widened to six and eight lanes. The Charlotte Outer Loop would be widened to six lanes from I-77 to Johnston Road by 2020 and further improved to eight lanes by 2030, including the Johnston Road Flyover. I-485 south between Johnston Road and US-74 east would be widened to six lanes by 2030. The last portion of I-485 (northeast segment) is assumed to be complete by 2020.

3.2.1 Travel Time Savings

In order to evaluate changes in travel times, sample origins and destinations were identified which would represent the primary movements most likely to use the *Fast Lanes* studied in Phase 2. The results predicted for 2030 are summarized in **Table 3-3**.

Table 3-3: 2030 Maximum Trip Time Savings
(Critical Direction with HOV 2+ Scenario)

Corridor	From	To	Length (Miles)	GP Travel Time (Minutes)	Managed Lanes Savings (Minutes)	Time Savings Per Mile (Minutes)
Origins to Center City Charlotte						
I-77 south	Rock Hill, York County	Center City Charlotte	20	28	7	0.35
I-77 south	Pineville/ Ballantyne area	Center City Charlotte	14	21	7	0.50
I-85 south	Gastonia	Center City Charlotte	24	43	19	0.79
I-85 south	Airport	Center City Charlotte	9	19	4	0.44
NC-16 west	Mountain Island	Center City Charlotte	10	23	8	0.80
I-77 north	Mooresville	Center City Charlotte	27	42	19	0.70
I-77 north	Davidson/ Cornelius	Center City Charlotte	20	35	17	0.85
I-85 north	China Grove, Rowan County	Center City Charlotte	33	46	16	0.48
I-85 north	UNC Charlotte	Center City Charlotte	10	26	7	0.70
US-74 east	Matthews	Center City Charlotte	9	27	8	0.89
Origins to Airport						
I-77 & I-85	Davidson/ Cornelius	Airport	24	41	11	0.47
I-77 & I-485	Rock Hill, York County	Airport	23	36	8	0.34
Origins to UNC Charlotte						
I-77 & I-85	Pineville/ Ballantyne area	UNC Charlotte	25	40	11	0.44
I-77 & I-85	Rock Hill, York County	UNC Charlotte	30	46	10	0.33
I-85	Gastonia	UNC Charlotte	28	49	17	0.62
Origins to Arrowood/ Tyvola area						
I-77	Davidson/ Cornelius	Arrowood/ Tyvola	27	46	18	0.67
I-85 & I-77	UNC Charlotte	Arrowood/ Tyvola	17	37	9	0.53
I-85 & I-485	Gastonia	Arrowood/ Tyvola	25	45	17	0.61
Through Trips						
I-85 Corridor	China Grove	Gastonia	51	57	10	0.20
I-77 Corridor	Mooresville	Rock Hill	46	63	20	0.43
I-85 & 77 Corridors	China Grove	Rock Hill	53	67	18	0.34
I-77, I-485 & I-85	Gastonia	Rock Hill	34	52	18	0.52

Table 3-4: 2013 Maximum Trip Time Savings
(Critical Direction with HOV 2+ Scenario)

Corridor	From	To	Length (Miles)	GP Travel Time (Minutes)	Managed Lanes Savings (Minutes)	Time Savings Per Mile (Minutes)
Origins to Center City Charlotte						
I-77 south	Rock Hill, York County	Center City Charlotte	20	23	4	0.20
I-77 south	Pineville/ Ballantyne area	Center City Charlotte	14	19	5	0.36
I-85 south	Gastonia	Center City Charlotte	24	33	9	0.38
I-85 south	Airport	Center City Charlotte	9	16	3	0.33
NC-16 west	Mountain Island	Center City Charlotte	10	18	5	0.50
I-77 north	Mooresville	Center City Charlotte	27	34	10	0.37
I-77 north	Davidson/ Cornelius	Center City Charlotte	20	28	10	0.50
I-85 north	China Grove, Rowan County	Center City Charlotte	33	37	8	0.24
I-85 north	UNC Charlotte	Center City Charlotte	10	23	5	0.50
US-74 east	Matthews	Center City Charlotte	9	26	5	0.56
Origins to Airport						
I-77 & I-85	Davidson/ Cornelius	Airport	24	34	6	0.25
I-77 & I-485	Rock Hill, York County	Airport	23	31	1	0.05
Origins to UNC Charlotte						
I-77 & I-85	Pineville/ Ballantyne area	UNC Charlotte	25	36	7	0.28
I-77 & I-85	Rock Hill, York County	UNC Charlotte	30	40	6	0.20
I-85	Gastonia	UNC Charlotte	28	39	7	0.25
Origins to Arrowood/ Tyvola area						
I-77	Davidson/ Cornelius	Arrowood/ Tyvola	27	38	11	0.40
I-85 & I-77	UNC Charlotte	Arrowood/ Tyvola	17	33	6	0.36
I-85 & I-485	Gastonia	Arrowood/ Tyvola	25	35	9	0.37
Through Trips						
I-85 Corridor	China Grove	Gastonia	51	50	4	0.08
I-77 Corridor	Mooresville	Rock Hill	46	54	12	0.26
I-85 & 77 Corridors	China Grove	Rock Hill	53	58	10	0.18
I-77, I-485 & I-85	Gastonia	Rock Hill	34	43	10	0.29

Table 3-3 shows the peak-hour trip time savings in 2030 for managed lanes users (i.e., transit riders, travelers in eligible high-occupancy vehicles, and motorists that are willing to pay a fee to use a *Fast Lane* during a peak hour). Trip time savings represent the difference between travel times in the general purpose and managed lanes along the same route. The corridors showing the highest savings on a per-mile basis would be:

- I-77 north between Davidson and Center City Charlotte, 17 minutes saved by using the managed lanes which would be 20 miles long.
- US-74 east between Matthews and Center City Charlotte, 8 minutes of travel time savings on a nine-mile *Fast Lanes* facility.
- I-85 south between Gastonia and Center City Charlotte, 19 minutes of travel time savings along 24 miles of managed lanes.
- NC-16 west between Mountain Island and Center City Charlotte, 8 minutes saved on 10 miles of managed lanes.
- I-85 north between UNC Charlotte and Center City Charlotte, 7 minutes saved on 10-mile *Fast Lanes* facility.

Table 3-4 describes the travel time savings for managed lanes users in 2013. Since there is less congestion predicted for 2013 than for 2030, the travel time savings in each corridor would be lower in 2013 than in 2030. However, four corridors have a projected peak-hour travel time savings of at least a half-minute per mile, an industry rule of thumb often applied when considering managed lanes implementation:

- US-74 east, 5 minutes of travel time savings.
- I-85 north, 5 minutes saved.
- I-77 north, 10 minutes of travel time savings.
- NC-16 west, 5 minutes saved.

3.2.2 2030 Level of Congestion

Reductions in delay and increases in reliability of travel in *Fast Lanes* are two of the most important reasons for their implementation. Congestion levels for 2030 were estimated based on forecasts of morning and afternoon peak-hour volumes and roadway capacities. **Table 3-5** shows the estimated percent of highway miles operating below, near or above roadway capacity in 2030.

Table 3-5: 2030 Levels of Congestion

Corridors / Segments	Length (Miles)	Percent of Miles: General Purpose Lanes: Free Flow	General Purpose Lanes: Near Capacity	General Purpose Lanes: At or Over Capacity	HOV Lanes: Free Flow	HOV Lanes: Near Capacity	HOV Lanes: At or Over Capacity
I-77 Corridor North of Center City Charlotte							
Iredell County	12	81%	8%	11%	100%	0%	0%
Iredell/ Meck CL to existing HOV	12	8%	12%	80%	83%	17%	0%
Existing HOV	9	25%	21%	54%	88%	4%	8%
Brookshire to John Belk	2	0%	8%	92%	76%	17%	7%
I-77 Corridor South of Center City Charlotte							
John Belk to I-485 south	9	60%	9%	31%	76%	2%	21%
I-485 south to York County	3	50%	0%	50%	88%	12%	0%
I-85 Corridor West of Center City Charlotte							
Exit 10 in Gaston County to I-485 west	20	36%	16%	48%	82%	14%	4%
I-485 west to I-77	8	31%	29%	40%	82%	14%	3%
I-85 Corridor East of Center City Charlotte							
I-77 to I-485 east	10	44%	16%	40%	83%	17%	0%
I-485 east to Cabarrus/ Rowan CL	15	51%	20%	29%	87%	12%	1%
Rowan County	5	64%	25%	11%	100%	0%	0%
NC-16 North Corridor: Brookshire Blvd	10	47%	8%	45%	100%	0%	0%
US-74 East Corridor: Independence Blvd	12	51%	14%	35%	84%	1%	15%
I-485 Corridor							
New section between I-77 north and I-85 north	6	62%	25%	13%	100%	0%	0%
Between I-77 south and US-74 east	15	39%	23%	38%	100%	0%	0%
Between I-85 south and I-77 south	10	34%	20%	46%	100%	0%	0%

Free Flow is VCR <0.80; Near Capacity is VCR between 0.81 and 0.90; At or Over Capacity is VCR >0.90.
Level of congestion is based on traffic estimates from the HOV2+ model scenario.

Table 3-5 indicates that in 2030 almost all users in the *Fast Lanes* would experience free flow travel conditions compared to just 60 percent of the miles of general purpose lanes. For most corridors, about half of the segments would have general purpose lanes operating at or above capacity, resulting in trip delays and unreliable travel times. These levels of congestion are projected to occur despite the widening of the I-77 and I-85 segments shown in the long range plans for the region. Without these planned improvements, even more congestion on general-purpose lanes would be likely.

3.2.3 Vehicle Trips

Increased efficiency of traffic flow and operations in a highway corridor is one of the potential benefits of managed lanes. **Table 3-6** shows the number of peak hour trips per lane that would be accommodated in 2030 along the various corridors being analyzed in Phase 2, while **Table 3-7** provides the same information for 2013. In these tables, the general purpose lanes would carry more vehicles than the HOV lanes but HOV lanes are intended generally to move more people and provide future capacity for growth beyond 2030. The demand estimates in **Table 3-6** reflect the following two key points:

- HOV lane volumes may be underestimated because the modeling assumes that general purpose lanes will have substantial capacity added as a result of highway improvements shown in the Long Range Transportation Plans.

- HOV lane volumes must be managed at an operating threshold of level of service C (a much lower vehicle throughput than operational capacity) to sustain reliability and travel times as compared to the general purpose lanes.

The table shows that vehicle demands would vary greatly by *Fast Lanes* segment. On I-485, especially the new northeast segment, demand in 2030 could be lower than on I-77 and I-85 closer to Center City Charlotte or US-74. This finding suggests that some of these segments have additional capacity to sell while others might not have extra capacity to sell, depending on the threshold of free use assigned to HOVs and the willingness of drive-alone motorists to pay.

Table 3-6: 2030 Vehicle Trips Per Lane

Corridors Segments	Length (Miles)	AM Inbound		PM Outbound	
		GP Lane	HOV Lanes	GP Lane	HOV Lanes
I-77 Corridor North of Center City Charlotte					
Iredell County	12	1,800	600	1,700	600
Iredell/ Meck CL to existing HOV	12	2,500	1,100	2,500	1,200
Existing HOV	9	2,500	1,000	2,400	1,000
Brookshire to John Belk	2	2,100	800	2,300	1,000
I-77 Corridor South of Center City Charlotte					
John Belk to I-485 south	9	2,000	1,100	2,100	1,300
I-485 south to York County	3	2,200	1,200	2,100	1,200
I-85 Corridor West of Center City Charlotte					
Exit 10 in Gaston County to I-485 west	20	2,300	1,100	2,200	1,100
I-485 west to I-77	8	2,100	900	2,200	1,100
I-85 Corridor East of Center City Charlotte					
I-77 to I-485 east	10	2,000	1,000	2,200	1,300
I-485 east to Cabarrus/ Rowan CL	15	1,900	1,000	2,200	1,200
Rowan County	5	1,800	800	1,900	900
NC-16 North Corridor: Brookshire Blvd	10	1,300	500	1,400	600
US-74 East Corridor: Independence Blvd	12	1,800	1,100	1,800	1,300
I-485 Corridor					
New section between I-77 north and I-85 north	6	1,600	300	1,800	300
Between I-77 south and US-74 east	15	2,000	600	2,200	800
Between I-85 south and I-77 south	10	1,500	100	1,800	300

HOV/ Managed Lanes: Fast Lanes operated with HOV 2+
Vehicle trips are vehicles per hour per lane (VPHPL), weighted average of vehicles on the links within the segments defined for the study corridors.

