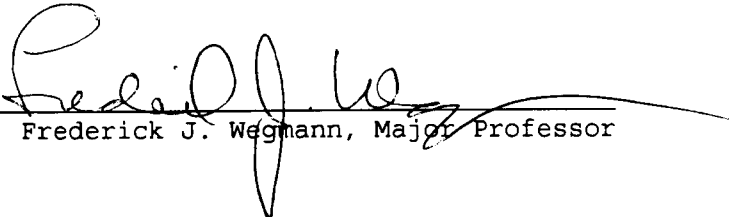
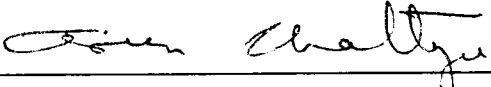
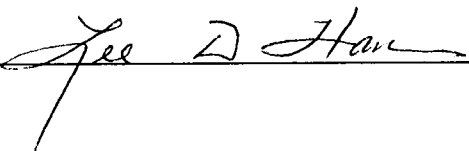


To the Graduate Council:

I am submitting herewith a thesis written by Steve Eric Stoner entitled "Evaluation of the Gatlinburg, Tennessee Trolley Service As It Impacts the Local Transportation System -- A Case Study". I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Civil Engineering.


Dr. Frederick J. Wegmann, Major Professor

We have read this thesis and
recommend its acceptance:

Accepted for the Council:


Associate Vice Chancellor
and Dean of the Graduate School

Evaluation of the Gatlinburg, Tennessee Trolley Service As It Impacts the Local Transportation System

A Case Study

A Thesis
Presented for the
Master of Science Degree
The University of Tennessee, Knoxville

Steve Eric Stoner
December 1994

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Most of all, the moral support and endless encouragement of my parents, Glen and Jannette, and brothers, Allen and Chris, has not been adequately acknowledged in words but is truly appreciated.

Abstract

This research has attempted to identify the transportation issues experienced within the City of Gatlinburg, Tennessee, a major tourist destination adjacent to the Great Smoky Mountains National Park. The limited land area availability and the dense commercial development which has evolved in the downtown area is occupied by tens of thousands of tourists on any given day during the peak tourism seasons. Such high travel demand in a relatively small area has created mobility and parking deficiencies and significant vehicle delay for travelers in the City.

In 1980, the State of Tennessee Department of Transportation implemented a public transportation service known as the Gatlinburg Trolley System to provide an alternative to pedestrians and motorists in order to improve mobility and increase safety. Use of the Trolley has been consistent since the beginning of the service which has allowed the service area to cover all the major routes of travel within the City.

The regional tourism industry continues to grow and the feasible options available to the City to improve mobility in Gatlinburg are decreasing. Based on the financial costs, continued investment in the Trolley service is justified and should not be underestimated as the element which avoids a break down of the local transportation network for millions of travelers through Gatlinburg each year.

Table of Contents

CHAPTER 1: INTRODUCTION.....	1
CHAPTER 2: STUDY AREA DESCRIPTION	4
Regional Characteristics	4
Major Roads Serving the City	6
Tourism Characteristics	9
CHAPTER 3: REVIEW OF RECOMMENDATIONS	13
1971 Comprehensive Plan.....	13
1975 Downtown Circulation Study.....	17
1978 Cherokee Orchard Road Relocation Report	21
1978 Recommended Transportation Alternatives in Gatlinburg, TN	21
1980 Gatlinburg Land Use Plan	28
1981 Community Facilities Plan.....	30
1991 Gatlinburg Land Use Plan	30
1992 Community Facilities Plan.....	32
Summary.....	34
CHAPTER 4: TROLLEY SERVICE	35
Service Review	35
Primary Lines	36
Secondary Lines	37
Historical Ridership.....	39
Transit Resources.....	43
CHAPTER 5: ANALYSIS PROCEDURE.....	51
Definition of Terms	51
Benefit Items	53
Delay at Critical Intersections	53
Daily Traffic Patterns During the Peak Period.....	54
Delay Reduction at the Critical Intersections Due to the Trolley	59
Cost Items	66
Survey of Trip Characteristics.....	67
Results of Trip Observation	69
Roadway Capacity Additions	77
VMT Removed by the Trolley	78
Downtown Parking Inventory	83
Parking Deficiency.....	88
Trolley Operational Expenses.....	89
Trolley Capital Expenses.....	91

CHAPTER 6: RESULTS.....	93
Benefit Items	94
<i>Traffic Congestion Delay Cost</i>	<i>94</i>
Cost Items	100
<i>Cost for Additional Parking</i>	<i>100</i>
<i>Cost for Roadway Reconfiguration and Additional Road Capacity.....</i>	<i>102</i>
<i>Trolley Operational Costs</i>	<i>104</i>
<i>Trolley Capital Costs</i>	<i>105</i>
Benefit-Cost Ratio	107
Analysis 1	114
Scenario A	114
Scenario B	114
Scenario C	117
Summary of Analysis 1	117
Analysis 2	118
Scenario A	121
Scenario B	121
Scenario C	121
Summary of Analysis 2	121
Study Limitations	122
CHAPTER 7: CONCLUSIONS	124
BIBLIOGRAPHY.....	129
APPENDICES.....	132
APPENDIX A.....	133
APPENDIX B.....	135
APPENDIX C.....	138
APPENDIX D.....	148
VITA.....	150

List of Figures

Figure 1. Gatlinburg, Tennessee Regional Area.....	2
Figure 2. Sevier County, Tennessee.....	5
Figure 3. Existing Downtown Gatlinburg Major Road Network.....	8
Figure 4. Seasonal Great Smoky Mountains National Park Visitation	10
Figure 5. Proposed Downtown Gatlinburg One-Way Pair System.....	16
Figure 6. Critical Delay Intersections in Downtown Gatlinburg.....	18
Figure 7. Proposed South Parkway Tunnel and Pedestrian Mall in Downtown Gatlinburg.....	20
Figure 8. Proposed Additional Capacity for North Parkway in Downtown Gatlinburg.....	22
Figure 9. Gatlinburg, TN Full-Time Population Trend.....	33
Figure 10. Trolley Coverage Area in the Downtown Gatlinburg.....	38
Figure 11. Historical Trolley Ridership.....	41
Figure 12. Annual Gatlinburg Tourists and Annual Trolley Ridership.....	42
Figure 13. Average Trolley Ridership per Month from 1980-1993.....	44
Figure 14. Hourly Travel Distribution at the North Parkway-East Parkway Intersection for July 26-27, 1993.....	45
Figure 15. Historical Trolley Fleet Size and Average Annual Trolley Riders per Trolley.....	47
Figure 16. Percentage of Annual Trolley Operation Expenses Recovered by Fares, Advertising, and Charter Revenue.....	48
Figure 17. Average Annual Total Cost per Trolley Ride.....	49
Figure 18. Lane Configuration at the North Parkway-East Parkway & South Parkway-River Rd-Cherokee Orchard Rd Intersections.....	55
Figure 19. Traffic Counts by Direction at the North Parkway-East Parkway Intersection from July 26-27, 1993.....	57
Figure 20. Existing Parkway Intersection Signal Phasing.....	60
Figure 21. Equivalent Existing Parkway Intersection Signal Phasing Used in HCS.....	62
Figure 22. Equivalent Parkway Intersection Signal Phasing Used in HCS without Trolley.....	65
Figure 23. Sample Trolley Rider Survey.....	68
Figure 24. Trolley Travel Group Size Distribution Based on Survey.....	70
Figure 25. Trolley Trip Length Distribution Based on Observation	72
Figure 26. Hypothetical Road Network for Downtown Gatlinburg.....	79
Figure 27. Downtown Gatlinburg Public Parking Supply	87
Figure 28. Average Annual Trolley Revenue, Expenses, and Subsidy	90
Figure 29. Tennessee DOT Annual Financial Contributions to Subsidize Trolley Operating Expenses	106

List of Tables

<i>Table 1. Turning Movement Counts for the North Parkway-East Parkway Intersection</i>	<i>58</i>
<i>Table 2. Vehicles per Hour Removed from the North Parkway-East Parkway Intersection by Trolley....</i>	<i>64</i>
<i>Table 3. Trolley Rider Characteristics by Parking Location.....</i>	<i>75</i>
<i>Table 4. Trolley Rider Characteristics by Length of Stay in Gatlinburg.....</i>	<i>76</i>
<i>Table 5. Calculation of Automobile Peak Daily VMT Removed by the Trolley.....</i>	<i>81</i>
<i>Table 6. Calculation of Net Peak Daily VMT Removed by the Trolley.....</i>	<i>82</i>
<i>Table 7. Downtown Gatlinburg Public Parking Inventory.....</i>	<i>86</i>
<i>Table 8. Estimated Delay in Hours at the North Parkway-East Parkway Intersection</i>	<i>96</i>
<i>Table 9. Estimated Delay in Hours at the North Parkway-East Parkway Intersection</i>	<i>97</i>
<i>Table 10. Estimated Delay at the North Parkway-East Parkway Intersection.....</i>	<i>98</i>
<i>Table 11. Estimated Annual Delay Values.....</i>	<i>99</i>
<i>Table 12. Annual Cost Savings as a Result of Reduced Delay.....</i>	<i>101</i>
<i>Table 13. Case I. - Base Case Benefits and Costs.....</i>	<i>109</i>
<i>Table 14. Case II. - Existing Case Benefits and Costs.....</i>	<i>110</i>
<i>Table 15. Case III. - Improved Trolley Service Benefits and Costs</i>	<i>111</i>
<i>Table 16. Case IV. - Road Improvements Benefits and Costs.....</i>	<i>113</i>
<i>Table 17. Summary of Monetary Values for Analysis 1</i>	<i>115</i>
<i>Table 18. Results of Benefit-Cost Analysis 1.....</i>	<i>116</i>
<i>Table 19. Summary of Monetary Values for Analysis 2.....</i>	<i>119</i>
<i>Table 20. Results of Benefit-Cost Analysis 2.....</i>	<i>120</i>

List of Equations

<i>Equation 1</i>	<i>51</i>
<i>Equation 2</i>	<i>52</i>
<i>Equation 3</i>	<i>112</i>

Chapter 1

Introduction

Public transportation systems in small cities often serve specific needs such as those of the elderly and the transit captive. Officials in these communities are faced with the constant challenge of providing an effective service which meets the local needs in an economical manner. An effective transit service must serve major trip generators, have reasonable headway, and operates during hours of travel demand among other characteristics. An economical service is also one which is affordable to the patrons as well as to the governments which support the service.