Table 3-7: 2013 Vehicle Trips Per Lane

Corridors Segments	Length (Miles)	AM Inbound		PM Outbound	
		GP Lane	HOV Lanes	GP Lane	HOV Lanes
I-77 Corridor North of Center City Charlotte					
Iredell County	12	1,400	300	1,400	200
Iredell/ Meck CL to existing HOV	12	2,400	900	2,400	900
Existing HOV	9	2,300	700	2,300	700
Brookshire to John Belk	2	2,000	500	2,200	700
I-77 Corridor South of Center City Charlotte					
John Belk to I-485 south	9	1,900	800	1,900	1,000
I-485 south to York County	3	2,000	900	1,900	900
I-85 Corridor West of Center City Charlotte					
Exit 10 in Gaston County to I-485 west	20	2,100	800	2,000	800
I-485 west to I-77	8	1,800	600	2,000	700
I-85 Corridor East of Center City Charlotte					
I-77 to I-485 east	10	1,900	700	2,100	900
I-485 east to Cabarrus/ Rowan CL	15	1,700	600	1,900	700
Rowan County	5	1,400	300	1,500	300
NC-16 North Corridor: Brookshire Blvd	10	1,100	400	1,100	400
US-74 East Corridor: Independence Blvd	12	1,700	900	1,700	1,100
I-485 Corridor					
New section between I-77 north and I-85 north	6	1,200	100	1,200	200
Between I-77 south and US-74 east	15	2,100	500	2,200	700
Between I-85 south and I-77 south	10	1,200	100	1,400	100

HOV/ Managed Lanes: Fast Lanes operated with HOV 2+

Vehicle trips are vehicles per hour per lane (VPHPL), weighted average of vehicles on the links within the segments defined for the study corridors.

3.2.4 Person Trips

The potential for greater person throughput is one of the primary benefits of implementing *Fast Lanes.* **Table 3-8** shows the comparable numbers of person trips along each of the Phase 2 corridors in 2030, assuming each is a HOV 2+ facility, while **Table 3-9** summarizes the same results for 2013. As shown in these tables, some of the general purpose segments would carry more persons per lane than the *Fast Lanes* segments because vehicle demand on general-purpose segments will be higher, typically indicative of a lack of adequate congestion to create modal and spatial shifting. Person-carrying capacity should be viewed from both the level of service and demand on a particular segment.

Along I-77 in Iredell County, general purpose lanes in 2030 are projected to carry 1,900 persons per lane in the peak hour (in 1,700 vehicles), while 1,500 persons (in 600 vehicles) would use the *Fast Lane* in the peak direction for that hour. The managed lane along I-77 is projected to serve over twice as many persons per vehicle per hour than the average general purpose lane, in addition to providing a better level of traffic service and a reliable travel time. For those segments where there is significant HOV demand (for example, the I-77 segment between Center City Charlotte and I-485 south), the HOV lane is estimated to carry 1,100 more persons per hour per lane compared to the average general purpose lane. Each *Fast Lane* will also preserve future capacity beyond 2030.

Table 3-8: 2030 Person Trips Per Lane Per Hour

Corridors Segments	Length (Miles)	AM Inbound		PM Outbound	
		GP Lane	HOV Lanes	GP Lane	HOV Lanes
I-77 Corridor North of Center City Charlotte					
Iredell County	12	2,000	1,600	1,900	1,500
Iredell/ Meck CL to existing HOV	12	2,600	2,900	2,700	2,900
Existing HOV	9	2,700	2,500	2,600	2,400
Brookshire to John Belk	2	2,300	1,900	2,500	2,600
I-77 Corridor South of Center City Charlotte					
John Belk to I-485 south	9	2,100	2,800	2,200	3,300
I-485 south to York County	3	2,300	3,000	2,200	3,000
I-85 Corridor West of Center City Charlotte					
Exit 10 in Gaston County to I-485 west	20	2,300	2,800	2,300	2,800
I-485 west to I-77	8	2,200	2,300	2,300	2,700
I-85 Corridor East of Center City Charlotte					
I-77 to I-485 east	10	2,100	2,400	2,300	3,100
I-485 east to Cabarrus/ Rowan CL	15	2,000	2,500	2,300	2,900
Rowan County	5	1,900	2,000	1,900	2,300
NC-16 North Corridor: Brookshire Blvd	10	1,400	1,300	1,500	1,400
US-74 East Corridor: Independence Blvd	12	1,900	2,800	2,000	3,300
I-485 Corridor					
New section between I-77 north and I-85 north	6	1,900	700	2,100	800
Between I-77 south and US-74 east	15	2,100	1,600	2,300	2,100
Between I-85 south and I-77 south	10	1,700	400	1,900	800

HOV/ Managed Lanes: Fast Lanes operated with HOV 2+
Person trips are persons per hour per lane (PPHPL), weighted average of person trips on the links within the segments defined for the study corridors.

Table 3-9: 2013 Person Trips Per Lane Per Hour

Corridors Segments	Length (Miles)	AM Inbound		PM Outbound	
		GP Lane	HOV Lanes	GP Lane	HOV Lanes
I-77 Corridor North of Center City Charlotte					
Iredell County	12	1,600	800	1,600	600
Iredell/ Meck CL to existing HOV	12	2,500	2,200	2,500	2,200
Existing HOV	9	2,500	1,800	2,400	1,800
Brookshire to John Belk	2	2,200	1,300	2,400	1,800
I-77 Corridor South of Center City Charlotte					
John Belk to I-485 south	9	2,000	2,000	2,100	2,300
I-485 south to York County	3	2,000	2,300	1,900	2,200
I-85 Corridor West of Center City Charlotte					
Exit 10 in Gaston County to I-485 west	20	2,200	2,000	2,100	2,000
I-485 west to I-77	8	1,900	1,500	2,100	1,700
I-85 Corridor East of Center City Charlotte					
I-77 to I-485 east	10	2,000	1,800	2,200	2,200
I-485 east to Cabarrus/ Rowan CL	15	1,800	1,500	2,000	1,800
Rowan County	5	1,600	900	1,700	700
NC-16 North Corridor: Brookshire Blvd	10	1,200	900	1,200	1,000
US-74 East Corridor: Independence Blvd	12	1,900	2,100	1,800	2,600
I-485 Corridor					
New section between I-77 north and I-85 north	6	1,400	300	1,500	500
Between I-77 south and US-74 east	15	2,200	1,200	2,300	1,700
Between I-85 south and I-77 south	10	1,300	300	1,500	300

HOV/ Managed Lanes: Fast Lanes operated with HOV 2+
Person trips are persons per hour per lane (PPHPL), weighted average of person trips on the links within the segments defined for the study corridors.

4.0 REVENUE AND COST ESTIMATES

This chapter describes the forecasted tolls and revenues associated with implementation of managed lanes in the Charlotte region. This chapter also summarizes estimated capital, operating and maintenance costs by corridor and segment to determine the financial feasibility of *Fast Lanes*.

As appropriate for a first-order assessment of a *Fast Lanes* network at a regional scale, simplified, yet conservative, approaches to forecasting revenues and costs were applied. Capital and operations and maintenance costs include significant contingencies. Revenue projections were generated by a tolling model which builds upon forecasts from the Metrolina regional travel demand model.

4.1 Revenue Forecasts

Annual revenues were predicted for HOT lanes for the years 2013 and 2030.

4.1.1 Approach for Revenue Projections

Toll revenues were dynamically optimized on a five-minute basis for individual corridor segments for the weekday morning peak, midday, afternoon peak and evening periods. Annual revenue forecasts reflect estimates of average weekday volumes and weekend performance using weekday-to-weekend factors from other cities in the United States.

From the modeling results, different revenue and toll estimates were generated by varying four key dimensions:

- **Pricing objective.** HOT lanes can be operated to achieve a variety of different objectives. Some facilities might be operated to maximize toll revenues, which is appropriate when the HOT lane facility must cover its capital costs. Other facilities that are not financially constrained can be operated to maintain a target level of service or to minimize aggregate travel time costs for commuters within a corridor or for the overall network. Tolls were established in the Charlotte Region *Fast Lanes* Study to 1) maximize toll revenues, and 2) minimize the aggregate dollar value of time costs in each corridor. For both scenarios, the managed lane was limited to carrying no more than 1,600 vehicles per hour per lane.

- **Carpool policy.** Tolls were estimated for these policy scenarios – HOV 2+ free, HOV 3+ free, and all users pay.

- **Input vehicle volumes.** Vehicle volumes used to generate the revenue forecasts from the tolling model were derived from Metrolina travel demand model runs: 1) where the current HOV 2+ free policy would be in effect for the HOT lanes (HOV 2+ network run), and 2) where the HOT lanes would be operated as general purpose lanes (unrestricted use network run).

- **Year of operation.** Modeling was completed for two planning years, 2013 and 2030.

4.1.2 Summary of Results

Table 4-1 summarizes the revenue forecasts for the Phase 2 *Fast Lane* system for the aforementioned operating strategies, carpool policy assumptions and input volume assumptions. The results in **Table 4-1** suggest that the revenue potential of a Charlotte HOT lane network is sensitive to the modeling assumptions, but this level of sensitivity is common. In particular, the table suggests that:

- An estimated $300 million would be generated annually in 2030 by the managed lanes system under the revenue maximization objective if all vehicles were to pay to use the *Fast Lanes*. This amount would be reduced by more than 50 percent under the travel time cost minimization operating strategy.

- Results obtained under the “HOV 2+ free network run” are more conservative than those generated under the “unrestricted use network run”.

- The choice of the HOT lane operating objective (travel time minimization versus toll revenue maximization) influences revenues to a greater degree as the carpool policies become more restrictive (everyone pays policy versus HOV 2+ use the lanes for free).

- Revenues are expected to increase over time as congestion in the Charlotte region grows.

Table 4-1: Projected HOT System Revenue Forecasts for 2013 and 2030

(2008 Dollars in Millions)

Travel Time Cost Minimization Objective				
Policy	**Unrestricted Network Run**		**HOV 2+ Free Run**	
	2013	**2030**	**2013**	**2030**
HOV 2+ Free; SOV pay	$20	$50	$6	$10
HOV 3+ Free; HOV 2+ and SOV pay	$37	$107	$15	$49
All pay	$47	$137	$21	$79
Revenue Maximization Objective				
Policy	**Unrestricted Network Run**		**HOV 2+ Free Run**	
	2013	**2030**	**2013**	**2030**
HOV 2+ Free; SOV pay	$23	$56	$7	$11
HOV 3+ Free; HOV 2+ and SOV pay	$66	$163	$27	$72
All pay	$114	$290	$55	$156

Table 4-2 summarizes the projected annual revenues at the corridor segment level for 2013 and 2030 based on the travel time cost minimization pricing objective and the “unrestricted use network run” from the regional model. **Table 4-3** shows the yearly revenue forecasts for the two horizon years under the revenue maximization pricing strategy and the same

“unrestricted use” scenario. **Table 4-4** and **Table 4-5** provide the revenue estimates for the other scenarios – “HOV 2+ free network run”. Since these revenue projections were estimated using a “sketch-level” model, they are general planning estimates and should not be used for investment analyses of specific projects.

Table 4-2: 2013 and 2030 Projected Annual Revenues (Travel Cost Minimizing Objective and Unrestricted Model Run)

Corridors / Segments	2013 HOV2+ Free	2013 HOV 3+ Free	2013 All Users Pay	2030 HOV 2+ Free	2030 HOV 3+ Free	2030 All Users Pay
I-77 Corridor North of Center City Charlotte						
Iredell County	$67,000	$122,000	$157,000	$601,000	$1,529,000	$2,093,000
Iredell/Mecklenburg county line to existing HOV	$4,197,000	$8,298,000	$10,714,000	$8,259,000	$19,511,000	$26,229,000
Existing HOV	$326,000	$532,000	$645,000	$1,091,000	$2,076,000	$2,610,000
Brookshire to John Belk	$3,142,000	$6,140,000	$7,604,000	$5,271,000	$12,484,000	$15,986,000
	$7,732,000	$15,092,000	$19,120,000	$15,222,000	$35,600,000	$46,918,000
I-77 Corridor South of Center City Charlotte						
John Belk to I-485 south	$399,000	$1,234,000	$1,640,000	$523,000	$4,208,000	$5,960,000
I-485 south to York County	$377,000	$682,000	$853,000	$2,315,000	$6,254,000	$8,397,000
	$776,000	$1,916,000	$2,493,000	$2,838,000	$10,462,000	$14,357,000
I-85 Corridor West of Center City Charlotte						
Exit 10 in Gaston County to I-485 west	$5,437,000	$8,838,000	$10,819,000	$17,841,000	$30,537,000	$38,184,000
I-485 west to I-77	$443,000	$830,000	$1,040,000	$1,586,000	$3,647,000	$4,739,000
	$5,880,000	$9,668,000	$11,859,000	$19,427,000	$34,184,000	$42,923,000
I-85 Corridor East of Center City Charlotte						
I-77 to I-485 east	$384,000	$760,000	$950,000	$1,370,000	$3,388,000	$4,393,000
I-485 east to Cabarrus/Rowan county line	$293,000	$563,000	$707,000	$1,649,000	$3,624,000	$4,697,000
Rowan County	$3,000	$6,000	$8,000	$103,000	$196,000	$255,000
	$680,000	$1,329,000	$1,665,000	$3,122,000	$7,208,000	$9,345,000
NC-16 North Corridor: Brookshire Blvd	$467,000	$985,000	$1,230,000	$771,000	$2,008,000	$2,613,000
US-74 East Corridor: Independence Blvd	$2,300,000	$5,515,000	$7,104,000	$5,557,000	$11,881,000	$15,052,000
I-485 Corridor						
New section between I-77 north and I-85 north	$1,000	$3,000	$5,000	$35,000	$87,000	$116,000
Between I-77 south and US-74 east	$1,763,000	$2,626,000	$3,052,000	$2,516,000	$4,429,000	$5,375,000
Between I-85 south and I-77 south	$11,000	$17,000	$20,000	$366,000	$556,000	$653,000
	$1,775,000	$2,646,000	$3,077,000	$2,917,000	$5,072,000	$6,144,000
Total	$19,606,000	$37,152,000	$46,547,000	$49,853,000	$106,414,000	$137,350,000

Table 4-3: 2013 and 2030 Projected Annual Revenues (Revenue Maximizing Objective and Unrestricted Model Run)

Corridors / Segments	2013 HOV 2+ Free	2013 HOV 3+ Free	2013 All Users Pay	2030 HOV 2+ Free	2030 HOV 3+ Free	2030 All Users Pay
I-77 Corridor North of Center City Charlotte						
Iredell County	$81,000	$246,000	$492,000	$623,000	$2,198,000	$4,600,000
Iredell/Mecklenburg county line to existing HOV	$4,414,000	$12,363,000	$22,911,000	$8,485,000	$26,423,000	$51,293,000
Existing HOV	$432,000	$1,180,000	$2,038,000	$1,194,000	$3,546,000	$6,448,000
Brookshire to John Belk Freeway	$3,340,000	$9,994,000	$17,278,000	$5,417,000	$19,185,000	$35,380,000
	$8,267,000	$23,783,000	$42,719,000	$15,719,000	$51,352,000	$97,721,000
I-77 Corridor South of Center City Charlotte						
John Belk to I-485 south	$402,000	$1,547,000	$2,704,000	$528,000	$4,688,000	$8,599,000
I-485 south to York County	$444,000	$1,199,000	$2,090,000	$2,371,000	$7,925,000	$14,459,000
	$846,000	$2,746,000	$4,794,000	$2,899,000	$12,613,000	$23,058,000
I-85 Corridor West of Center City Charlotte						
Exit 10 in Gaston County to I-485 west	$6,523,000	$15,248,000	$25,466,000	$21,023,000	$50,131,000	$86,995,000
I-485 west to I-77	$488,000	$1,240,000	$2,047,000	$1,637,000	$4,621,000	$7,803,000
	$7,011,000	$16,488,000	$27,513,000	$22,660,000	$54,752,000	$94,798,000
I-85 Corridor East of Center City Charlotte						
I-77 to I-485 east	$435,000	$1,213,000	$2,006,000	$1,417,000	$4,393,000	$7,454,000
I-485 east to Cabarrus/Rowan county line	$348,000	$951,000	$1,612,000	$1,741,000	$4,935,000	$8,555,000
Rowan County	$5,000	$14,000	$25,000	$124,000	$344,000	$642,000
	$788,000	$2,178,000	$3,643,000	$3,282,000	$9,672,000	$16,651,000
NC-16 North Corridor: Brookshire Blvd	$547,000	$547,000	$1,378,000	$1,961,000	$896,000	$2,644,000
US-74 East Corridor: Independence Blvd	$2,922,000	$2,922,000	$10,629,000	$18,942,000	$6,665,000	$21,339,000
I-485 Corridor						
New section between I-77 north and I-85 north	$2,000	$7,000	$14,000	$43,000	$180,000	$352,000
Between I-77 south and US-74 east	$2,968,000	$8,373,000	$14,000,000	$3,025,000	$8,544,000	$14,408,000
Between I-85 south and I-77 south	$25,000	$66,000	$106,000	$557,000	$1,419,000	$2,302,000
	$2,995,000	$8,446,000	$14,120,000	$3,625,000	$10,142,000	$17,063,000
Total	$23,375,000	$65,646,000	$113,692,000	$55,746,000	$162,515,000	$289,789,000

Table 4-4: 2013 and 2030 Projected Annual Revenues (Travel Cost Minimizing Objective and HOV 2+ Network Run)

Corridors / Segments	2013 HOV2+ Free	2013 HOV 3+ Free	2013 All Users Pay	2030 HOV 2+ Free	2030 HOV 3+ Free	2030 All Users Pay
I-77 Corridor North of Center City Charlotte						
Iredell County	$42,000	$79,000	$103,000	$271,000	$764,000	$1,059,000
Iredell/Mecklenburg county line to existing HOV	$1,355,000	$3,412,000	$4,563,000	$1,543,000	$8,579,000	$12,389,000
Existing HOV	$217,000	$388,000	$480,000	$514,000	$1,232,000	$1,611,000
Brookshire to John Belk	$345,000	$2,017,000	$2,756,000	$353,000	$5,468,000	$8,250,000
	$1,959000	$5,896,000	$7,902,000	$2,681,000	$16,043,000	$23,309,000
I-77 Corridor South of Center City Charlotte						
John Belk to I-485 south	$111,000	$692,000	$960,000	$20,000	$2,321,000	$3,557,000
I-485 south to York County	$361,000	$649,000	$812,000	$1,398,000	$4,114,000	$5,576,000
	$472,000	$1,341,000	$1,772,000	$1,418,000	$6,435,000	$9,133,000
I-85 Corridor West of Center City Charlotte						
Exit 10 in Gaston County to I-485 west	$1,448,000	$3,122,000	$4,037,000	$2,201,000	$11,773,000	$16,817,000
I-485 west to I-77	$253,000	$529,000	$675,000	$423,000	$2,849,000	$4,022,000
	$1,701,000	$3,651,000	$4,712,000	$2,624,000	$14,622,000	$20,839,000
I-85 Corridor East of Center City Charlotte						
I-77 to I-485 east	$182,000	$454,000	$585,000	$305,000	$1,693,000	$2,335,000
I-485 east to Cabarrus/Rowan county line	$157,000	$339,000	$434,000	$571,000	$2,070,000	$2,827,000
Rowan County	$3,000	$6,000	$8,000	$78,000	$154,000	$202,000
	$342,000	$799,000	$1,027,000	$954,000	$3,917,000	$5,364,000
NC-16 North Corridor: Brookshire Blvd	$218,000	$749,000	$1,010,000	$303,000	$1,407,000	$2,065,000
US-74 East Corridor: Independence Blvd	$478,000	$2,272,000	$3,581,000	$726,000	$4,939,000	$8,048,000
I-485 Corridor						
New section between I-77 north and I-85 north	$1,000	$3,000	$4,000	$12,000	$37,000	$49,000
Between I-77 south and US-74 east	$301,000	$490,000	$583,000	$671,000	$1,299,000	$1,610,000
Between I-85 south and I-77 south	$14,000	$19,000	$22,000	$181,000	$274,000	$321,000
	$316,000	$512,000	$609,000	$864,000	$1,610,000	$1,980,000
Total	$5,485,000	$15,221,000	$20,610,000	$9,568,000	$48,973,000	$70,739,000

Table 4-5: 2013 and 2030 Projected Annual Revenues (Revenue Maximizing Objective and HOV 2+ Network Run)

Corridors / Segments	2013 HOV 2+ Free	2013 HOV 3+ Free	2013 All Users Pay	2030 HOV 2+ Free	2030 HOV 3+ Free	2030 All Users Pay
I-77 Corridor North of Center City Charlotte						
Iredell County	$53,000	$171,000	$355,000	$285,000	$1,172,000	$2,601,000
Iredell/Mecklenburg county line to existing HOV	$1,454,000	$5,488,000	$11,416,000	$1,651,000	$11,924,000	$27,478,000
Existing HOV	$280,000	$866,000	$1,589,000	$564,000	$2,156,000	$4,344,000
Brookshire to John Belk Freeway	$397,000	$3,368,000	$7,402,000	$409,000	$7,739,000	$19,618,000
	$2,184,000	$9,893,000	$20,762,000	$2,909,000	$22,991,000	$54,041,000
I-77 Corridor South of Center City Charlotte						
John Belk to I-485 south	$114,000	$888,000	$1,707,000	$21,000	$2,590,000	$5,487,000
I-485 south to York County	$436,000	$1,151,000	$2,005,000	$1,457,000	$5,387,000	$10,178,000
	$550,000	$2,039,000	$3,712,000	$1,478,000	$7,977,000	$15,665,000
I-85 Corridor West of Center City Charlotte						
Exit 10 in Gaston County to I-485 west	$1,783,000	$5,857,000	$11,396,000	$2,743,000	$17,827,000	$39,555,000
I-485 west to I-77	$285,000	$837,000	$1,463,000	$453,000	$3,503,000	$6,842,000
	$2,068,000	$6,694,000	$12,859,000	$3,196,000	$21,330,000	$46,397,000
I-85 Corridor East of Center City Charlotte						
I-77 to I-485 east	$203,000	$748,000	$1,345,000	$318,000	$2,259,000	$4,419,000
I-485 east to Cabarrus/Rowan county line	$189,000	$604,000	$1,083,000	$612,000	$2,899,000	$5,640,000
Rowan County	$5,000	$13,000	$24,000	$95,000	$280,000	$533,000
	$397,000	$1,365,000	$2,142,000	$1,025,000	$5,438,000	$10,592,000
NC-16 North Corridor: Brookshire Blvd	$245,000	$1,026,000	$1,653,000	$335,000	$1,819,000	$3,134,000
US-74 East Corridor: Independence Blvd	$594,000	$4,204,000	$9,020,000	$783,000	$8,231,000	$19,228,000
I-485 Corridor						
New section between I-77 north and I-85 north	$1,000	$6,000	$11,000	$14,000	$77,000	$161,000
Between I-77 south and US-74 east	$583,000	$2,084,000	$3,928,000	$835,000	$2,976,000	$5,613,000
Between I-85 south and I-77 south	$32,000	$76,000	$119,000	$297,000	$770,000	$1,256,000
	$616,000	$2,166,000	$4,058,000	$1,146,000	$3,823,000	$7,030,000
Total	$6,651,000	$27,387,000	$54,515,000	$10,874,000	$71,605,000	$156,085,000

4.2 Comparison of Toll Estimates to Revenue Forecasts for Other Cities

The tolling model used in the Charlotte Region *Fast Lanes* Study has been used to predict revenues for other HOT lane projects in the United States. In **Table 4-6**, the system revenue estimates presented in **Table 4-1** were converted to revenue per lane mile so that the projections for this study can be compared more easily with forecasts from other cities.

Table 4-7 and **Table 4-8** provide estimates of forecasted toll levels per mile for the morning and afternoon peak for the various modeling assumptions used in the Charlotte study. **Table 4-9** summarizes the tolling model forecasts for five other metropolitan areas. A comparison of these results with the Charlotte revenue forecasts indicates that:

- The proposed I-15 HOT facility in Salt Lake City is projected to provide slightly greater revenues per mile than Charlotte's HOT lanes. Expected tolls are also expected to be higher on that facility.

- The proposed San Francisco-Oakland (Bay Area) HOT lane system includes interconnected facilities operating in one of the most congested metropolitan areas in the country. The proposed I-680 HOT lane shown in **Table 4-7** is expected to be constructed before the rest of the Bay Area network is developed. Revenues per lane mile and average peak period toll charges are much higher for the proposed HOT lanes in the Bay Area than predicted in this study for Charlotte.

- The tolling model was used to forecast revenues for the I-394 HOT facility in Minneapolis for three pricing objectives. Similar to observations made with toll modeling for this study, the revenue forecasts for I-394 depend greatly on the selected pricing objective. The actual revenues for the I-394 facility have been closely replicated by the tolling model. The Minneapolis HOT lane facility is the most similar to the proposed Charlotte HOT lane network of all locations where the tolling model has been used.

- As part of a study of widening SR-217 in Portland, the tolling model was used to estimate revenues for a short express lane facility on that freeway. The estimates for the Portland freeway fall within the range of forecasts obtained for the scenario of "everyone pays" to use *Fast Lanes* in the Charlotte region in 2013.