Gatlinburg, Tennessee, population 3,417, located in Sevier County in east Tennessee, is one such small city with very definite transportation needs. The town rests at the foothills of the Great Smoky Mountains National Park (GSMNP) and serves as a gateway to the Park. Two major routes, US Highway 441 and US Highway 321, accommodate most traffic into and out of Gatlinburg, Tennessee (Figure 1). These roads merge into what is known as the "Parkway" corridor in downtown. This undivided four-lane corridor fronts a large number of motel units, specialty shops, and restaurants. As a result of the travel demand in the area, the Parkway carries large quantities of through vehicle traffic, local vehicle traffic, and pedestrian traffic which causes significant congestion and consequently delay to travelers. Due to

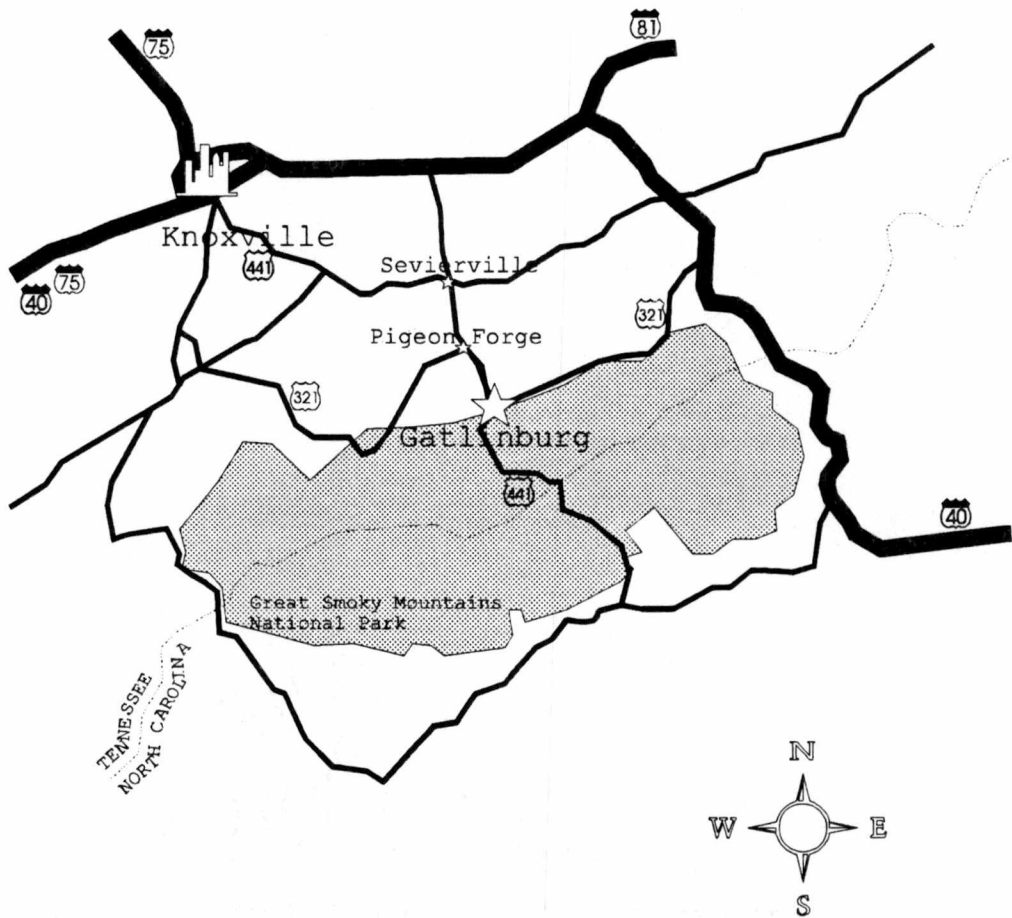
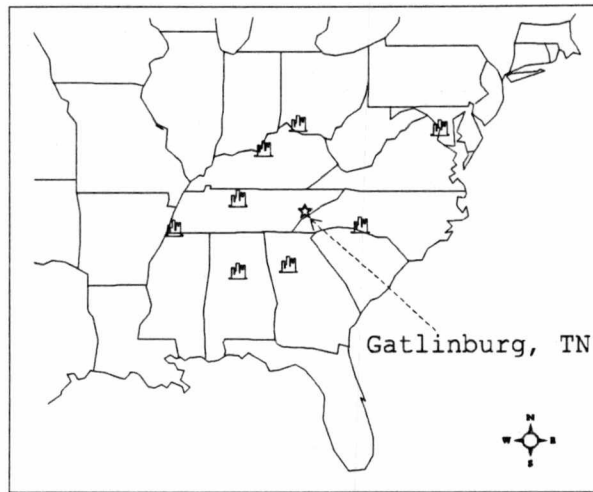


Figure 1. Gatlinburg, Tennessee Regional Area

approximately eight and one half million Park visitors each year (1991 Land Use Plan) and the City's ease of access from Interstates 40 and 81, travel demand during the summer tourist season has increased to a level where the community's road network and parking facilities operate near capacity. Alternatives available to the City for providing adequate intracity transportation resources were very limited and very expensive.

In 1980, Gatlinburg implemented a public transportation system to address many of the mobility needs of tourists and local citizens. A review of past planning documents which outlined local transportation issues, including the history and operations of the Trolley, was conducted. Though past recommendations which called for road reconfiguration and pedestrian mall development were not implemented, a public transportation service known as the "Gatlinburg Trolley" (hereafter simply referred to as the Trolley) was added to improve travel conditions. The Trolley System consists of a fleet vehicles with Trolley frames attached to medium-size, rubber-wheeled bus chassis. The purpose of this study is to evaluate the financial and mobility impacts that this public transportation service has on the local transportation system of Gatlinburg, Tennessee.

Chapter 2

Study Area Description

Millions travel to and through Gatlinburg each year. Most of these travelers are tourists who visit the City during the peak travel season which occurs during the summer months. The characteristics of the travel through the area are directly influenced by the seasonal tourist attractions and the layout of the road network. A thorough description of the study area is presented.

Regional Characteristics

Located approximately forty miles southeast of Knoxville, Tennessee, Gatlinburg is considered to be a major resort location in the region. Since the establishment of the Great Smoky Mountains National Park in 1934, Gatlinburg has gradually developed from a small farming community into a resort town for Park visitors by offering motel units and restaurants which cannot be found inside the Park. The mountainous terrain and small town lifestyle offered an attractive setting for tourists to relax and shop. As a result, the tax revenue collected in Gatlinburg made the City an important link in the State's economy (Davis 1994).

In the past ten to fifteen years, the success and popularity of Gatlinburg has expanded into neighboring communities. Pigeon Forge and

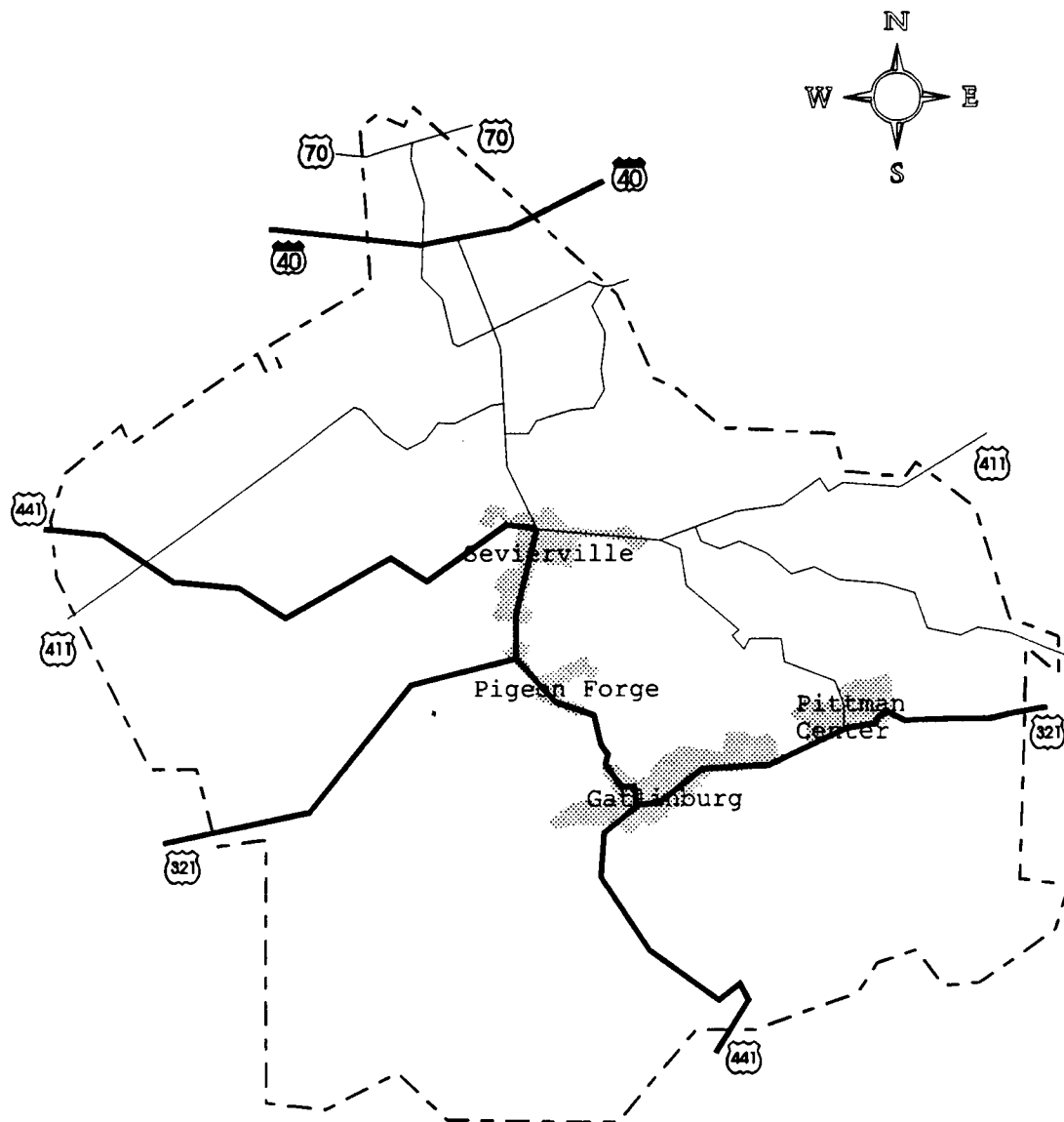


Figure 2. Sevier County, Tennessee

Sevierville, which are also located in Sevier County (Figure 2), have capitalized on the tourism market. Pigeon Forge, located about five miles North of Gatlinburg, has become a major commercial retail shopping destination in the region. Pigeon Forge, like Gatlinburg, also offers thousands of motel units and camp sites and also accommodates millions of tourists each year. Sevierville, the historic county seat located about two miles north of Pigeon Forge, has also entered the retail and lodging market, though not quite to the extent of Pigeon Forge and Gatlinburg, but the tourism industry in Sevierville is growing. Both Pigeon Forge and Sevierville have land area available for growth and will thereby add tourist capacity to the region over the next several years. Though the cities complement one another, a friendly rivalry among the communities to offer more attractive destinations to the tourists has developed. Though Gatlinburg has historically been the leading tourist destination in the region, the City suffers a disadvantage in potential growth due to its topographical constraints.