Table 4-6: Revenue Estimates per Lane Mile (2008 Dollars)

Travel Time Cost Minimization Objective				
Policy	**Unrestricted Network Run**		**HOV 2+ Free Run**	
	2013	**2030**	**2013**	**2030**
HOV 2+ Free	$62,000	$159,000	$17,000	$30,000
HOV 3+ Free	$118,000	$339,000	$48,000	$156,000
All pay	$148,000	$437,000	$66,000	$225,000
Revenue Maximization Objective				
Policy	**Unrestricted Network Run**		**HOV 2+ Free Run**	
	2013	**2030**	**2013**	**2030**
HOV 2+ Free	$74,000	$178,000	$21,000	$35,000
HOV 3+ Free	$209,000	$518,000	$87,000	$228,000
All pay	$362,000	$923,000	$174,000	$497,000

Table 4-7: Estimated Tolls per Vehicle-Mile (AM Peak) (2008 Dollars)

Travel Time Cost Minimization Objective				
Policy	**Unrestricted Network Run**		**HOV 2+ Free Run**	
	2013	**2030**	**2013**	**2030**
HOV 2+ Free	$0.07	$0.23	$0.03	$0.09
HOV 3+ Free	$0.06	$0.18	$0.03	$0.10
All pay	$0.06	$0.18	$0.03	$0.09
Revenue Maximization Objective				
Policy	**Unrestricted Network Run**		**HOV 2+ Free Run**	
	2013	**2030**	**2013**	**2030**
HOV 2+ Free	$0.12	$0.29	$0.05	$0.10
HOV 3+ Free	$0.27	$0.59	$0.12	$0.27
All pay	$0.48	$1.10	$0.24	$0.62

Table 4-8: Estimated Tolls per Vehicle-Mile (PM Peak) (2008 Dollars)

Travel Time Cost Minimization Objective				
Policy	**Unrestricted Network Run**		**HOV 2+ Free Run**	
	2013	**2030**	**2013**	**2030**
HOV 2+ Free	$0.06	$0.16	$0.02	$0.05
HOV 3+ Free	$0.05	$0.14	$0.03	$0.08
All pay	$0.05	$0.13	$0.03	$0.08
Revenue Maximization Objective				
Policy	**Unrestricted Network Run**		**HOV 2+ Free Run**	
	2013	**2030**	**2013**	**2030**
HOV 2+ Free	$0.10	$0.22	$0.03	$0.07
HOV 3+ Free	$0.22	$0.47	$0.10	$0.23
All pay	$0.39	$0.89	$0.21	$0.50

Table 4-9: Summary of Recent HOT Lanes Studies Results that Used Tolling Model

	I-15 HOT Lanes, Salt Lake City, UT	Bay Area (San Francisco-Oakland, CA) HOT Lane Network Study		I-680 in Northern California	I-394 MnPASS HOT Facility Minneapolis, MN			US-217 in Portland, OR
Facility Characteristics								
Priced Lane Miles	I-64 to I-73 depending on network	488.1	488.1	15.2	21.2	21.2	21.2	10.5
Carpool Policy	HOV 2+ Free	HOV 2+ Free	HOV 3+ Free	HOV 2+ Free	HOV 2+ Free	HOV 2+ Free	HOV 2+ Free	Everyone pays
Pricing Objective	Revenue Max	Min Travel Cost	Min Travel Cost	Revenue Max	Revenue Max	Min Travel Cost	Maintain Target LOS	Maintain Target LOS
Max HOT Lane Vehicles/ Lane/ Hour	None	1600	1600	1550	None	None	1450	850
Pricing Approach	Dynamic	Dynamic	Dynamic	Dynamic	Static	Static	Static	Static
Year Modeled	2015	2015	2015	2010	2005	2005	2005	2014
Dollars	2000	2005	2005	2006	2005	2005	2005	2004
Hours/ Days of Operation	24 / 7	24 / 7	24 / 7	24 / 7	9 / 5	9 / 5	9 / 5	24 / 7
Directional	No	No	No	Yes	Yes	Yes	Yes	No
Revenue and Toll Levels								
Annual Revenue per Lane Mile	$70,000 to $160,000	$350,000	$900,000	$320,000 to $440,000	$65,000	$25,000	$30,000	$290,000
Annual Peak Period Toll per Mile	$0.10 to $0.32	$0.24	$0.21	$0.33 to $0.37	$0.16	$0.03	$0.06	$0.37

Source: (1) I-15 HOT Lane Study Memo dated, 12/6; (2) Existing and Funded Network Results, 10/31/06; (3) Memo to ACCMA, 3/31/06; (4) Memo titled "Analysis of I-394 Hot Lane Facility", 11/2005.

4.3 Comparison of Toll Projections to Actual Revenues in Other Cities

In recent years, several HOT lane facilities have been implemented. **Table 4-10** summarizes operating conditions, revenue and toll levels for three HOT facilities currently in service:

- I-394, which was discussed in the preceding section
- I-15 in San Diego, California
- SR-91 in Orange County, California

Table 4-10: Summary of Facility Characteristics, Revenue and Tolls for Existing HOT Lane Facilities

	SR-91 (Orange County, CA)	I-15 (San Diego, CA)	I-394 (Minneapolis, MN)
Priced Lane Miles	40 miles (2 lanes in each direction for 10 miles)	16 miles (2 reversible lanes for 8 miles)	21.2 miles (1 lane in each direction for 8 miles plus 2 reversible lanes for 3 miles)
Carpool Policy	HOV 3+ get 50% discount during peak periods, free during off-peak	HOV 2+ ride free	HOV 2+ ride free
Pricing Approach	Static	Dynamic	Dynamic
Hours/ Days of Operation	24 / 7	13.3 / 5	9 / 5
Directional	No	Yes	Yes
Annual Revenue per Lane Mile (approximate)	$1,245,000	$125,000	$40,000
Annual Peak Period Toll per Mile (approximate)	$0.20 to $0.96	$0.06 to $1.00	$0.10 to $0.45

Tolling model results for the Charlotte HOT lane system in 2013 represent the closest comparison to the results for these three facilities. The following conclusions can be made from comparison of Charlotte model results to these locations:

- A comparison of Charlotte's results under a HOV 2+ carpool policy with information from San Diego and Minneapolis indicates that Charlotte would generate less revenue per lane mile than I-15 and about the same level as I-394. Forecasts of peak period tolls are generally lower than what is being charged on these two HOT lanes.
- The SR-91 HOT lanes are generating much higher revenue per lane-mile than the forecasts for the Charlotte system under any operating policy or set of assumptions.

The tolls per mile on SR-91 also are significantly greater than those forecast for proposed Charlotte HOT lane facilities.

These differences in revenue forecasts can be attributed to the relatively lower congestion levels and different assumed values of time and other factors that distinguish the Charlotte region from HOT lanes elsewhere, including both existing and proposed facilities. The results from the tolling model for Charlotte are consistent with findings from other cities when the differences in operating environment and policies are considered. Most importantly, this comparison should serve to increase the decision maker's confidence in the toll and revenue forecasts for *Fast Lanes* in the Charlotte region.

4.4 Estimated Capital Costs for Fast Lane Implementation

4.4.1 Methodology Overview and Key Assumptions

Construction cost estimates for implementing *Fast Lanes* along the corridors which advanced to Phase 2 were based on a NCDOT's planning-level methodology which uses costs-per-mile. This methodology also was used for construction cost estimates for the *2030 Long Range Transportation Plan* for the Mecklenburg-Union urbanized area so there is consistency in cost estimates.

Cost estimates were prepared for the following two design approaches:

- "Full feature" using widths provided by NCDOT for shoulders and lanes and for the buffer separation between the managed lane and the adjacent general purpose lane. This approach requires major widening to provide the new travel lanes and full shoulders where they currently don't exist. This approach produced ultimate or build-out cost estimates.

- Use of design exceptions where needed or appropriate, consistent with practices employed along a portion of I-77 to implement the HOV lane between I-85 and I-277 (Brookshire Freeway), as well as in many cities around the United States. *Fast Lanes* projects have often been created by converting the inside shoulder to a managed lane and narrowing adjacent lanes so as to provide the benefits of HOV or HOT lanes as early as possible at an affordable cost without requiring new right-of-way.

Figure 4-1 compares a "full feature" cross section with the "minimum" cross section that would be developed on constrained highway segments by allowing design exceptions. **Table 4-1** lists the assumptions for estimating the costs for direct connectors between adjacent freeways. **Table 4-12** summarizes roadway design principles assumed for the "full feature" approach, while **Table 4-13** lists the corresponding assumptions when design exceptions are used. Under the latter approach, widening for new managed lanes would be minimized as much as possible to remain within the existing paved cross-section, or certainly the right-of-way. If needed, travel lanes and the inside shoulder would be narrowed, assuming they have not been narrowed previously. In some cases, additional pavement may be required in the existing median or on the right side of the highway. Where there is simply not enough space within the existing right-of-way to allow for a new *Fast Lane*, new right-of-way would have to be purchased. The end result would be a narrower cross section on constrained portions of Charlotte region freeways. This approach would require approval of some design exceptions by NCDOT, SCDOT and FHWA.

Figure 4-1: Typical Cross Sections

("Full Feature" versus Design Exceptions)

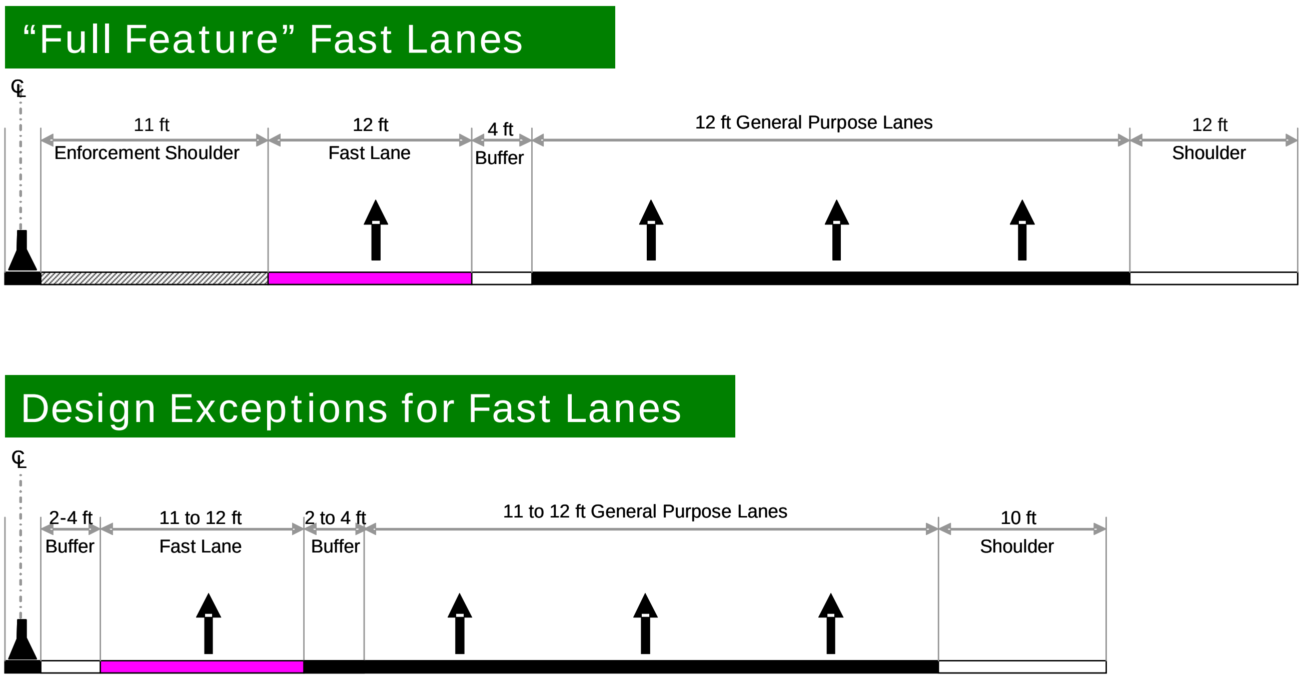


Table 4-11: Assumptions for Direct Connectors/ Flyovers

Evaluation and construction cost estimates for direct connectors were prepared separately from cost estimates for mainline improvements.

- A two-way third level flyover from median to median was assumed for each alternative.
- Depending on available median space, reconstruction of the existing roadway was considered in the estimate. It was assumed that approximately one-half mile would need to be reconstructed to provide sufficient space for the direct connection merging and diverging lanes and median transitions.
- The "design exceptions" alternative was used as the existing condition for the proposed direct connections. Only upstream and downstream structures with significant median space or interchanges and roadway segments that were reconstructed as part of the "design exceptions" alternative were assumed to accommodate the direct connections without major widening or reconstruction.

Table 4-12: Assumptions for “Full Feature” Design Standard

Converting Existing or Future HOV lanes to HOT lanes

- For I-77 from the I-277 (Brookshire Blvd) interchange to I-485 North, the existing HOV lane could be converted to a HOT lane with modifications to include a minimum separation of four feet between HOT lanes and the general purpose lanes and an increased inside shoulder width to be used as an enforcement shoulder.
- Future proposed projects for I-77 from I-485 North through Iredell County are likely to include an extension of the HOV lanes. It was assumed that an HOV lane would be accommodated in the design with a typical section similar to what exists south of I-485. However, modification of the existing inside shoulder width would be necessary to accommodate the increased enforcement shoulder.
- Where insufficient median width exists, some changes in alignments will be necessary to accommodate the increased enforcement shoulder, standard lane widths and increased separation between the HOT lane and the general purpose lanes.
- New signing, pavement markings and ITS installations would be necessary along the corridor.