Major Roads Serving the City

Topographical constraints have caused the development of downtown Gatlinburg to be very dense. The land suitable for commercial development in the CBD is practically completely occupied and is surrounded by steep mountains in either direction. The dense land use and the high cost of real estate has kept the road network and parking facilities to a minimum. In addition, the terrain makes the cost of construction of such infrastructure very expensive.

Due to the shape of the west fork of the Little Pigeon River valley in which Gatlinburg lies, development has occurred along two distinct corridors--a North-South corridor and an East corridor. A major arterial lies in each of these corridors--US 441 in the North-South and US 321 to the East. US 441 links Gatlinburg directly to Interstate 40 from the North and becomes the major route connecting Tennessee and North Carolina across the Park. As a result, the development originated along this corridor and traffic is most intense there. Near the center of town, US 321, which overlaps US 441 from Pigeon Forge, diverts eastward to the neighboring county and also to Interstate 40. Development in the City has expanded along this corridor in recent years which seemed to also increase tourist traffic. The intersection of these roads (which are known as "North Parkway", "South Parkway", and "East Parkway") is a critical intersection in the City where major delay occurs (Figure 3). Detailed analysis of this intersection is discussed in Chapter 5.

The network of local roads in the CBD are lined with motel units and various commercial developments. Local ordinances do not require commercial developments to provide parking for their patrons. Public parking is offered through a network of publicly-owned and privately-owned pay lots and two park-and-ride lots which are free to motorists. Further description of the parking conditions are also detailed in Chapter 5. The limited availability of parking, in addition to the existing traffic congestion on the Parkways, produce high traffic

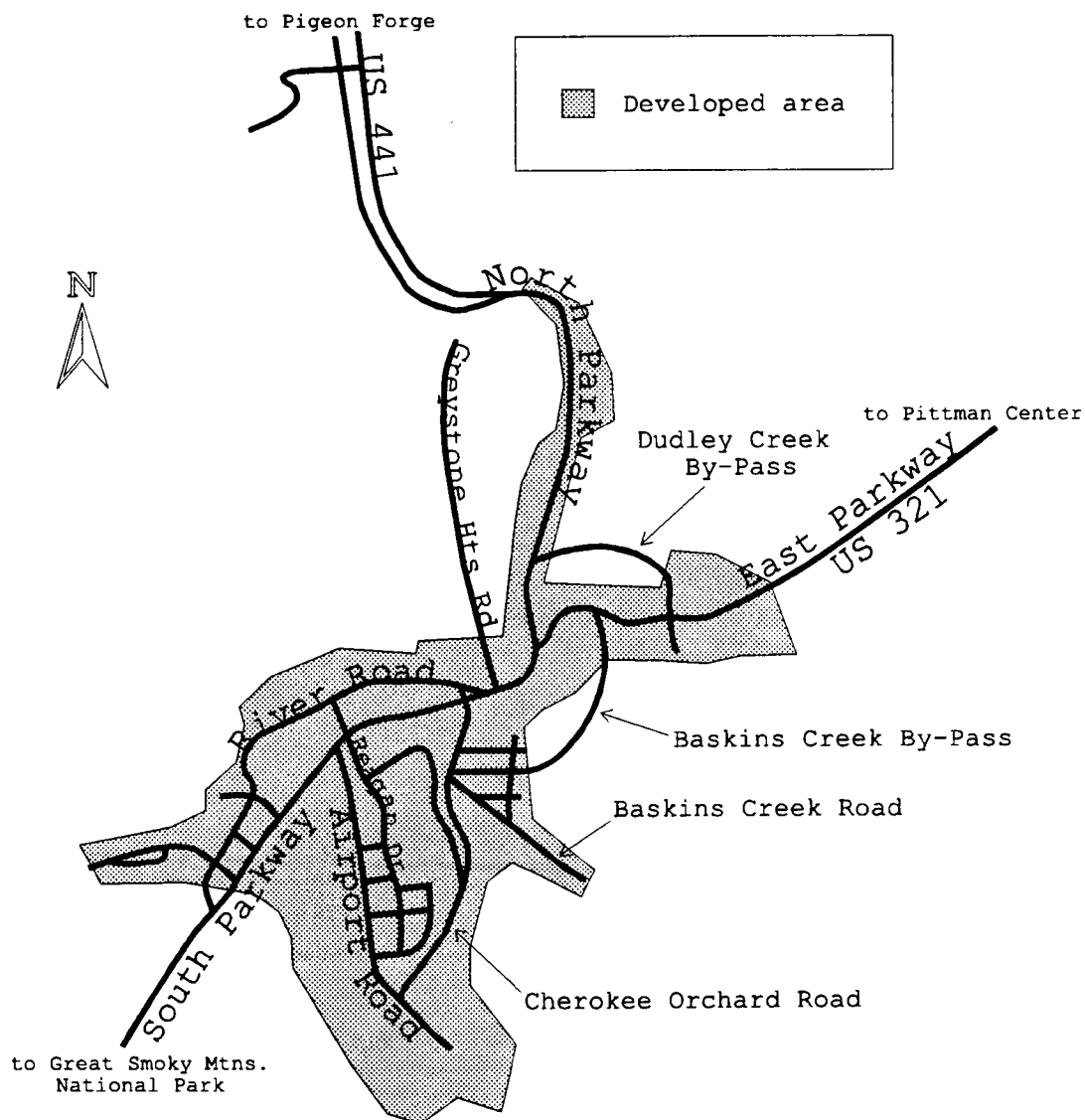
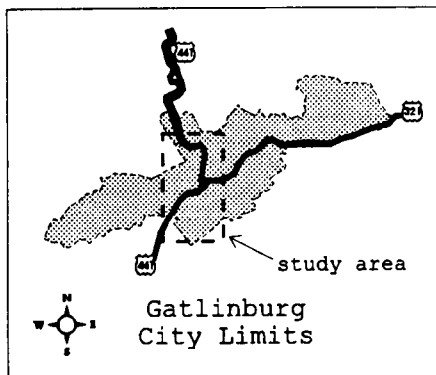
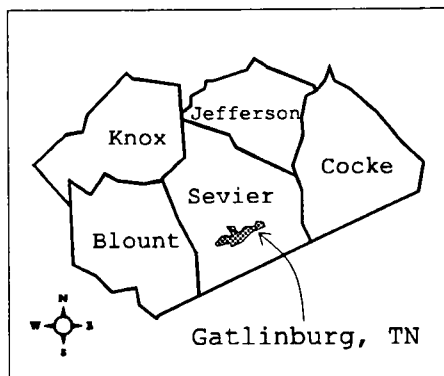


Figure 3. Existing Downtown Gatlinburg Major Road Network

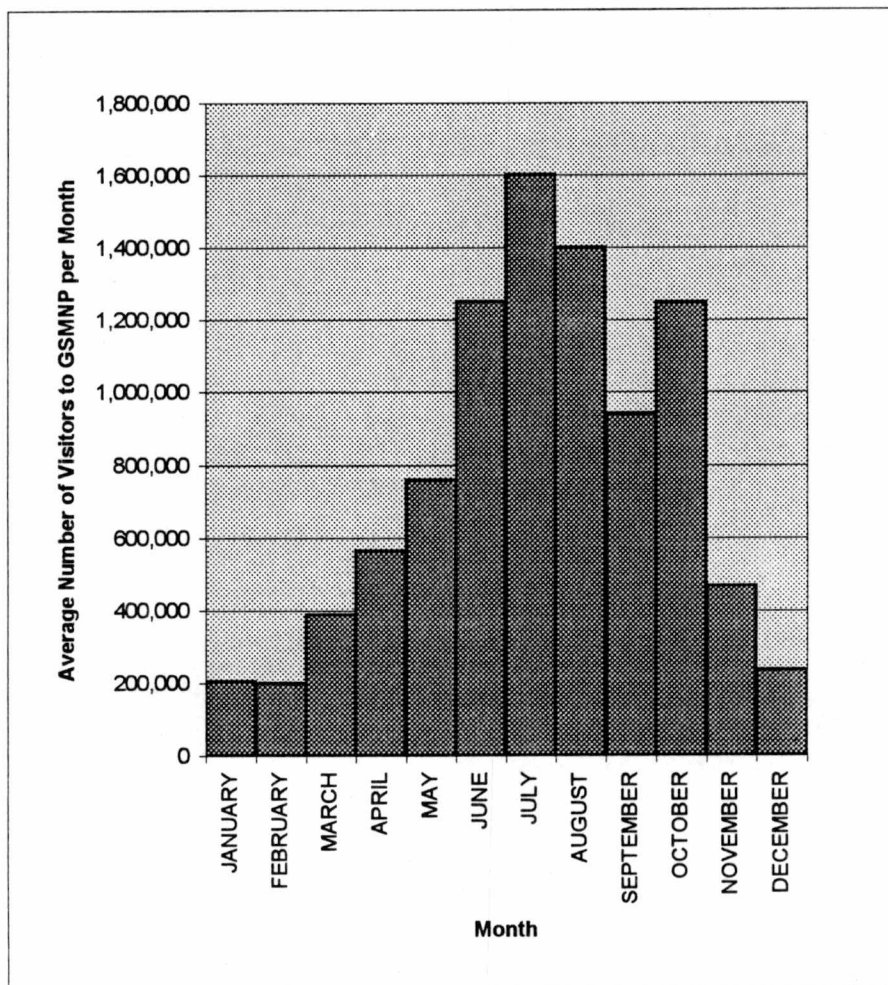
volumes on the local roads in downtown, particularly River Road, Airport Road, and Baskins Creek/Cherokee Orchard Road.

Tourism Characteristics

The travel demand in Gatlinburg varies throughout the year. For this report, travel is determined by the number of visitors to the City which is proportional to the visitation to GSMNP. Park visitation peaks in the summer and autumn months (as shown in Figure 4) due to the pleasant weather and seasonal beauty of the mountains, while Gatlinburg, in an effort to stabilize the local economy, is attempting to also encourage tourism during the winter months by promoting holiday activities, shopping, and snow skiing.

Though the total annual visitors to GSMNP has fluctuated from about 7,000,000 to over 10,000,000 between 1970 and 1990, typical annual visitation approaches the average of approximately 8,500,000 visitors per year. Based on Park visits, the annual Gatlinburg visitation has been determined to average about 70% of the National Park visitation over the past twenty years according to the Tennessee State Planning Office. This percentage however, has apparently increased steadily from about 67% to about 74% between 1970 and 1990 (1981 Community Facilities Plan and 1991 Gatlinburg Land Use Plan).

The City of Gatlinburg does not have a traditional transportation environment because of the extreme variation in travel demand throughout the year. Vehicle traffic is very extreme at times and must utilize



Source: 1991 Land Use Plan

Figure 4. Seasonal Great Smoky Mountains National Park Visitation

only a limited street network, while traffic is not a problem during the non-peak season. Not only does the vehicle traffic congest the streets, but significant pedestrian movement exists which raises safety concerns. With an increase in tourism expected in the region, the transportation and other issues which Gatlinburg currently faces will become more critical in the coming years.

Preliminary results of an inventory of traffic conditions in Gatlinburg conducted by Wilbur Smith and Associates has shown an existing Levels-of-Service (as defined in the 1985 Highway Capacity Manual) on the local road network of "D"'s and "E"'s for the thirtieth highest hour of travel. The level of service (LOS) projections for the next twenty-year period are estimated at "E"'s and "F"'s if no major improvements occur (Grubb, 1994). Both the existing and the expected LOS's indicate that the travel conditions in Gatlinburg are below typically accepted service levels which cause such problems as significant delay to travelers, higher vehicle operating costs, and increased air pollution just to name a few.

The following chapter includes reviews of various short- and long-range planning documents which have been developed for the Gatlinburg area. Transportation and other issues confronting the community which could interfere with the tourism industry and the overall quality of life in Gatlinburg have been identified and studied by local, State, and Federal agencies and private organizations as early as 1971. From these

observations, several proposals have been made in the attempt to eliminate the potential problems which Gatlinburg has been expected to experience. Many of the proposals are outlined.

Chapter 3

Review of Recommendations

Gatlinburg had seen steady commercial growth by the 1970's, because many of the Great Smoky Mountains National Park visitors were looking for lodging and other services not provided inside the Park. An effort by Gatlinburg to capitalize on the economic benefits of the tourism industry necessitated evaluation of the City's resources and infrastructure to accommodate the expected demands brought by the tourists. The following are reviews of documents that have been produced since 1971 to evaluate the existing and future adequacy of the City's resources, including the local road network and land availability, to accommodate tourism.

1971 Comprehensive Plan

Gatlinburg contracted with Harland Bartholomew and Associates in 1971 to develop a comprehensive plan for the City's existing and expected needs. The plan identified issues that could be addressed before major problems evolved. Three issues were identified as the most significant:

- alleviation of major traffic congestion and flood threats to downtown for improved efficiency and safety;

- implementation of an aesthetic control policy which included development of a pedestrian mall to reduce pedestrian-vehicle conflict; and
- enactment of a development control policy and a national promotion effort to maintain Gatlinburg's presence as a cultural center and a superlative vacation and residential community.

In 1970, the year-round population of Gatlinburg was 2,200 while the average daily population during the peak season exceeded 18,000 persons including seasonal employees and tourists. To support the commercial activity, seventy percent of the land use in downtown consisted of commercial development which was significant considering the topographical limitations the City faced. At that time only fifteen percent of the remaining vacant land in the concentrated area was suitable for development based on the topography alone.

At the center of downtown were two consecutive critical intersections--North Parkway-East Parkway and South Parkway-River Road-Cherokee Orchard Road. The intersections formed an "hour glass" shape, and, due to the local traffic patterns, this segment was unavoidable by most vehicle trips in and through the City. The funneling of traffic through this segment of road caused delay and was expected to lead to major traffic congestion problems in the future. A one-way pair system was recommended to relieve the problem. The one-way pair involved constructing a short stretch of roadway parallel to North Parkway. Several alternatives with similar plans existed, but the general idea

involved southbound traffic traveling from North Parkway continuing southbound on River Road, and northbound traffic traveling from South Parkway continuing and merging into a two-way flow on North Parkway. East Parkway and Cherokee Orchard Road would extend to the new River Road (Figure 5).

This change in the road network would facilitate the implementation of a new pedestrian mall. The pedestrian mall would be located in the middle of existing tourist-oriented development between the one-way roads. By adding pedestrian overpasses leading from new parking structures, pedestrians would be able to access the CBD without interfering with vehicle traffic. Also, it was suggested that the new centralized mall area could be served by a mini-transit system such as a fleet of small electric vehicles.

It was estimated that by the year 1990, the City would suffer an estimated deficiency of 2,300 parking spaces if no parking was added to the current supply. This prompted the recommendation for building a series of centrally located parking lots and structures. Such parking facilities would encourage a dense concentration of general activity in the central corridor of downtown. Also, the traffic demand in Gatlinburg was conservatively estimated to increase by eighty percent by 1990. These facts supported the plan's proposed \$17,000,000 in roadway, pedestrian, parking, and traffic operations investment. However, no action was taken to implement the infrastructure improvements due to the

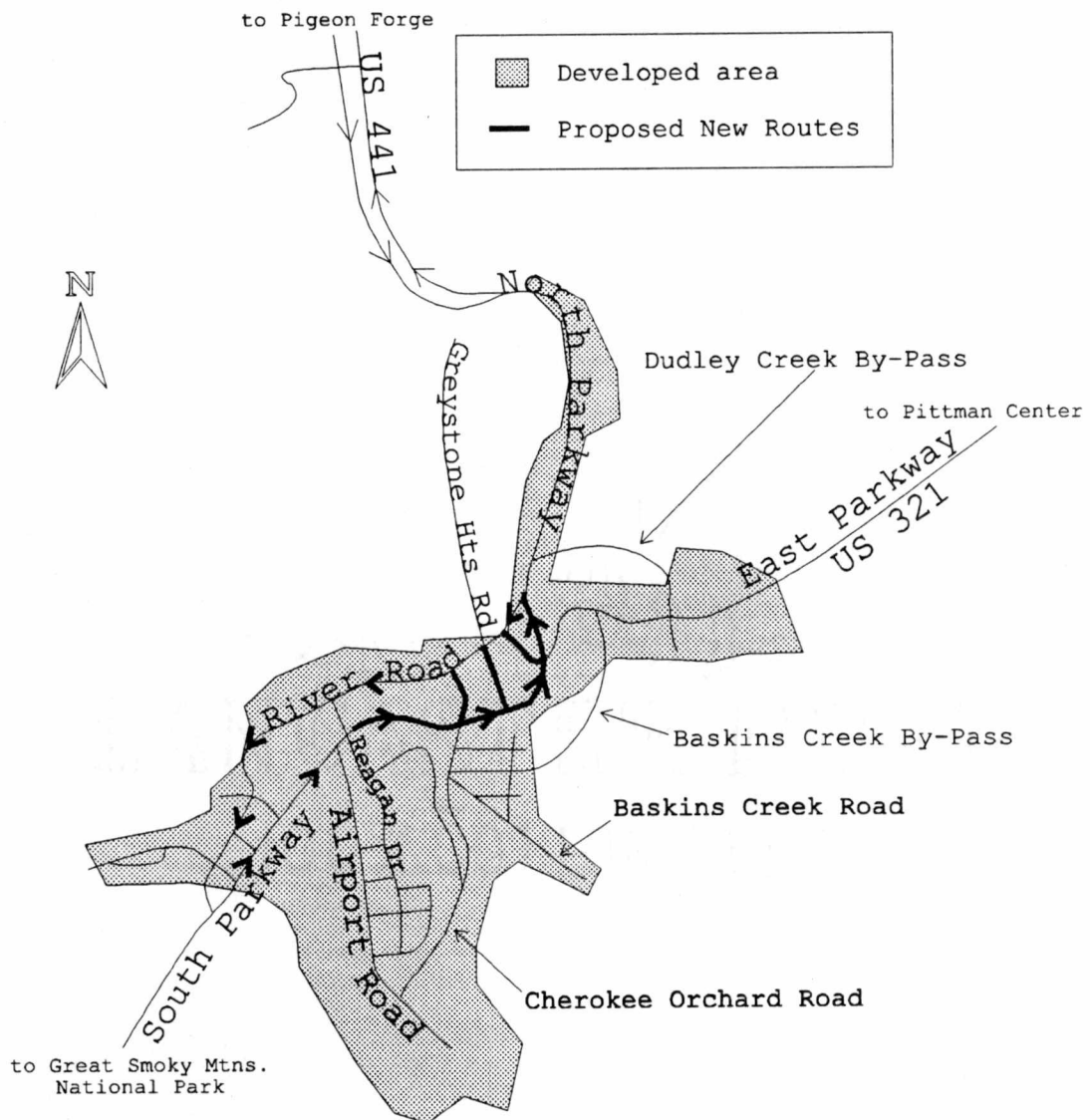
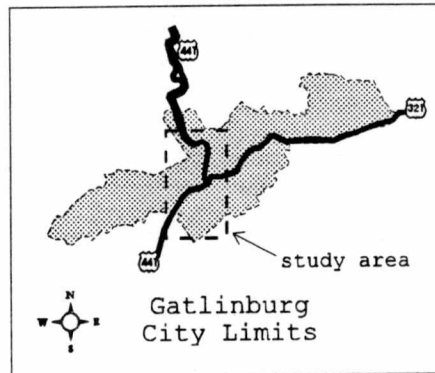
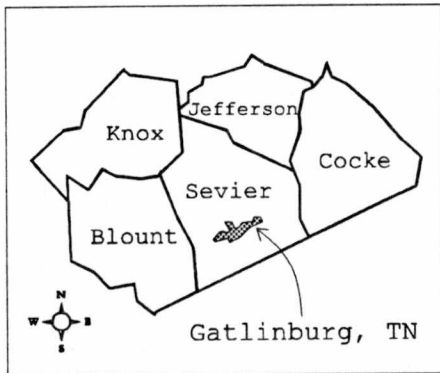


Figure 5. Proposed Downtown Gatlinburg One-Way Pair System

financial cost and any interference with tourism activities which would occur during construction.