Widening for New *Fast Lanes*

- One *Fast Lane* in each direction of traffic flow was assumed for most freeway segments. The only exceptions include I-77 between I-485 South and I-277 (John Belk Freeway) and Independence Blvd from I-485 East to I-277 where two ETL lanes were also analyzed. Additional general purpose lanes were included based on the 2030 LRTPs.
- The proposed typical section includes a minimum of 12-foot lanes, 11-foot enforcement shoulder and a 12-foot outside shoulder. A minimum separation of four feet between a *Fast Lane* and a general purpose lane was assumed. Full continuous enforcement shoulders would be included throughout the corridors.
- With the proposed typical sections, any current deficiencies such as reduced lane and shoulder widths would be brought up to the current design standards.
- This design approach will require widening both in the median (where feasible) and outside lanes. In some cases, this approach will require widening beyond the available right-of-way.
- The estimated right-of-way costs are based on current land use values provided by MUMPO. It was assumed that right-of-way will be required when existing frontage roads are relocated and interchanges are rebuilt.
- Similar to the “design exceptions” assumptions, existing overpasses and interchanges were evaluated to determine if proposed typical section widths could fit within the existing bridge footprint without replacement. If this was not the case, then full replacement of the interchange or overpass was assumed.
- With the exception of locations involving significant widening, it is assumed that existing mainline bridges over roadways, railroads and streams will be widened and the existing vertical clearance requirements can be maintained. Exceptions include locations where two or more lanes plus enforcement shoulders are proposed, or where the existing typical section currently contains a reduced lane and/or shoulder width resulting in additional widening to bring existing lanes up to standard.
- Existing frontage roadways with insufficient separation between the mainline travel lanes would be relocated.
- New signing, pavement markings and ITS installations would be necessary along all alternatives at an estimated cost of $2.5 million per directional mile.
- Potential future direct connections to specific cross-streets or express bus park-and-ride lots were not included in these estimates. Table 4-11 summarizes the estimated costs for direct connections.
- Merge lanes at access and egress locations were not included in the cost estimates.

Table 4-13: Assumptions for "Design Exceptions" Approach

Converting Existing or Future HOV lanes to HOT Lanes • For I-77 from I-277 (Brookshire Blvd) interchange to I-485 North, the existing HOV lane will be converted to a HOT lane without major geometric modifications. Existing lane widths and shoulder widths will remain the same. • Future proposed projects for I-77 from I-485 North through Iredell County may include an extension of the HOV lanes. It was assumed that an HOV lane would be accommodated in the design with a typical section similar to what exists south of I-485. • No changes in roadway alignments, lane widths and shoulder widths will be made for this conversion. • New signing, pavement markings and ITS installations would be necessary throughout the I-77 HOV conversion.
Widening for New *Fast Lanes* • One additional Fast Lane will be added in each direction for each alternative. No additional general purpose lanes are assumed, and if programmed, are not included in cost estimates. • Proposed projects requiring bridge replacement would be designed to accommodate the additional width required for Fast Lanes implementation. This incremental cost difference associated with widening is included in the cost estimate. These projects include future widening of I-85 north of I-485 Northeast, US-74 (Independence Boulevard) east of Albemarle Road, and I-485 (Southern Outer Loop widening). • Widening is proposed without any reduction in existing lane widths in areas where sufficient median width is available to accommodate widening. Where this is not the case, existing lane and shoulder widths are proposed to be reduced to fit within the existing roadway and/or right-of-way footprint with limited additional pavement width needed. It is assumed that for such pinch points, lane widths could be reduced to a minimum of 11 feet and inside shoulder widths to a minimum of two feet. The buffer width between the Fast Lanes and the general purpose lanes could be reduced to a minimum of two feet. Outside shoulder widths could be reduced to a minimum of 10 feet. • Only in cases where the existing footprint underneath the existing bridges or interchange bridges could not accommodate the reduced typical width would full bridge or interchange replacement be assumed. • Widening of existing mainline bridges would be based on the proposed roadway typical section. Any widening on mainline existing bridges is assumed to meet all vertical clearance requirements. • With the modified lane widths and reduced shoulder widths, the inside (median) shoulder could possibly require reconstruction to remove the existing shoulder break, widening in areas where full depth pavement currently does not exist and construction of additional drainage features to reduce water spread along the inside barrier wall. Due to these uncertainties, minimal reconstruction is assumed along the existing inside shoulder to accommodate any lanes shifting inward. In addition, the cost of milling and/or overlaying the existing roadway to remove the existing markings is included in this estimate where applicable. • Limited spot enforcement shoulders are assumed in areas where sufficient median width is available. No adjustments in the mainline travel lane geometry will be made to accommodate these enforcement areas. • Most alternatives will fit within existing right-of-way. The exception includes I-77 south of I-277 (Brookshire Freeway) where reconstruction of the existing roadway will require new right-of-way, regardless of the HOV or HOT alternative. • The estimated right-of-way costs are based on current land use values provided by the MUMPO. It was assumed that right-of-way will be required where interchanges must be replaced. • All existing frontage roads will retain their current configurations and widths. • New signing, pavement markings and ITS installations would be necessary for all alternatives, at an estimated cost of $2.5 million per directional mile. • No lane separation treatment is assumed for separating the Fast Lanes and free lanes. • No direct ramp connections at freeway interchanges with Fast Lanes are included. Table 4-11 summarizes the estimated costs for direct connections. • Merge lanes at access and egress locations were not included in these cost estimates.

4.4.2 Capital Cost Estimates

Table 4-14 summarizes the capital costs estimated for *Fast Lanes* by corridor segment for both the "Full Feature" and "Design Exception" approaches. All costs are expressed in 2008 dollars.

As shown in **Table 4-14**, implementation of the entire network studied in Phase 2 could cost between $3.2 billion and $6 billion depending on the design philosophy. Estimated right-of-way costs of $37 million and the costs for direct connections between adjacent freeways ($822 million) are included in these network cost estimates.

Table 4-14: Capital Cost Estimates by Segment

Corridors / Segments	Length (Miles)	Estimated Cost (2008 Dollars in Millions) Reduced Design	Full Feature	ROW / Direct Connectors
I-77 Corridor North of Center City Charlotte				
Iredell County	12	$30	$151	
Iredell/ Meck CL to existing HOV	12	$30	$131	
Existing HOV	9	$38	$148	
Brookshire to John Belk	2	$425	$470	$1
Total		**$523**	**$900**	**$1**
I-77 Corridor South of Center City Charlotte				
John Belk to I-485 south	9	$308	$515	$2
I-485 south to York County	3	$40	$91	
Total		**$348**	**$606**	**$2**
I-85 Corridor West of Center City Charlotte				
Exit 10 in Gaston County to I-485 west	20	$361	$697	$2
I-485 west to I-77	8	$100	$522	$8
Total		**$461**	**$1,219**	**$10**
I-85 Corridor East of Center City Charlotte				
I-77 to I-485 east	10	$125	$391	$7
I-485 east to Cabarrus/ Rowan CL	15	$196	$400	
Rowan County	5	$63	$116	
Total		**$384**	**$907**	**$7**
NC-16 North Corridor: Brookshire Freeway	10	$97	$129	$4
Total		**$97**	**$129**	**$4**
US- 74 East Corridor: Independence Blvd	12	$115	$458	$12
Total		**$115**	**$458**	**$12**
I-485 Corridors				
New section between I-77 north and I-85 north	6	$79	$187	
Between I-77 south and US-74 east	15	$198	$454	$1
Between I-85 south and I-77 south	10	$129	$242	
Total		**$406**	**$883**	**$1**
Two-Way Direct Connections				
I-77 (N-North of 485) to I-485 (NE)				$59
I-77 (N-South of 485) to I-485 (NE)				$59
I-77 (N-North of 85) to I-85 (S)				$95
I-77 (S) to 5th Street				$87
I-77 (S) to I-485 (S)				$69
I-85 (S) to I-485 (W)				$94
I-77 (S) to 4th Street				$77
I-85 (S) to NC 16 (S)				$69
I-85 (N) to I-485 (NE)				$73
I-485 (S) to US 74 (N)				$71
I-485 (S) to US 74 (S)				$69
Total				**$822**
Total Managed Lanes System	**158**	**$2,334**	**$5,102**	**$859**

4.5 Operations and Maintenance Cost Estimates

4.5.1 Methodology Overview

Operations & maintenance (O&M) costs for the Charlotte Regional *Fast Lanes* Study were developed based on experiences of other toll and HOT lane facilities around the country. Due to the inconsistency between organizations in how they incur costs and report them, unit cost estimates were adapted from data available from other areas to apply to potential facilities which are in the planning phase in the Charlotte region. The approach used to estimate O&M costs for *Fast Lanes* implementation is appropriate for a “feasibility-level” analysis.

When possible, estimates and assumptions were obtained from North Carolina sources, such as NCDOT. The NCTA also was consulted to ensure consistency on study assumptions and unit cost estimates for toll-related expenses. Assumptions also were developed using data and results from the following toll projects:

- Mountain View Corridor in Salt Lake City, Utah
- Columbia River Crossing in Washington and Oregon
- SR-520 in Washington
- Inter-County Connector in Maryland
- Bay Area Transportation Authority in San Francisco/Oakland, California
- E-470 in Denver, Colorado

Inputs and assumptions used from NCTA and other toll agencies include tolling capital costs, back office and customer service costs, enforcement and courtesy patrol costs, and variable toll operations costs. **Table 4-15** lists the number of lane-miles and possible tolling points for the five corridors studied in Phase 2. The HOT and HOV scenarios include facilities along all five corridors, while the express toll lanes (ETL) system would only exist along I-77 and US-74.

Table 4-15: *Fast Lanes* Corridors, Lane-Miles and Tolling Locations

	HOV/ HOT Scenarios		**ETL Scenario**	
Corridors	**Lane Miles**	**Tolling Points**	**Lane Miles**	**Tolling Points**
I-485	64	20		
I-77	90	30	180	30
I-85	117	38		
NC-16 North	20	6		
US-74 East	24	8	48	8
Total System	**315**	**102**	**228**	**38**

To estimate O&M costs for HOV and HOT facilities, each corridor was assumed to contain one managed lane in each direction of traffic flow. The roadway layout for HOT and HOV lanes was assumed to include a narrow buffer-separated concurrent-flow design, meaning the dedicated managed lane in each direction will be separated from general purpose lanes by pavement markings. The ETL system would use a barrier system in order to separate two lanes of tolled traffic from the general purpose lanes.

Tolling points for the HOT and ETL scenarios were assumed to be placed at an average of three-mile intervals, not accounting for unique demand, operation and design factors at this level of study. Additional toll readers or optional readers could be installed along roadway segments where ingress/egress violations could occur, but these relatively minor costs have not been included in this set of assumptions. In fact, no other project implemented to date employs this technology.

Construction of tolling gantries and complementary ITS improvements, together with implementation of public informational campaigns, will be performed in conjunction with the actual construction of HOT or ETL facilities and would be expected to be completed prior to the assumed opening date of 2013. Annual O&M costs for the *Fast Lanes* system have been projected for a period of 30 years.

To account for expected inflation, an annual escalation rate of 5 percent was used for both general and construction inflation[1]. Unless otherwise noted, all figures presented in this report were escalated to 2008 dollar terms. Contingencies to account for price fluctuations and unforeseen costs have been incorporated in the roadway estimates (30 percent) and tolling infrastructure costs (20 percent).

The following sections provide more detailed information on cost estimation by O&M category.

4.5.2 Estimated Roadway O&M Costs

Roadway O&M cost estimates were based on a current NCDOT contract with a private company to provide maintenance services on 131 directional miles of interstate roadway in Mecklenburg, Gaston and Cleveland counties. The contract covers highway surface upkeep, but excludes major renovation and rehabilitation costs, sign repair, snow removal, fence repair, and other related expenses. This contract amounts to a per lane-mile cost of about $8,000 per year. Additional costs for signage and other miscellaneous costs were assumed to amount to approximately $500 per lane-mile per year for the *Fast Lanes* portion of the roadway.

4.5.3 Fixed Tolling O&M Cost Estimates

Toll System Maintenance

Maintenance costs for the tolling system are expected to be about 15 percent of capital expenditures (computer system plus tolling infrastructure less utility buildings), and include software updates, replacement parts, and non-staff support. This cost was allocated to each corridor based on the number of tolling points. The toll system's O&M costs are not

[1] Average Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W) in the South region over the last 12 months from the US Bureau of Labor Statistics. Actual average over 12 months of 4.8% was rounded to 5%. This CPI series was used to be consistent with NCDOT maintenance department practice.

relevant for the HOV scenario. ITS system maintenance is anticipated to be about 5 percent of capital expenditures, or $30,000 per directional mile per year.

Enforcement and Courtesy Patrols

Additional deployment of highway patrol officers would be required on each corridor to improve the level of service and to enforce toll collection. Current North Carolina State Highway Patrol (NCSHP) presence was assumed to be maintained in the corridors for enforcement assistance, but additional NCSHP patrols will be needed as follows:

- An additional six patrols for the HOT lanes network
- An additional three patrols for the HOV and ETL systems

Fewer patrols would be needed for the HOV and ETL systems because there would be no tolling under HOV operations and reduced access and no occupancy enforcement for ETL corridors. It was assumed that NCSHP will perform these services at a cost of approximately $225,000 per year per patrol. This is the estimated cost of the equipment and vehicle, full-time labor represented by a single officer, and dispatch support services.

In addition to expanded enforcement, additional courtesy patrols, or NCDOT IMAP vehicles, should be budgeted for the toll scenarios. These courtesy patrols will ensure that any incidents or accidents on tolled lanes are promptly addressed so that traffic continues to flow smoothly. An additional six courtesy patrols were assumed for HOV and HOT lanes. An additional two additional patrols are assumed for the ETL system. Courtesy patrols were assumed to cost $100,000 per year, which includes the cost of the vehicle, labor, and dispatch.