1975 Downtown Circulation Study

The Gatlinburg Planning Commission assisted by the East Tennessee Section of the Tennessee State Planning Office conducted a study of vehicular and pedestrian movement in downtown Gatlinburg in 1975. The study acknowledged that Gatlinburg's tourism industry was being adversely effected by the existence of mobility and parking problems in the CBD. It was felt that the problems facing Gatlinburg would also eventually impact the entire county of Sevier. The State was promoting its growing tourism industry during this period and viewed Gatlinburg's success as a positive influence on the prosperity of the statewide economy.

The study defined three intersections which were critical to traffic flow through the CBD (Figure 6):

- North Parkway-East Parkway;
- South Parkway-River Road-Greystone Heights Road-Cherokee Orchard Road; and
- Airport Road-South Parkway.

The mix of vehicle and pedestrian traffic at these critical intersections posed safety concerns and major delay problems. Arteries such as Airport Road where parking facilities were located and major motel unit construction was occurring, made pedestrian traffic a

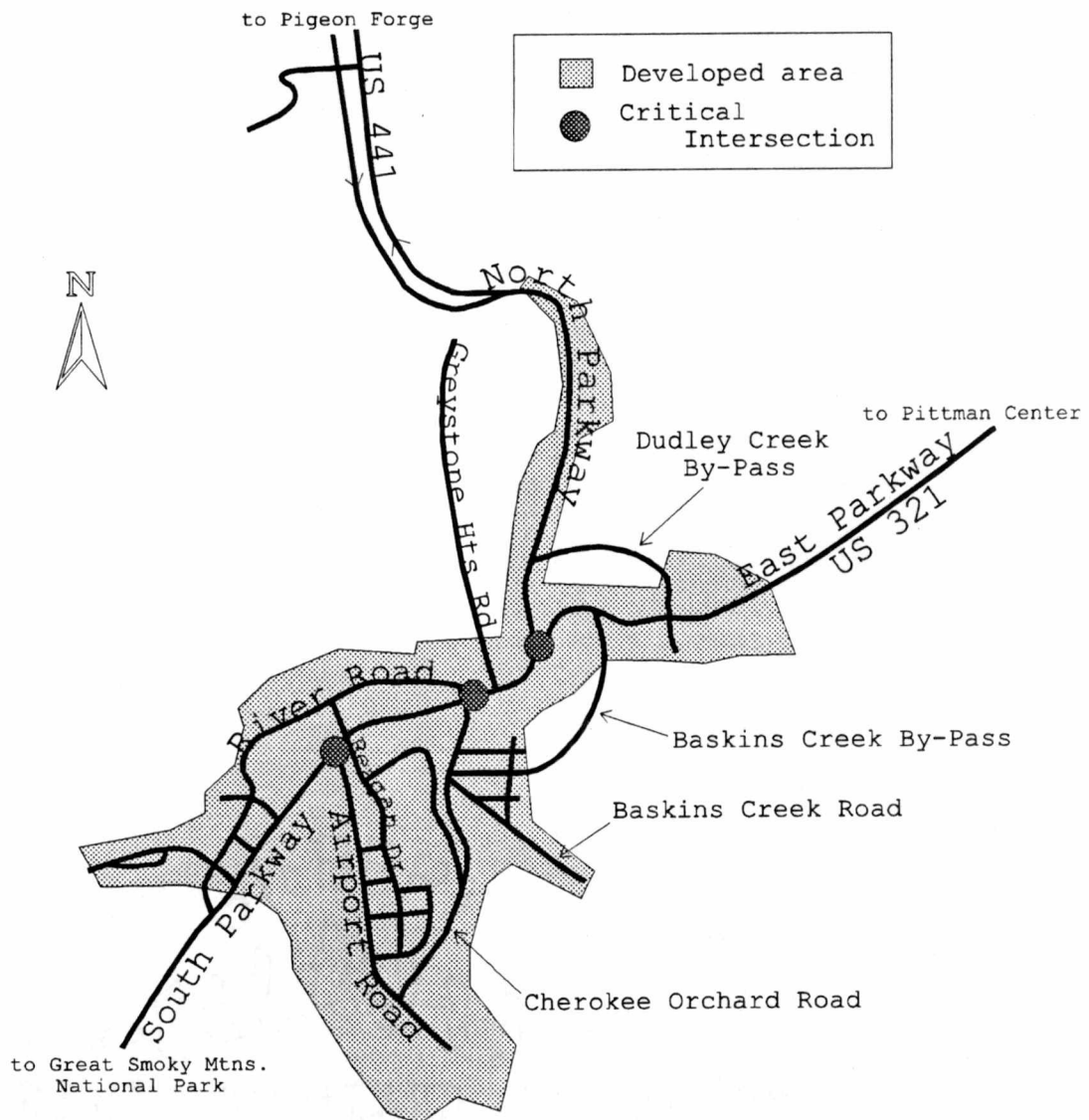
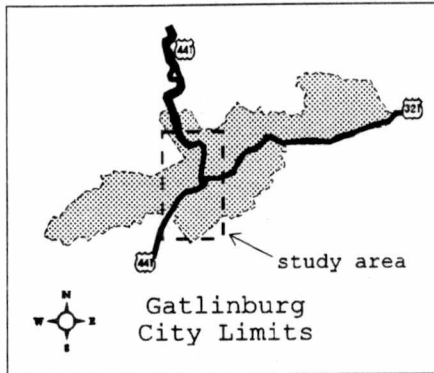
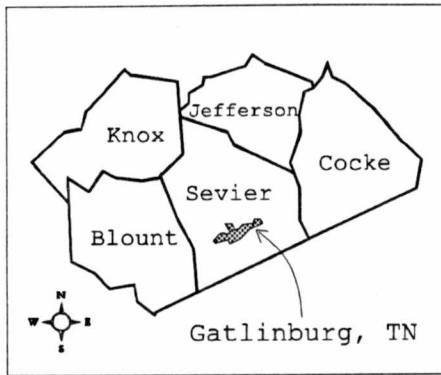


Figure 6. Critical Delay Intersections in Downtown Gatlinburg

permanent factor toward the consideration of any transportation plans for the City.

Construction of new roads alone would not solve the Parkway corridor congestion problems. Travel demand was estimated to double by 1990. The existing street network was declared inadequate for these projected demands. Widening existing streets was not an option because of the commercial establishments which were located very near the street edge and because of the demand for sidewalk space by the pedestrian environment. Interest had increased in the previous pedestrian mall proposal. However, existing land uses were not compatible with the plans for construction of a pedestrian corridor parallel to and between South Parkway and River Road. Therefore, a proposal was developed to construct a pedestrian mall over a submerged South Parkway in addition to the execution of the one-way pair concept (Figure 7).

Due to the high cost of the improvements recommended, an incremental approach was proposed to decrease the one-time cost and minimize disruption to tourism activities. The first phase called for extending Airport Road to River Road for a cost of \$26,675 (1975 dollars) plus land acquisition costs. This would improve access to the motel district and provide an alternative to using South Parkway for motorists. Phase two involved implementing one-way southbound traffic onto River Road and one-way northbound traffic onto South Parkway. The reconfiguration would reduce the left turn conflicts and the risk to pedestrians by having fewer directions of vehicle traffic to avoid. The

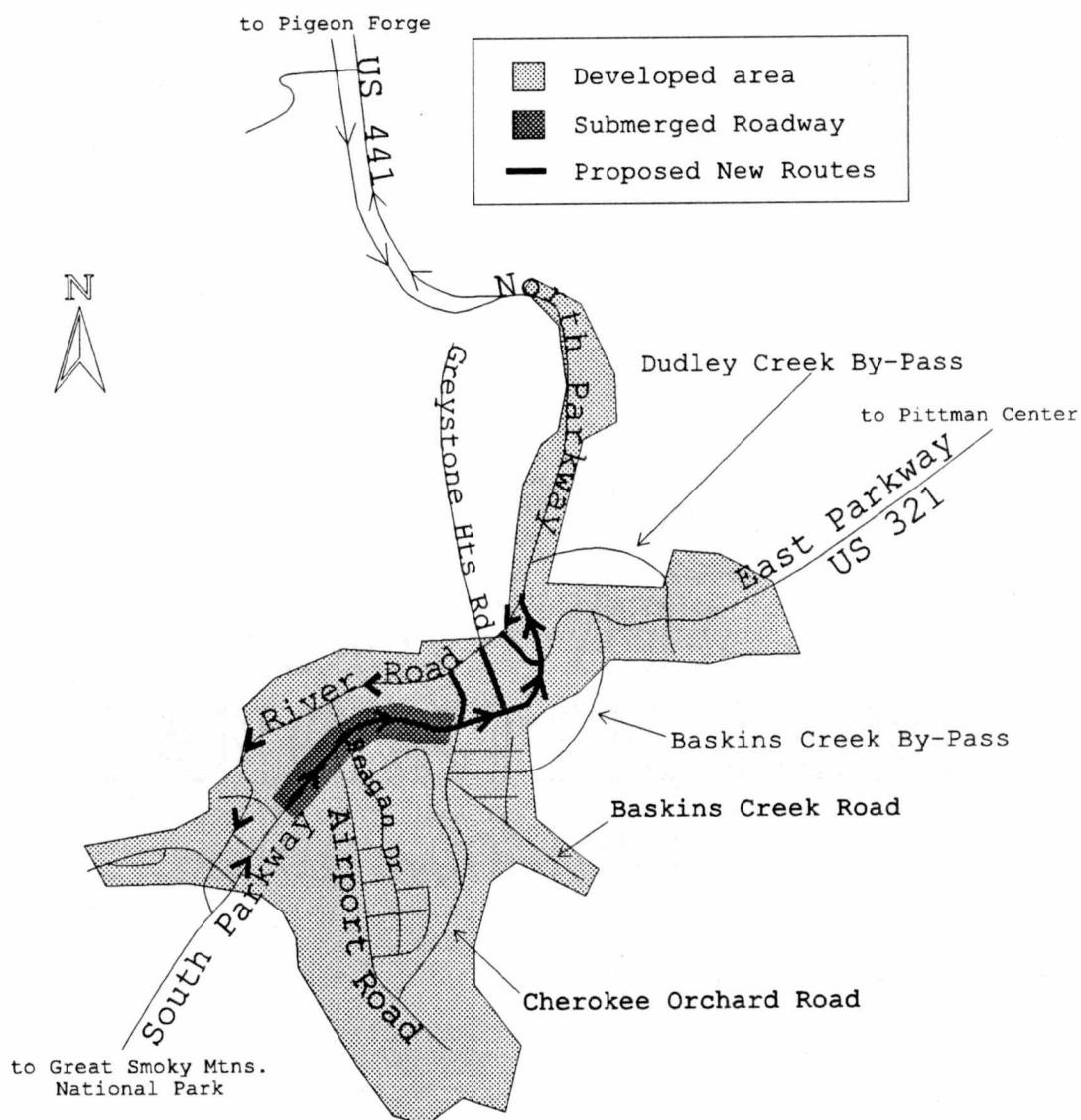
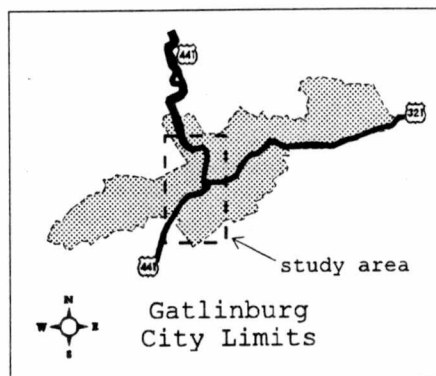
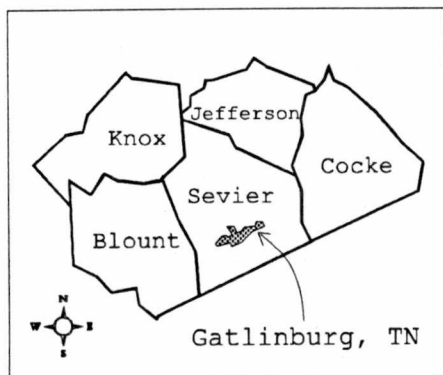


Figure 7. Proposed South Parkway Tunnel and Pedestrian Mall in Downtown Gatlinburg

estimated cost for signal coordination was \$54,000 (1975 dollars). Next, construction of a parking garage was recommended at the City parking lot located on the corner of South Parkway and Airport Road. The estimated \$3,020,000-project would provide 1,007 spaces as opposed to the existing 250 spaces. In addition to these recommendations, the elimination of unnecessary sidewalk obstructions such as vending booths was encouraged to maximize the effective pedestrian walking width.

Again, no major construction or road reconfiguration took place. Travel patterns continued as they had existed and congestion increased.

1978 Cherokee Orchard Road Relocation Report

Gatlinburg requested a study to be performed by Flynt Engineering which investigated the construction of new roadway capacity. The new road was outlined in the plan in order to implement a one-way pair over the North-South length of the City. The road would be constructed just West of the Little Pigeon River and parallel to the existing North Parkway from where North Parkway changes from a four-lane two-way divided highway to a two-lane two-way facility to the South Parkway-River Road-Cherokee Orchard Road intersection (Figure 8). The estimated cost of the project was approximately \$8,000,000 (1978 dollars). The plan was not implemented.

1978 Recommended Transportation Alternatives in Gatlinburg, TN

The Tennessee Department of Transportation (TDOT) outlined several options available to the City of Gatlinburg for improving mobility in a

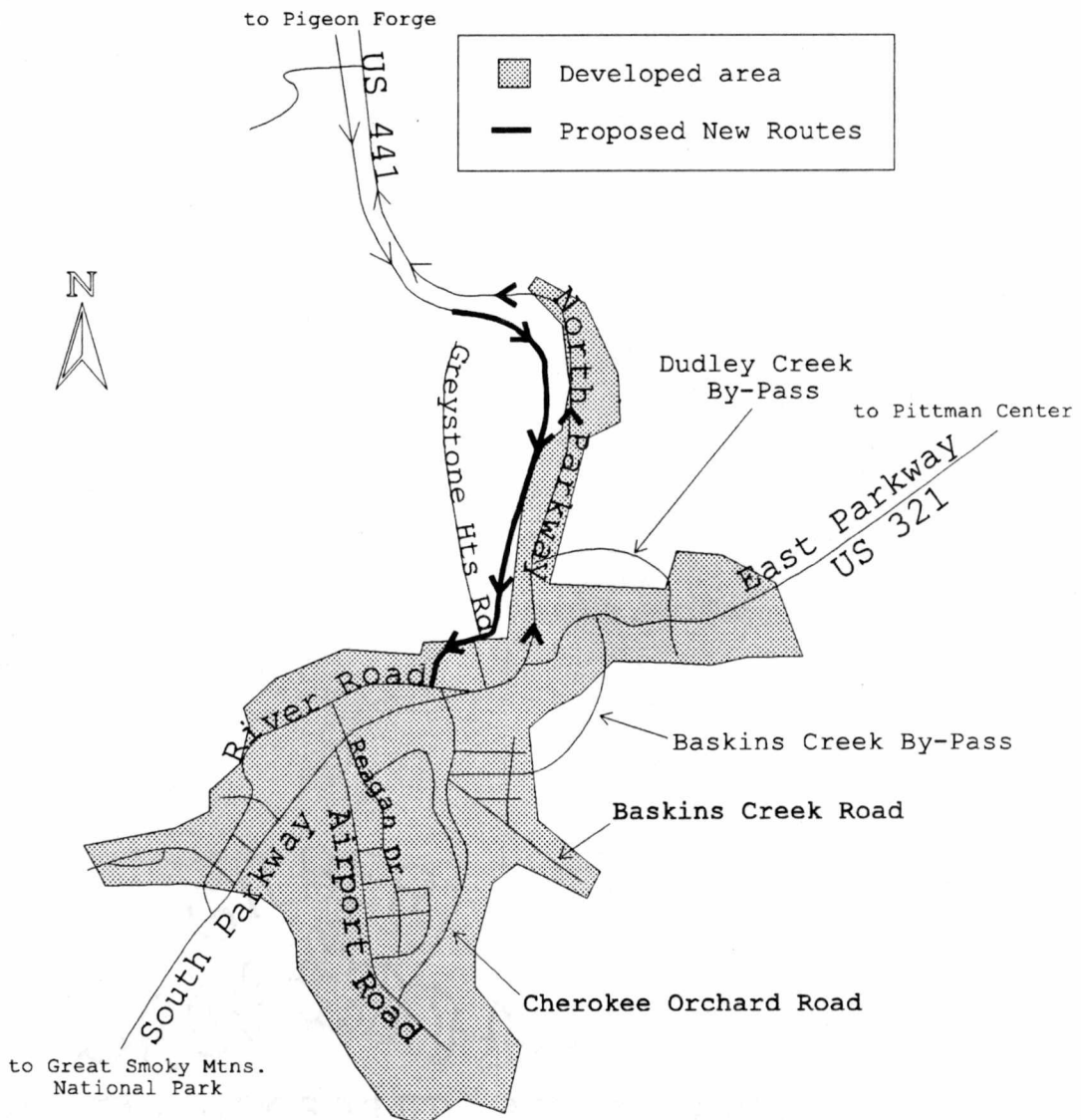
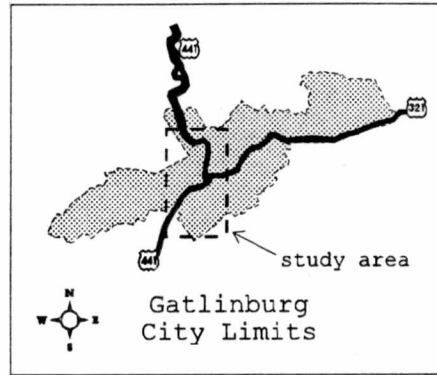
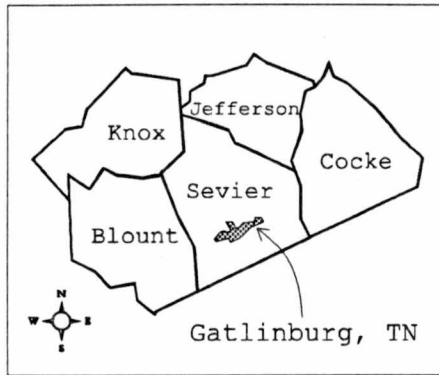


Figure 8. Proposed Additional Capacity for North Parkway in Downtown Gatlinburg

1978 document. After collecting and analyzing data that inventoried the existing conditions of Gatlinburg transportation, the State elected to focus on the intercity or internal transportation needs of Gatlinburg-- mainly tourist travel. The study concluded that no single strategy would solve mobility problems, therefore a multifaceted set of recommendations was produced. The addition of a public transportation service and modification of the existing roadway system were suggested to provide the greatest potential for a positive impact.

The study considered the origin-destination patterns of tourists in Gatlinburg to be the direct cause of the congestion on the existing road network. The goal was to redirect these patterns onto a more efficient system. Travelers would be encouraged to utilize other modes of travel such as transit and walking to overcome their dependence on private automobiles. Since many downtown trips were short enough for walking, a high number of pedestrian movements caused concern for pedestrian safety.

An insufficient number of parking facilities and inadequate locations of these facilities were a major source of additional congestion in the downtown area because drivers circulated the streets more while trying to find available parking. Similarly, unfamiliarity with the local area by tourists induced circuitous travel through the City which caused even more congestion. These factors made transportation planning a difficult task.

The local policy was suggested to concentrate on a public transportation service supplemented by a comprehensive communication system, and a parking management strategy. As defined by TDOT, transit service would address five major issues:

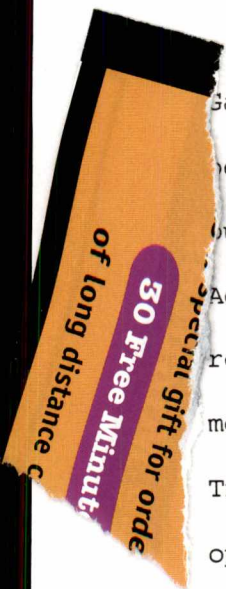
- accessibility,
- service quality,
- environmental aspects,
- financial requirements, and
- economic considerations.

Accessibility must be provided to all groups within the specified service area independent of trip purpose or special needs. A high quality of service would assure residents and tourists of a reliable and dependable transportation option that provided effective headways and service coverage in order to compete with the private automobile. Environmental aspects considered removing vehicle traffic from the roadways as a way to inhibit the necessity of constructing new roads which would thereby destroy more of the natural environment. Transit would also abate air and noise pollution in the local area. Financial requirements and economical considerations were critical considering how any additional traffic congestion would jeopardize tourism in Gatlinburg and consequently impact local and State tax revenues. Recovering adequate operating expenses through the transit option was necessary,

particularly due to the probable fact that no Federal operating funds would be available.