For the HOT lane scenario, these enhancements to law enforcement and courtesy patrols were assumed to provide two additional patrols to each corridor (four additional patrols in the I-85 corridor due to its length), representing about 26 miles per new patrol. The HOV system would require the same number of courtesy patrols as the HOT lane network, but only three more patrols, resulting in about 35 miles per new patrol. The ETL system would include two additional enforcement patrols and one courtesy patrol in the I-77 corridor and one patrol of each type in the US-74 corridor. These increases in service would provide an additional coverage of 23 miles per new patrol for the ETL system.

Tolling Back Office Operations

A tolling back office will be required to handle transactions, provide customer service, provide facilities for courtesy patrols, and monitor the tolled system. Although some of these costs could be shared with the NCTA, this study assumes an independent operation.

Annual lease costs were assumed for a 15,000 square foot space at approximately $25 per square foot for the HOT lane scenario, and a 7,500 square foot space at the same price per square foot for the ETL scenario. The ETL system would require about half as many employees as the HOT lanes system. Although tolling operations often outsource some or all of back office functions, which affects staffing needs, it was assumed for this study that operations, billing, collection, and customer services would be performed in-house.

4.5.4 Variable Tolling O&M Cost Estimates

Toll Transactions

The cost to process a normal transponder transaction is estimated to be about $0.25 based on experience with existing projects. This cost is based on a single trip along the tolled system. The number of transactions is expected to escalate at an average rate of about 3 percent per year across all corridors.

Toll Violations

While the majority of costs associated with unauthorized use of the toll lanes are expected to be collected in fines, some leakage is expected. For non-transponder transactions (considered as violations), an additional processing cost of $1.00 was assumed. Violators are expected to account for 5 percent of all transactions.

Credit Card Fees

About 85 percent of transponder accounts were assumed to be funded with credit card transactions. Credit card operating costs are expressed as 2 percent of the portion of total revenue associated with credit cards.

4.5.5 Major Rehabilitation and Renovation Cost Estimates

Roadway

Major pavement rehabilitation of the toll lanes is a cost anticipated to be covered by toll revenues. There are two types of pavement re-construction expected to occur over the life of each facility:

- General surface rehabilitation or large-scale pavement upgrade
- Mill and overlay which includes grinding the surface of the pavement down and re-surfacing

A mill and overlay is assumed to be needed every 20 years beginning in 2033. The estimated cost for this activity is $125,000 per lane mile in 2008 dollars. A surface rehabilitation will be needed once between mill and overlay projects, and a rehabilitation cost of $50,000 per lane mile in 2008 dollars was assumed. These figures include a contingency of 30 percent as assumed for construction costs.

Tolling System

The computer system and open road tolling lane equipment would need replacement every ten years. Computer system costs were allocated to each corridor based on lane miles. Replacement of the computer hardware and software for the entire managed lane network is estimated to cost $3.5 million. The open road tolling equipment replacement was assumed to cost $250,000 per reader for the HOT scenario and $500,000 for the ETL scenario. Cost estimates reflect addition of a contingency of 20 percent.

Tolling infrastructure components not requiring major rehabilitation and renovation are the ITS system and utility buildings. These would have ongoing maintenance expenses that would eliminate the need for periodic rehabilitation.

4.5.6 O&M Cost Estimates

Table 4-16 summarizes the estimated O&M costs (in 2008 dollars) for the three types of *Fast Lanes* strategies as discussed in preceding sections. In order to fund major rehabilitation and renovation in the years required, payments would be made annually to a renovation and rehabilitation fund. These payments would vary by roadway and increase with expected inflation. No interest earnings were assumed on these fund payments. This table and **Table 4-17** also include estimates of O&M costs for 2013 in order to make comparisons with revenue projections for that year.

Table 4-16: Operation and Maintenance Costs

Cost Categories	Annual Cost (2008 Dollars)		
	HOV	HOT	ETL
Roadway Maintenance			
Pavement Maintenance (per lane-mile)	$8,000	$8,000	$8,000
Sign Maintenance (per lane-mile)	$500	$500	$500
Contingency (per lane-mile)	$2,600	$2,600	$2,600
Lane Miles	315 miles	315 miles	228 miles
Annual Roadway O&M Cost	**$3,496,500**	**$3,496,500**	**$2,530,800**
Toll Operation and Maintenance			
General & Administrative (1)	$0	$909,700	$454,800
Toll System Maintenance	$0	$5,112,000	$3,942,000
ITS System Maintenance	$0	$9,438,600	$3,427,200
Enforcement (2)	$675,000	$1,350,000	$675,000
Courtesy Patrol (3)	$600,000	$600,000	$200,000
Staffing (4)	$0	$2,759,400	$1,512,000
Annual Toll O&M Cost	**$1,275,000**	**$20,169,700**	**$10,211,000**
Fixed Roadway and Toll O&M Cost	**$4,771,500**	**$23,666,200**	**$12,741,800**
Cost Categories	**Annual Cost (2013 Dollars)**		
	HOV	**HOT**	**ETL**
Total O&M Costs (in 2013)			
Roadway O&M Costs	$4,462,500	$4,462,500	$3,230,000
Toll O&M Costs	$1,627,200	$25,742,200	$13,032,100
Variable Tolling O&M Costs	$0	$17,434,800	$7,518,900
Payments to Cover Major R&R Costs	$12,907,000	$19,994,000	$14,837,000
O&M Cost for 2013	**$18,996,700**	**$67,633,500**	**$38,618,000**

(1) G&A includes banking, legal, marketing, office related lease and utilities, consulting, and others.
(2) Enforcement includes supplements to existing State Highway Patrol enforcement
(3) Courtesy patrol includes services similar to NCDOT's current motorist assistance level of service
(4) Staffing includes toll- related operations & service managers, technical and personnel staff

Table 4-17: O&M Costs Estimated for 2013 by Corridor and Segment

Corridors / Segments	Length (Miles)	Annual O&M Costs for 2013		
		HOV	HOT	ETL
I-77 Corridor North of Center City Charlotte				
Iredell County	12	$1,337,400	$5,163,500	$7,763,900
Iredell/ Meck CL to existing HOV	12	$1,337,400	$5,163,500	$7,763,900
Existing HOV	9	$1,003,000	$3,872,700	$5,822,900
Brookshire to John Belk*	2	$223,000	$860,500	$1,293,900
Total		**$3,900,800**	**$15,060,200**	**$22,644,600**
I-77 Corridor South of Center City Charlotte				
John Belk to I-485 south	9	$1,003,000	$3,872,700	$5,822,900
I-485 south to York County	3	$334,400	$1,291,000	$1,941,000
Total		**$1,337,400**	**$5,163,700**	**$7,763,900**
I-85 Corridor West of Center City Charlotte				
Exit 10 in Gaston County to I-485 west	20	$2,413,800	$8,779,000	
I-485 west to I-77	8	$965,500	$3,511,600	
Total		**$3,379,300**	**$12,290,600**	
I-85 Corridor East of Center City Charlotte				
I-77 to I-485 east	10	$1,206,900	$4,389,500	
I-485 east to Cabarrus/ Rowan CL	15	$1,810,300	$6,584,300	
Rowan County	5	$603,400	$1,994,800	
Total		**$3,620,600**	**$13,168,600**	
NC-16 North Corridor: Brookshire Blvd	10	$1,357,500	$4,129,000	
Total		**$1,357,500**	**$4,129,000**	
US-74 East Corridor: Independence Blvd	12	$1,605,200	$5,558,200	$8,209,500
Total		**$1,605,200**	**$5,558,200**	**$8,209,500**
I-485 Corridors				
New section between I-77 north and I-85 north	6	$734,700	$2,373,500	
Between I-77 south and US-74 east	15	$1,836,700	$5,933,800	
Between I-85 south and I-77 south	10	$1,224,500	$3,955,900	
Total		**$3,795,900**	**$12,263,200**	
System Total (in 2013)	**158**	**$18,996,700**	**$67,633,500**	**$38,618,000**

4.6 Comparison of Estimated Revenues and Costs

Annual estimated operating revenues as presented in Section 4.1 were compared to the annual O&M costs outlined in Section 4.5 to determine the financial feasibility of implementing HOT lanes in the Charlotte region. **Table 4-18** and **Table 4-19** compare the revenues and O&M costs projected for 2013 by corridor and individual segment for both pricing strategies based on two carpool policies (everyone pays versus HOV 2+ vehicles use the HOT lane for free). Both tables also include the estimated capital costs, inflated to the year 2013, for implementing *Fast Lanes* along each of the Phase 2 corridors.

Table 4-18: 2013 Revenue and Cost Comparisons (Revenue Maximizing Objective)

Corridors		Costs and Revenues (2013 Dollars in Millions)											
Segments		Ann. Revenue for HOV 2+ (1)		Ann. Revenue for Unrestricted Use (1)		O&M Cost (2)	Ratio of MIN Rev / O&M Cost		Ratio of MAX Rev / O&M Cost		Capital Cost (3)	
I-77 Corridor North of Center City Charlotte	Length	MIN	MAX	MIN	MAX		HOV 2+	Unrestricted	HOV 2+	Unrestricted	Design Excep	NCDOT STD
Iredell County	12	0.1	0.4	0.1	0.5	5.1	0.02	0.02	0.08	0.10	38.3	192.2
Iredell/ Meck CL to existing HOV	12	1.5	11.4	4.4	22.9	5.1	0.29	0.86	2.23	4.49	138.5	266.8
Existing HOV	9	0.3	1.6	0.4	2.0	3.9	0.08	0.41	0.29	0.51	112.4	252.8
Brookshire to John Belk	2	0.4	7.4	3.3	17.3	0.9	0.44	3.67	8.22	19.22	751.7	810.5
Corridor Total	35	2.2	20.8	8.3	42.7	15.0	0.15	0.55	1.39	2.85	1,040.9	1,522.3
I-77 Corridor South of Center City Charlotte												
John Belk to I-485 south	9	0.1	1.7	0.4	2.7	3.9	0.02	0.10	0.44	0.69	423.2	688.9
I-485 south to York County	3	0.4	2.0	0.4	2.1	1.3	0.31	0.31	1.54	1.62	61.1	126.2
Corridor Total	12	0.5	3.7	0.8	4.8	5.2	0.10	0.15	0.71	0.92	484.3	815.1
I-85 Corridor West of Center City Charlotte												
Exit 10 in Gaston County to I-485 west	20	1.8	11.4	6.5	25.5	8.8	0.20	0.74	1.30	2.90	460.3	892.2
I-485 west to I-77	8	0.3	1.5	0.5	2.0	3.5	0.09	0.14	0.43	0.57	278.2	826.0
Corridor Total	28	2.1	12.9	7.0	27.5	12.3	0.17	0.57	1.05	2.24	738.5	1,718.2
I-85 Corridor East of Center City Charlotte												
I-77 to I-485 east	10	0.2	1.3	0.4	2.0	4.5	0.04	0.09	0.29	0.44	160.1	507.4
I-485 east to Cabarrus/ Rowan CL	15	0.2	1.1	0.3	1.6	6.6	0.03	0.17	0.12	0.24	316.6	577.0
Rowan County	5	-	-	-	-	2.0	-	-	0.01	0.01	80.1	148.5
Corridor Total	30	0.4	2.5	0.8	3.6	13.1	0.03	0.06	0.19	0.27	556.8	1,232.9
NC-16 North Corridor: Brookshire Freeway	10	0.2	1.7	0.5	2.0	4.1	0.05	0.12	0.41	0.49	173.0	218.7
US-74 East Corridor: Independence Blvd	12	0.6	9.0	2.9	18.9	5.6	0.11	0.52	1.61	3.38	226.1	680.6
I-485 Corridor												
New I-485 section between I-77N and I-85N	6	-	-	-	-	2.4	-	-	-	-	176.8	315.8
I-485 south between I-77 and US-74 east	15	0.6	3.9	3.0	14.0	5.9	0.10	0.51	0.66	2.37	401.6	728.2
I-485 west from I-85 south to I-77 south	10	-	0.1	-	0.1	3.9	-	-	0.03	0.03	231.5	375.3
Corridor Total	31	0.6	4.1	3.0	14.1	12.2	0.05	0.25	0.33	1.16	809.9	1,418.9
System Total	158	6.7	54.5	23.4	113.7	67.6	0.10	0.35	0.81	1.68	4,029.5	7,606.7

(1) Annual Revenue is based on HOV2+ and unrestricted use network runs of regional model and two carpool policies.
***HOV 2+** means single-occupant vehicles (SOV) pay toll to use the managed lanes.*
***Unrestricted Use** means ALL vehicles must pay to use the managed lanes.*
(2) O&M is annualized cost for the year 2013.
(3) Capital Cost includes ROW cost and also the cost of direct connectors allocated to each segment based on lengths of impacted segments.