The comprehensive communication system proposed by TDOT was intended to familiarize the typical traveler with the City of Gatlinburg. Several objectives could be accomplished with this strategy. Internal circulation could be dramatically reduced by improving signs that more clearly guided motorists to such destinations such as parking facilities. More than safety and efficiency would be achieved through better signs. Signage could provide information about established public transportation and perhaps encourage motorists to leave their cars parked during their visit. Pedestrians would also benefit from increased communication. A conveniently located tourist information center could provide maps of the area and transit information while serving as an intermodal transfer location.

A successful plan to improve internal circulation through Gatlinburg as outlined by TDOT involved public transportation, pedestrian movement, and minor traffic improvements. Some initial public transportation services existed in the CBD in the form of the Aerial Tramway which linked downtown to Ober Gatlinburg, a mountaintop resort, and the Skylift which also connected downtown to the mountaintops. The Comanche Train (known originally as the Chucky Jack Train), a privately owned internal circulation service, which began operation in 1956 as a shuttle to a local theater, laid the foundation for a more comprehensive transit system (Maples, 1994). (The Comanche Train ceased operation some time in the early 1980's due to inability to



compete with the new transit service.) It was felt though these modes served mobility needs, they did not provide a proper, conventional public transportation service due to their for-profit aspirations and limited services. However, it was recommended that any public transportation service cooperate with the privately-owned transportation providers to meet all tourists' mobility needs.

Development of an effective circulation system also included the improvement of pedestrian flow through downtown. Providing attractive pedestrian facilities such as crosswalks, sidewalks, alleyways, and connections through stores would improve access and minimize interference with automobiles. Clear foot paths from the streets to parking facilities would make long-term parking more attractive. The installation of more signalized crosswalks would also improve pedestrian safety and reduce jaywalking. Addition of split-rail fences and benches along the sidewalk edges sidewalks along busy streets was proposed to help channel pedestrian movements away from vehicle paths.

Better information to tourists concerning available parking would reduce unnecessary driving. Integrating public transit service with the addition of parking would offer even more flexibility for the integration of fringe-area parking facilities such as park-and-ride lots. Availability of these facilities could also be advertised by improved signage and by transit maps.

The poor physical characteristics of existing parking facilities also impacted traffic congestion. Deficient turning radii and ticket

distribution location, and insufficient storage bays caused troublesome turning movements into and out of parking lots which added to the queuing that already occurred in the streets during periods of heavy travel demand.

Several alternative forms of public transportation were evaluated for Gatlinburg. These included:

- taxicab,
- dial-a-ride,
- local bus,
- express bus,
- light rail transit,
- light guideway transit, and
- rapid rail transit.

Consideration of the estimated travel demand and capital investment requirements lead to the State's recommendation of operating a 20- to 25-passenger local shuttle bus service through downtown. The bus would serve lodging establishments, parking facilities, and other tourist destinations. Participation from public and private sector than provides was essential for success.

Minor road improvements were also recommended in order to improve mobility. The extension of Airport Road to River Road was given strong encouragement for improving circulation in this area of significant trip generation. The estimated cost of the construction was \$243,000 (1978 dollars) plus land acquisition costs. Also, improvement of the Cherokee Orchard Road-River Road-South Parkway intersection was advocated for the purpose of implementing a one-way pair arrangement on River Road and South Parkway. The estimated cost for signal and sign upgrade for the one-way pair was \$70,000 to \$80,000 (1978 dollars).

The key facets of the TDOT plan were: the implementation of an integrated transportation network including public transportation and an improved pedestrian environment, a comprehensive communication system, improved internal circulation measures, and a parking management strategy. Ultimately, many of these recommendations were implemented, but the major thrust of the plan was the establishment of a local bus-type public transportation service. The service was supplemented by added fringe-area parking, increased crosswalks, and increased informational signing. The one-way pair system was not implemented.

1980 Gatlinburg Land Use Plan

The East Tennessee Section of the State Planning Office prepared the 1980 Land Use Plan for Gatlinburg. As defined in the Plan, the most significant issue faced by the community during this period continued to be the responsibility of the City to provide services and accommodations for the peak daily population. By this time the peak daily population reached approximately nine times (36,000) that of the almost 4,000 full-

time residents. Topographical limitations in the concentrated area of development continued to create critical problems due to the demand for space. Traffic congestion and parking availability were two of the most critical topics, and the continued economic success of the community was thought to be at risk due to these problems.

Annual visitation to Gatlinburg in 1980 was approximately 6,000,000 people. Projections showed that annual tourism would increase by a rate of 1,000,000 persons every five years for the next twenty years. The economy of the region continued to be highly dependent on the tourism industry from year to year. In Sevier County, sales of goods and services to tourists increased by \$41,000,000, or 85%, between 1974 and 1978. As had been typical, almost 70% of annual tax revenues were collected during the months of June through October. Commercial land usage increased by 44% in Gatlinburg during the previous ten years to a total of 389 acres, and the overall percentage of total developed area within the City increased from 18% to 47% during the previous decade including annexation.

The goals outlined in the Land Use Plan called for a continuation of a high standard of community development that would maintain Gatlinburg's national status as a premier resort community. Implementation of the transportation network previously proposed by TDOT was recommended to receive high priority in order to improve mobility in the area. Where possible, additional off-street parking was recommended to allow for maximization of the street area for traffic movement.

1981 Community Facilities Plan

The 1981 Community Facilities Plan was also prepared by the East Tennessee Section of the State Planning Office to assist local officials in decision making regarding the community interests. Several aspects of the City's responsibilities were addressed. A public transportation service known as the "Gatlinburg Trolley System" was instituted in 1980. It was suggested in the Facilities Plan that the Trolley would receive operational funding from revenue generated by the City-owned parking lots, and the two services would be administered by a Mass Transit/Parking Lot Department. The Plan also recommended the execution of a study to locate additional off-street parking facilities.

1991 Gatlinburg Land Use Plan

This 1991 document updated the 1980 Land Use Plan for Gatlinburg. The local full-time population was reported to be less than 3,500, but the estimated daily peak population was estimated at 60,000 individuals. Vehicle and pedestrian congestion were again listed as the major concerns of the community. Traffic volumes were predicted to continue increasing but at a slower rate than in the past, and more group-oriented vehicles such as vans and buses were expected in the future.

The growth of the physical size of Gatlinburg was determined to have ceased at 3,148 developed acres due to the lack of economically developable land within the area. The economic health of the City continued to grow, however. The observation was made in the Plan that the increase in activities and marketing of the winter season began to improve the winter economic slump.

During the previous decade, the region observed the emergence of Gatlinburg's neighboring community, Pigeon Forge, as a prominent tourist destination. Pigeon Forge offered different characteristics than Gatlinburg--a more discount retail and entertainment orientation as opposed to Gatlinburg's crafts and relaxation orientation. A study conducted in 1986 showed 51% of Gatlinburg's visitors also visited Pigeon Forge during their stay. A similar study conducted in 1989 showed that the percentage had increased to 66%, while 86% of Pigeon Forge's visitors visited Gatlinburg. These data infer the complementary nature of the two communities and a new aspect of intercommunity transportation needs. The Plan endorsed the cooperation of the communities within the county to work together to serve region-wide transportation needs.

In the Land Use Plan, it was recommended that the City of Gatlinburg provide an efficient pedestrian and vehicular circulation system with appropriate capacities and linkages. A pedestrian flow study was to be conducted and a plan implemented by the City for improved pedestrian mobility in the CBD. Future emphasis on vehicular access to the community would be placed on arterial routes other than North Parkway. The local policy requiring the provision of off-street parking by all new land uses except commercial developments would continue. Expansion of the public transportation services would also continue relative to demand. Joint local efforts to develop a comprehensive public transportation service for the cities of Gatlinburg, Pigeon Forge, and Sevierville would proceed.

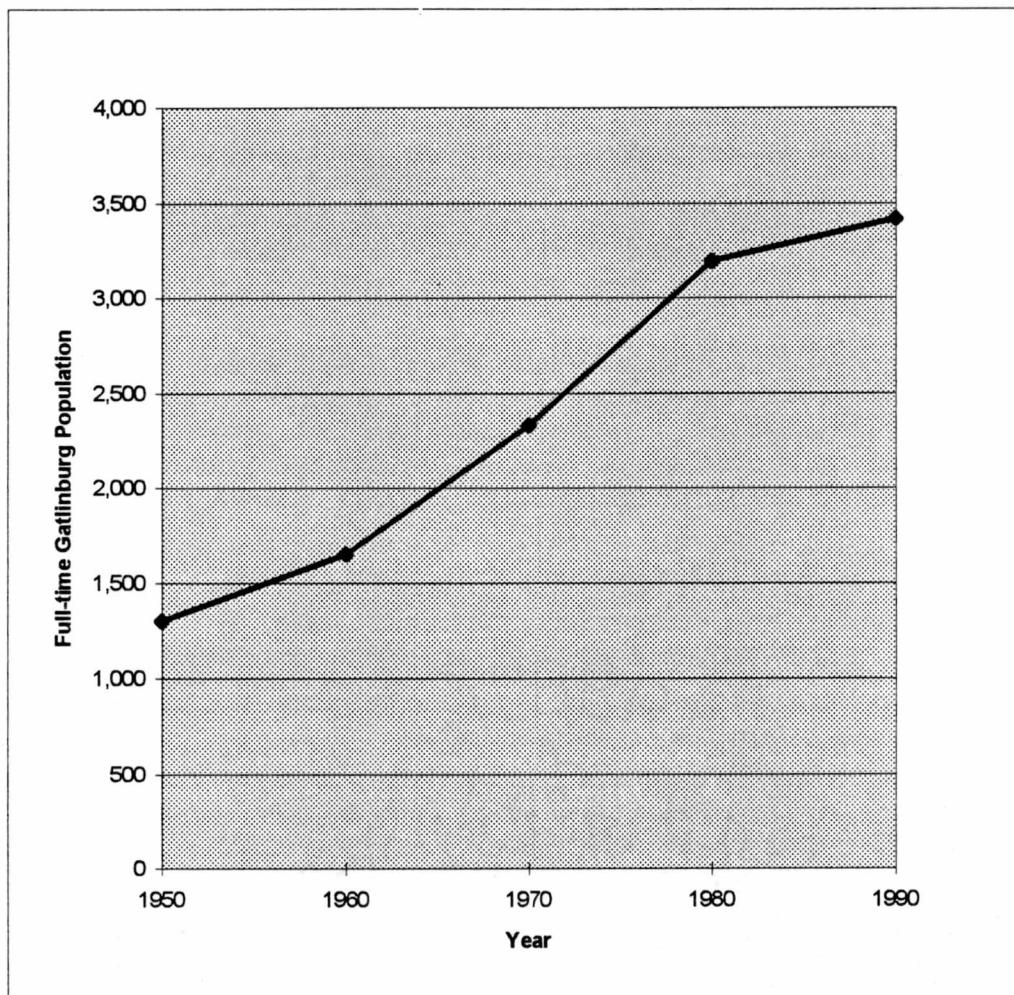
1992 Community Facilities Plan

The 1992 Community Facilities Plan updated the 1981 Plan of the same name. The Plan noted that despite the cities annexation of 500 residents between 1980 and 1990, the City's growth rate based on full time population decreased dramatically and unexpectedly during that time compared to the previous decades (Figure 9). The cause for this population change was not explained in the Plan but could represent a saturated condition in Gatlinburg based on land area or unwillingness of new residents to accept the extremely congested conditions.