Table 4-19: 2013 Revenue and Cost Comparisons (Travel Time Cost Minimization Objective)

Corridors		Costs and Revenues (2013 Dollars in Millions)										
Segments		Ann. Revenue for HOV 2+ (1)		Ann. Revenue for Unrestricted Use (1)		O&M Cost (2)	Ratio of MIN Rev / O&M Cost		Ratio of MAX Rev / O&M Cost		Capital Cost (3)	
I-77 Corridor North of Center City Charlotte	Length	MIN	MAX	MIN	MAX		HOV 2+	Unrestricted	HOV 2+	Unrestricted	Design Excep	NCDOT STD
Iredell County	12	0.1	0.1	0.1	0.1	5.1	0.02	0.02	0.02	0.02	38.3	192.2
Iredell/ Meck CL to existing HOV	12	1.4	4.5	4.2	10.7	5.1	0.27	0.88	0.82	2.08	138.5	266.8
Existing HOV	9	0.2	0.5	0.3	0.7	3.9	0.05	0.13	0.08	0.18	112.4	252.8
Brookshire to John Belk	2	0.3	2.8	3.1	7.6	0.9	0.33	3.11	3.44	8.44	751.7	810.5
Corridor Total	35	2.0	7.9	7.7	19.1	15.0	0.13	0.53	0.51	1.27	1,040.9	1,522.3
I-77 Corridor South of Center City Charlotte												
John Belk to I-485 south	9	0.1	1.0	0.4	1.6	3.9	0.02	0.26	0.10	0.41	423.2	688.9
I-485 south to York County	3	0.4	0.8	0.4	0.9	1.3	0.30	0.62	0.30	0.69	61.1	126.2
Corridor Total	12	0.5	1.8	0.8	2.5	5.2	0.10	0.35	0.15	0.48	484.3	815.1
I-85 Corridor West of Center City Charlotte												
Exit 10 in Gaston County to I-485 west	20	1.5	4.0	5.5	10.8	8.8	0.17	0.45	0.63	1.23	460.3	892.2
I-485 west to I-77	8	0.2	0.7	0.4	1.1	3.5	0.06	0.20	0.11	0.31	278.2	826.0
Corridor Total	28	1.7	4.7	5.9	11.9	12.3	0.14	0.36	0.48	0.97	738.5	1,718.2
I-85 Corridor East of Center City Charlotte												
I-77 to I-485 east	10	0.2	0.6	0.4	1.0	4.5	0.04	0.13	0.09	0.22	160.1	507.4
I-485 east to Cabarrus/ Rowan CL	15	0.1	0.4	0.3	0.7	6.6	0.02	0.06	0.05	0.11	316.6	577.0
Rowan County	5	-	-	-	-	2.0	-	-	-	-	80.1	148.5
Corridor Total	30	0.3	1.0	0.7	1.7	13.1	0.02	0.08	0.05	0.13	556.8	1,232.9
NC-16 North Corridor: Brookshire Freeway	10	0.2	1.0	0.5	1.2	4.1	0.05	0.24	0.12	0.29	173.0	218.7
US-74 East Corridor: Independence Blvd	12	0.5	3.6	2.3	7.1	5.6	0.09	0.64	0.41	1.27	226.1	680.6
I-485 Corridor												
New I-485 section between I-77N and I-85N	6	-	-	-	-	2.4	-	-	-	-	176.8	315.8
I-485 south between I-77 and US-74 east	15	0.3	0.6	1.8	3.0	5.9	0.05	0.10	0.31	0.51	401.6	728.2
I-485 west from I-85 south to I-77 south	10	-	-	-	-	3.9	-	-	0.03	0.03	231.5	375.3
Corridor Total	31	0.3	0.6	1.8	3.0	12.2	0.02	0.05	0.15	0.25	809.9	1,418.9
System Total	158	5.5	20.6	19.6	46.5	67.6	0.08	0.31	0.29	0.69	4,029.5	7,606.7

(1) Annual Revenue is based on HOV2+ and unrestricted use network runs of regional model and two carpool policies.
***HOV 2+** means single-occupant vehicles (SOV) pay toll to use the managed lanes.*
***Unrestricted Use** means ALL vehicles must pay to use the managed lanes.*
(2) O&M is annualized cost for the year 2013.
(3) Capital Cost includes ROW cost and also the cost of direct connectors allocated to each segment based on lengths of impacted segments.

The following conclusions can be drawn based on the revenue and cost projections presented in those tables:

- Depending on the revenue maximization pricing objective for HOT lanes, the US-74 east, I-77 north, and I-85 south corridors show the greatest opportunity for forecasted revenues to exceed projected O&M costs, even as early as 2013. The results from **Table 4-18** indicate the high potential of revenues covering the O&M costs for HOT lanes implemented along these corridors. The upper estimate of projected revenues for the travel time cost minimization objective also would cover O&M costs in 2013 for the US-74 east and I-77 north corridors.

- Individual segments along the remaining corridors show promise with regard to revenue/O&M cost coverage. Estimated revenues generated in 2013 along the southern segment of I-485, between I-77 and US-74, would be over twice as high as the forecasted O&M costs, using the most revenue-intensive pricing objective. Projected revenues for HOT lanes for the I-77 section from I-485 into York County would be roughly 50 percent higher than estimated O&M costs in 2013.

5.0 NEXT STEPS

This chapter identifies the next steps in the planning and design of managed lanes in the Charlotte region. The Charlotte Region *Fast Lanes* Study represents the first stage in a series of technical, institutional and financial analyses that will successively lead to implementation of the regional managed lanes network.

This chapter identifies key policy decisions, institutional relationships, and operational strategies associated with beginning a managed lanes program in the Charlotte region. First, study findings should be considered in updates to the Long Range Transportation Plans (LRTPs) for the metropolitan planning organizations in the Charlotte region. Additional data and studies will be needed on a corridor-by-corridor basis to identify the physical attributes and operational characteristics of each *Fast Lanes* corridor. Phasing of improvements will be important in achieving the highest potential for early success and in minimizing impacts and risk associated with *Fast Lanes* implementation. Phasing of improvements also will consider the programming of other projects in the study corridors to the extent possible.

5.1 Formal Interagency Partnering

A formal interagency process and mechanism should be established to ensure coordination in both states (North Carolina and South Carolina) and among regional partners for planning, data collection, design, demand modeling and funding of *Fast Lanes*. The formal group (which may involve continuation of the Regional Technical Team and preparation of a memorandum of agreement) could focus on issues such as determining the pricing/vehicle eligibility requirements for managed lanes, collecting data on travel behavior characteristics and *Fast Lanes* use, and identifying financing strategies to cover the O&M costs of managed lanes.

5.2 Incorporate Study Findings in LRTP Updates

The four Metropolitan Planning Organizations in the Charlotte region should reflect the results of the Phase 2 corridor evaluations, as discussed in a later section of this chapter, in their LRTP updates.

5.3 Corridor-Level Engineering and Usage Studies

The advancement of *Fast Lanes* in the Charlotte region will require more detailed operations analysis and refined engineering design of potential managed lanes at the individual corridor level. Work elements that could be undertaken in these corridor studies include, but likely are not limited to:

5.3.1 Revised demand projections

The focus of this work will be to revise the demand estimates for managed lanes treatments along a corridor based on updated design and phasing assumptions, because the Charlotte Region *Fast Lanes* Study assumed an entire network of managed lanes. The effort will provide for feedback between the corridor-specific tolling model and the Metrolina travel demand model. The task also would include traffic simulation modeling to evaluate potential bottlenecks at facility termini and identify possible mitigation strategies.

5.3.2 Revised revenue estimates and potential tolls

The updated demand forecasts will generate refined estimates of traffic, travel behavior and revenue where HOT lanes are being considered. This task will identify optimal tolls for each proposed HOT lane facility and the corresponding revenues which could be generated from these tolls.

5.3.3 Corridor-level design and operations

This effort would include detailed operations analysis and refined designs based on more detailed planning and engineering. Design considerations would address the feasibility of implementing the "full feature" design alternatives, versus the need to request specific design exceptions from FHWA, NCDOT and SCDOT. This task would include capital cost estimates based on the approved designs. Operational issues would be addressed based on the managed lanes treatment being considered for each corridor, followed by estimating corresponding O&M costs. This task also would involve identification of cost-effective enhancements such as direct access ramps and transit park-and-ride facilities in order to maximize the benefits of the *Fast Lanes* treatment.

To illustrate the type of work to be undertaken in this portion of the study, the following issues or questions would be explored and answered:

- What operational issues would establish project limits?
- Are there special enforcement needs? Are shoulders available for monitoring areas?
- What are the incident management needs?
- For tolling, how many tolling zones and installations are envisioned for each direction?
- What will be the preferred delivery and maintenance approach for tolling systems?
- What electronic toll collection protocols are being planned by NCTA for other toll roads in North Carolina and the Charlotte region?
- What conceptual signing or pavement markings are needed for either HOV or HOT lanes?
- Are there needs for traffic detection in the pavement? Will cameras be employed? What other Intelligent Transportation Systems (ITS) should be considered?

5.3.4 Financial feasibility and phasing

For possible HOT lanes or ETL facilities, this effort will involve a comparison of forecasted toll revenues and costs attributable to a priced facility over its life cycle. A comprehensive cash flow analysis will match revenue/funding sources and financing with capital and O&M costs to identify potential funding gaps and possible phasing of improvements. For HOV facilities, this task will involve identification of funding sources for project implementation, including the need for phasing. The timing of other programmed improvements in the corridor and their impacts on the proposed project would be considered as part of this work element. Other factors such as the planned implementation of supportive transit services or corridor maintenance/improvement projects should also be considered in phasing decisions.

5.3.5 Phase 2 corridor evaluation

The following factors were used to evaluate the Phase 2 corridors for the next phase of possible implementation of managed lanes:

- **Demand**. The projected number of persons and vehicles using a *Fast Lane* during peak periods, particularly when compared to forecasted trips in the adjacent general-purpose lanes.

- **Travel time savings**. The estimated time saved during peak periods by *Fast Lanes* users compared to motorists traveling in the general-purpose lanes. The number of minutes saved per mile of managed lane facility was used to evaluate each corridor and corridor segment.

- **Comparison of estimated revenues to forecasted O&M costs**. The extent to which projected revenues for a corridor or corridor segment would cover estimated O&M expenses. This annual revenue-to-cost comparison provides a general indication of the financial feasibility of implementing HOT lanes in a corridor.

- **Other projects or studies impacting the timing of *Fast Lanes* implementation**. These would include positive or negative impacts on implementation of managed lanes associated with other corridor projects which have been completed or are already programmed.

Figure 5-1 shows corridor limits, while **Table 5-1** summarizes the evaluation of the Phase 2 corridors using the aforementioned factors.

Figure 5-1: Phase 2 Corridors

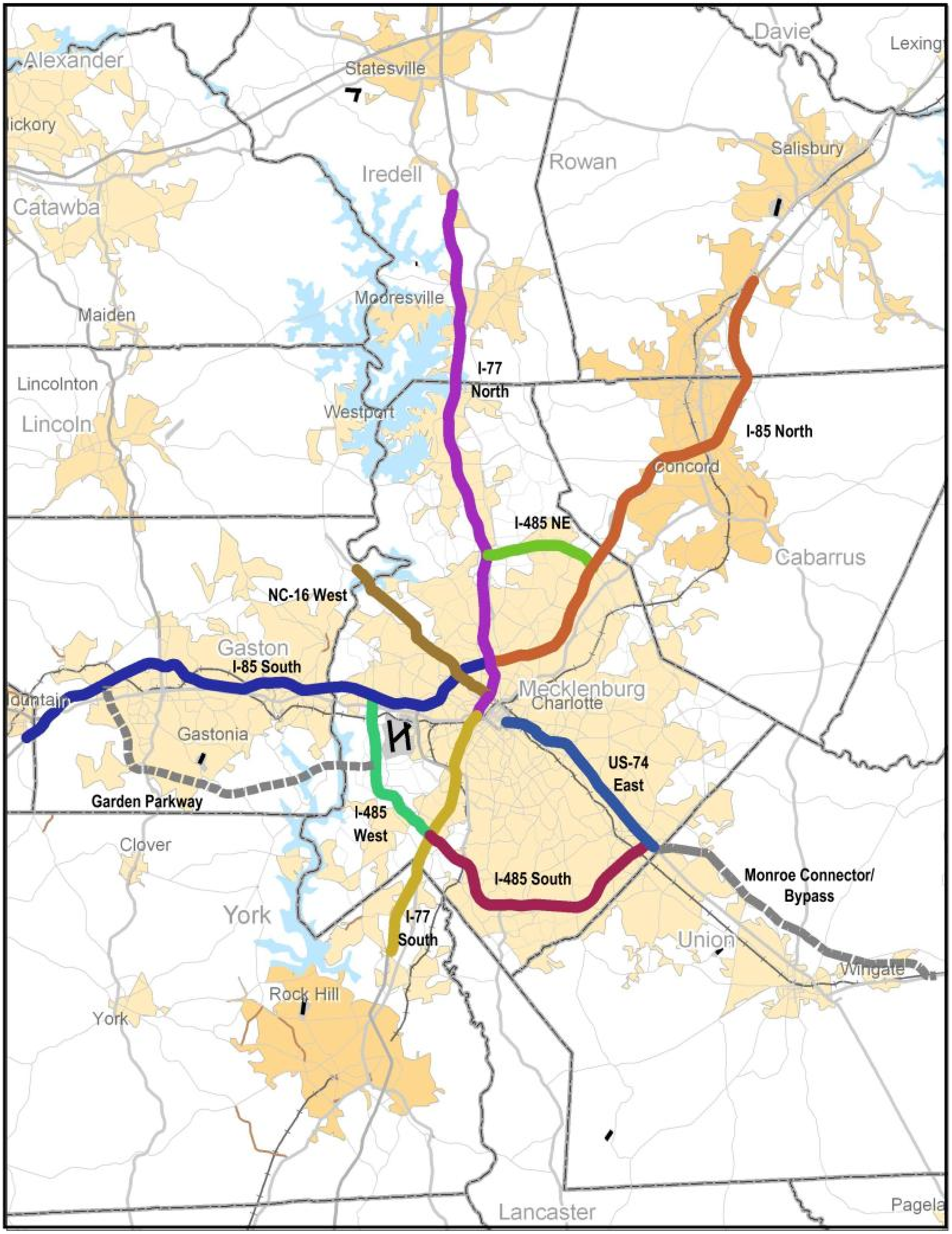


Table 5-1: Corridor Evaluation

Corridor	Demand for *Fast Lanes*		Peak Hour Travel Time Savings from Use of *Fast Lanes*		Estimated Percentage of Annual Revenues Compared to O&M Costs		Other Projects/Studies Impacting Phasing
	2013	**2030**	**2013**	**2030**	**2013**	**2030**	
I-77 North	700 – 900 vph[1] *(1,800-2,200 pph [2])*	1,000-1,200 vph *(2,500-2,900 pph)*	10 minutes saved between Davidson & Center City Charlotte (0.5 minutes/mile)	17 minutes saved between Davidson and Center City Charlotte (0.9 minutes/mile)	For existing HOV lane plus its extension to Iredell County Line ***Rev. Max.*** [3] 150-300% ***Travel Time Cost Min.*** [4] 60-120%	***Rev. Max.*** [3] 200-400% ***Travel Time Cost Min.*** [4] 60%-200%	• HOV lane in operation since 2004 (current demand of 300 vehicles or 1000 persons/peak hour) • NCDOT began HOV-to-HOT conversion feasibility study in February 2009 • NCDOT is also conducting a physical feasibility study for HOV lane extension between I-85/I-77 interchange and 5th Street • NCDOT is preparing environmental documents and preliminary design for widening lanes and shoulders between I-277 (Brookshire Freeway) and I-85/I-77 interchange • NCDOT will be conducting planning, engineering and environmental analysis for widening I-77 between NC-73 in Huntersville and I-40 in Statesville.
US-74 East	900-1,100 vph *(2,100-2,600 pph)*	1,100-1,300 vph *(2,800-3,300 pph)*	5 minutes saved between Matthews & Center City Charlotte (0.7 minutes/mile)	8 minutes saved between Matthews and Center City Charlotte (0.9 minutes/mile)	***Rev. Max.*** 160-340% ***Travel Time Cost Min.*** 40-125%	***Rev. Max.*** 250-280% ***Travel Time Cost Min.*** 70-200%	• Rapid transit technology (BRT or LRT) east to I-485 is undecided; CATS has placed corridor transit planning/design on hold. • NCDOT is designing the next US-74 project between Sharon Amity Road and Conference Drive. • The City of Charlotte modified requirements for transitional setback to include general purpose lanes, rapid transit service and managed lanes. • NCTA is completing environmental documents for the Monroe Connector/Bypass; the 21-mile toll road is estimated to open to traffic in 2013.
I-85 North	700-900 vph *(1,500-2,200 pph)*	1,200-1,300 vph *(2,900-3,100 pph)*	5 minutes saved between UNCC & Center City Charlotte (0.6 minutes/mile)	7 minutes saved between UNCC and Center City Charlotte (0.7 minutes/mile)	North to I-485 ***Rev. Max.*** 30-50% ***Travel Time Cost Min.*** 10-20%	***Rev. Max.*** 50 – 80% ***Travel Time Cost Min.*** 15-45%	NCDOT is designing widening between Bruton Smith Blvd (Exit 49) and NC-73 (Exit 55); construction scheduled to begin in 2011

(1) vph = vehicles per hour

(2) pph = person per hour

(3) Rev. Max. = Revenue Maximization

(4) Travel Time Cost Min. = Travel Time Cost minimization

Table 5-1 (continued): Corridor Evaluation

Corridor	Demand for *Fast Lanes*		Peak Hour Travel Time Savings from Use of *Fast Lanes*		Estimated Percentage of Annual Revenues Compared to O&M Costs		Other Projects/Studies Impacting Phasing
	2013	**2030**	**2013**	**2030**	**2013**	**2030**	
I-85 South	600-800 vph *(1,500-2,000 pph)*	1,100 vph *(2,700 pph)*	9 minutes saved between Gastonia & Center City Charlotte (0.4 minutes/mile)	19 minutes saved between Gastonia and Center City Charlotte (0.8 minutes/mile)	***Rev. Max.*** 100-225% ***Travel Time Cost Min.*** 50-100%	***Rev. Max.*** 235-480% ***Travel Time Cost Min.*** 100-220%	
I-77 South	800-1,000 vph *(2,000-2,300 pph)*	1,200-1,300 vph *(3,000-3,300 pph)*	4 minutes saved between Rock Hill & Center City Charlotte (0.2 minutes/mile)	7 minutes saved between Rock Hill and Center City Charlotte (0.3 minutes/mile)	***Rev. Max.*** 70-90% ***Travel Time Cost Min.*** 15-50%	***Rev. Max.*** 185-270% ***Travel Time Cost Min.*** 30-170%	• NCDOT conducting a physical/operational feasibility study for HOV lanes and widening between Fifth Street in Center City Charlotte and South Carolina state line. • SCDOT interested in *Fast Lanes* in York County
I-485 South	500-700 vph *(1,200-1,700 pph)*	600-800 vph *(1,600-2,100 pph)*	6 minutes saved between I-77 near Pineville and US-74 near Matthews (0.3 minutes/mile)	6 minutes saved between I-77 near Pineville and US-74 near Matthews (0.3 minutes/mile)	***Rev. Max.*** 70-250% ***Travel Time Cost Min.*** 30-50%	***Rev. Max.*** 25-110% ***Travel Time Cost Min.*** 20-40%	• NCDOT considering peak-period shoulder use east of I-77 (potential for *Fast Lane*). • NCDOT designing I-485 widening to six lanes between I-77 and US-521.
NC-16 North	400 vph *(900-1,000 pph)*	600 vph *(1,400 pph)*	5 minutes saved between Mountain Island & Center City Charlotte (0.5 minutes/mile)	8 minutes saved between Mountain Island and Center City Charlotte (0.8 minutes / mile)	***Rev. Max.*** 40-50% ***Travel Time Cost Min.*** 10-30%	***Rev. Max.*** 40-50% ***Travel Time Cost Min.*** 10-40%	
I-485 West	100 vph *(300 pph)*	100-300 vph *(400-80 pph)*	1 minutes saved between I-85 southI-77 south	3 minutes saved between I-85 south and I-77 south (0.1 minute/mile)	***Rev. Max.*** ***& Travel Time Cost Min.*** 3%	***Rev. Max.*** ***& Travel Time Cost Min.*** 4-8%	
I-485 Northeast	100-200 vph *(300-500 pph)*	300 vph *(800 pph)*	Not applicable	< 1 minute saved between I-85 north & I-77 north	Not applicable	***Rev. Max.*** 1-7% ***Travel Time Cost Min.*** 2%	• NCDOT designing this un-built segment between I-77 north and I-85 north

(5) vph = vehicles per hour
(6) pph = person per hour
(7) Rev. Max. = Revenue Maximization
(8) Travel Time Cost Min. = Travel Time Cost minimization

Based on the information in **Table 5-1**, the following conclusions would apply to each corridor:

I-77 North

The demand for *Fast Lanes* in the I-77 corridor ranks near the top for the Phase 2 corridors and the forecasted travel time savings for managed lanes users in 2030 would exceed the industry rule-of-thumb of a half-minute per mile savings. Projected revenues for HOT lane operations along the corridor would also be greater than forecasted O&M expenses in 2030 for both pricing strategies.

The only managed lanes facility in the state exists in this corridor. NCDOT has four feasibility, planning or environmental studies underway along the corridor. Work began in February 2009 on a feasibility study to assess the benefits and costs of extending the existing HOV lane from its current terminus near I-485 (south of Exit 23) to Griffith Street in Davidson (Exit 30). A complementary study will assess the potential for converting either the existing HOV lanes or the lengthened HOV facility to HOT lanes, with both studies scheduled to be completed in spring 2010. NCDOT's engineering and operations studies will begin to address many of the issues associated with expanded HOV implementation and the technical, institutional and financial feasibility of HOT lanes in North Carolina.

US-74 East

This corridor shows great demand for managed lanes with noticeable travel time savings even in the short-term. Based on the revenue maximization pricing strategy, forecasted revenues if a HOT lane was implemented would be about three times greater than projected O&M costs for both 2013 and 2030. If NCDOT and the City of Charlotte can coordinate planning and design work along the corridor, there would be an opportunity to reflect *Fast Lanes* concepts in upcoming plans and projects. The NCTA is currently completing environmental analysis and conceptual design of the planned Monroe Connector-Bypass, a 21-mile toll facility which will begin at the eastern terminus of the study corridor near I-485 and end near the Town of Marshville in eastern Union County. This toll facility is expected to open to traffic by 2013.

I-85 North

The I-85 North corridor is characterized by significant demand for *Fast Lanes* and shows the potential for travel time savings for managed lanes users which would exceed the industry rule-of-thumb for both 2013 and 2030. There could be the opportunity for implementing *Fast Lanes* quicker and at a lower cost through design exceptions along portions of I-85 in Mecklenburg County. More detailed corridor-level analysis not only would resolve engineering issues associated with managed lanes implementation, but also would evaluate the benefits of improvements such as a direct *Fast Lanes* connector between I-85 and I-77. NCDOT should consider future *Fast Lanes* implementation in projects to widen I-85 to eight lanes between Bruton Smith Boulevard (Exit 49) and NC-152 (Exit 68) in Rowan County.

I-85 South

This corridor also ranks among the highest corridors in *Fast Lanes* demand, and the estimated travel time savings between Gastonia and Center City Charlotte would be greater than the industry rule-of-thumb. Estimated revenues for 2013 and 2030 compare very favorably to projected O&M costs if HOT lanes were implemented using either pricing objective. The physical attributes of the I-85 corridor in Gaston County, however, would make it costly to add managed lanes to the existing cross-section. There is little opportunity for constructing a *Fast Lanes* facility west of I-485 using design exceptions.

I-77 South

Although this corridor ranks near the top in *Fast Lanes* demand for both 2013 and 2030, travel times savings per mile would be lower than for the I-77 north, US-74 east, and I-85 corridors. This condition is based on the likelihood that the re-construction of this freeway is included in the Mecklenburg-Union LRTP and also assumes building more general purpose lanes. NCDOT will be conducting a feasibility study (FS-0810A) to consider options for improving the corridor between Fifth Street in Center City Charlotte and the South Carolina state line, and this study should consider managed lanes alternatives. SCDOT's interest in implementing managed lanes along I-77 in York County south of I-485 presents an opportunity to explore design issues associated with extending the HOV or HOT facility as far north of I-485 into Mecklenburg County as feasible. More detailed analysis of this portion of I-77 could also explore how new capacity planned along I-485 could connect to the potential I-77 South *Fast Lanes*.

I-485 South

This corridor is just below the top five corridors in *Fast Lanes* demand in 2013 and 2030. As discussed in the previous section, NCDOT is considering short-term alternatives for increasing capacity along I-485 east of the interchange with I-77 until a programmed widening of the interstate to six lanes between I-77 and US-521 (Johnston Road). Based on the revenue maximization pricing objective, I-485 would have a positive revenue-to-operating cost ratio in 2013 and 2030.

NC-16 North

Although this corridor ranks below the previously-mentioned corridors in managed lanes demand, it compares very favorably to other corridors in travel time savings per mile for *Fast Lanes* users in both 2013 and 2030. The projected revenues for HOT lanes operation, however, would fall well below estimated O&M costs for both planning years. Nevertheless, there could be need for managed lanes beyond the 2030 planning horizon. The potential for managed lanes should be considered as improvements are studied in the future.

I-485 West and Northeast

These two I-485 segments demonstrate little demand for or travel time savings with *Fast Lanes* implementation by 2030. However, continued growth could create a demand for managed lanes beyond 2030. Managed lanes provide an opportunity to preserve the capacity of any new lanes being considered for implementation along I-485.

5.4 Policy for Allocating HOT Lane Revenues

A decision-making and consultation structure should be developed for allocating HOT or ETL revenues. The consultation structure would include state, regional, city and county agencies in addition to possible *Fast Lanes* operating entities. The group could establish strategies when 1) annual revenues do not meet operating costs, 2) costs and revenues are equal, and 3) yearly revenues exceed O&M costs.

5.5 Governance Clarification for HOT Lanes Implementation

The question as to whether HOT lanes or tolling can be implemented on federally-funded highways will have to be determined. The authority could change under a re-authorized federal transportation law. NCDOT, SCDOT, the City of Charlotte and other partner agencies should work closely with each state's Congressional delegation to modify language in federal law to allow congestion pricing on Interstate roads. The authority for tolling new and/or existing lanes should be explored through continued discussion among NCDOT, SCDOT, NCTA, the City of Charlotte and other partner agencies.