The need to improve mobility facilities continued. Recommendations for expanding the street network included:

- extending Airport Road to River Road;
- closing Maple Lane for conversion to a pedestrian way;
- transforming South Parkway and River Road to a one-way pair; and
- improving Dudley Creek By-Pass for improved access from North Parkway to East Parkway.

Expanding the fourteen vehicle Trolley fleet and linking the service with Pigeon Forge and Sevierville was also suggested.



Source: 1992 Community Facilities Plan

Figure 9. Gatlinburg, TN Full-time Population Trend

Summary

Many of the recommendations over the two decades year period for Gatlinburg were consistent. The issues of traffic congestion and limited space were clearly established and addressed, however very limited implementation of the recommendations to remedy these problems occurred with the exception of adding the Trolley service. The Trolley service has seen great success, but mobility continues to be a major issue due to demand spillover from the growing tourism industries in the region from areas such as Pigeon Forge and Sevierville. The next chapter assesses the Gatlinburg Trolley Service from its inception in 1980 to the end of 1993.

Chapter 4

Trolley Service

The Gatlinburg Trolley began limited service in the downtown area in May of 1980. Over the years, the success of the service and growing demand allowed the fleet size to increase and the service coverage area to grow and cover the entire CBD and some outlying areas. As of early 1994, two primary routes and two secondary routes serve most locations of interest to tourists in Gatlinburg including two park-and-ride lots which serve as convenient transfer points.

Service Review

The system-wide Trolley service routes are shown on the system map in Appendix A. The downtown area is served by the Green and Orange Lines which are considered the primary Trolley lines because most of the ridership occurs on these lines. Fares for the primary lines are 25¢ per person. The Red Line and Yellow Line serve the Dollywood theme park in Pigeon Forge and the Glades arts and crafts community, respectively. These two Trolley lines have a different fare structure and have lower overall ridership and are therefore considered secondary lines.

All lines serve one of two City-owned park-and-ride lots located to the North and to the East of downtown. During the peak travel season which begins in early April and lasts through late October, Trolleys operate daily from 8:00 AM to midnight. Service during the off-peak season varies by time of day, day of week, and month of year; during

some years the service is closed during the months of January through March due to low demand. During peak season operation, headways are approximately twenty minutes on downtown lines, while headways on secondary lines vary between twenty minutes and one hour depending on travel demand and traffic congestion. Charter service for large groups and accommodations for the disabled are available upon request.

Primary Lines

The Green Line, one of the two primary lines, begins its route at the North park-and-ride lot on US 441 and travels via North Parkway to River Road (avoiding South Parkway due to potential traffic congestion). The route makes a small loop near the south end of River Road along LeConte Road, South Parkway, and Ski Mountain Road where it returns to River Road and follows the same route back to the North park-and-ride lot. The length of the route is approximately three miles from the park-and-ride lot to the extreme south end of the route (about six miles for a complete loop).

The Orange Line, the other primary downtown line, begins at the Gatlinburg Community Center building and serves the Gatlinburg-Pittman High School, the East park-and-ride lot, and the local Post Office-City Hall-Police Department complex in the east part of the City just off US 321. The route travels US 321 (East Parkway) into downtown to North Parkway. Except for an approximate two-block distance, the Orange Line also avoids South Parkway when possible by diverting onto Baskins Creek/Cherokee Orchard Road and Airport Road. On Airport Road, the route reverses at a turn-around located at the Gatlinburg Convention

Center building and follows the same route back to the East park-and-ride lot. The end-to-end length of the Orange Line route is about six miles (a twelve-mile total loop).

The coverage area of the Green and Orange Lines based on a 1/4-mile walking distance is shown in Figure 10 with the Trolley routes highlighted. The entire developed area of downtown (including parking facilities) is shown to be within a reasonable walking distance to the Trolley service. As mentioned, travel by the Trolley on South Parkway is avoided because of the lack of space available to avoid disrupting vehicle traffic flow during passenger drop-offs and pick-ups. Though South Parkway is a major pedestrian corridor, extensive Trolley service on this roadway would likely increase overall traffic congestion. However, a Trolley pullout complete with a traffic signal that utilizes a Trolley-actuated phase has been constructed in front of the Gatlinburg Chamber of Commerce building located at the North Parkway-East Parkway intersection. Tourist information, public parking, and other public facilities such as sitting areas and restrooms are available at this location making it an optimal transfer point for both the Green and Orange Lines.

Secondary Lines

The secondary Trolley routes include the Red and Yellow Lines. The Red Line is the only intercity public transportation currently offered between Gatlinburg and Pigeon Forge. The route, which is similar to a traditional express route, begins at the North park-and-

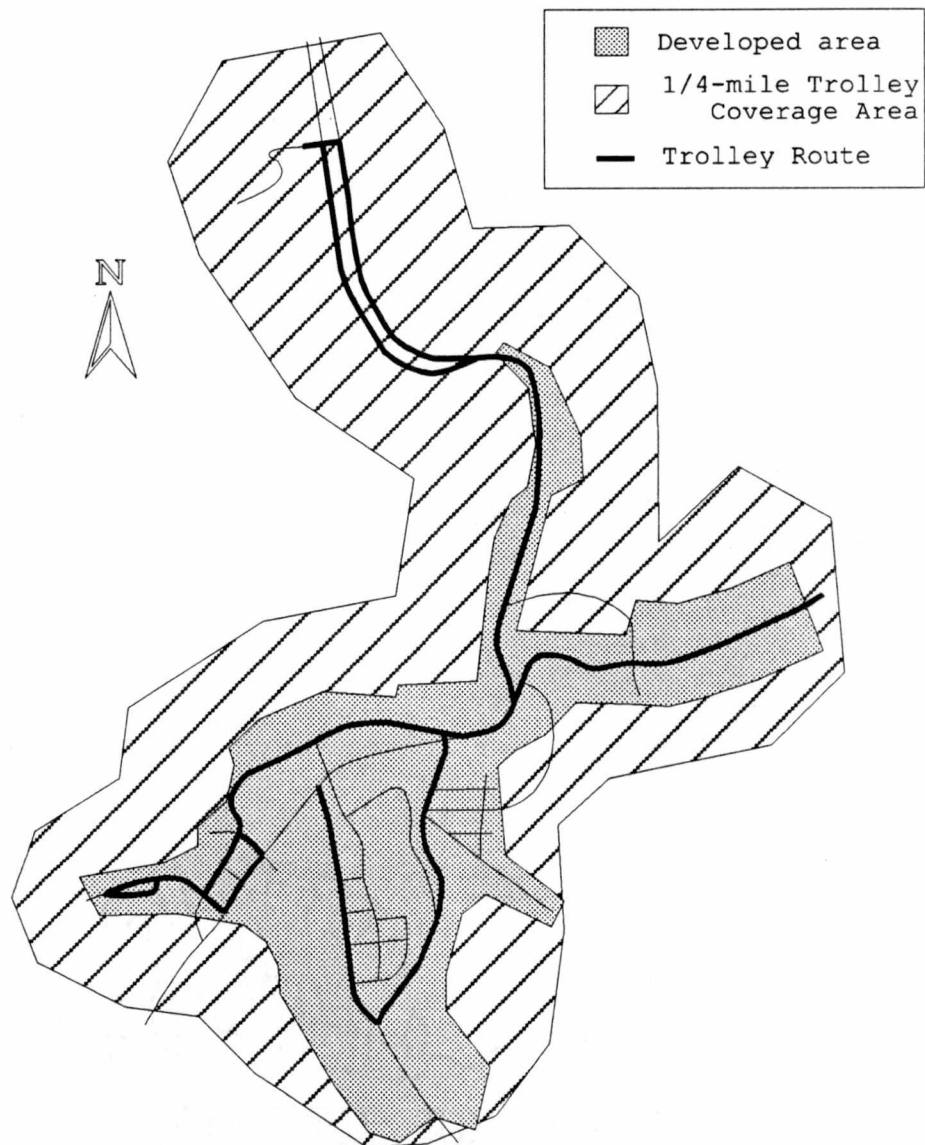
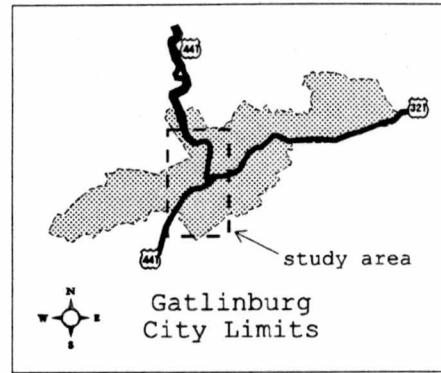
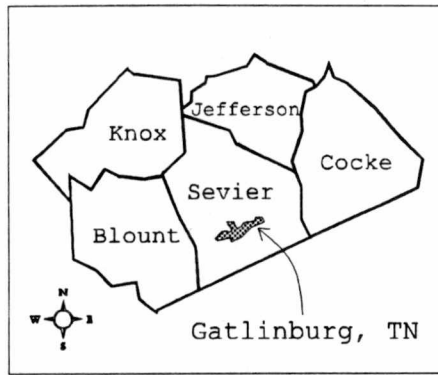


Figure 10. Trolley Coverage Area in Downtown Gatlinburg

ride lot, travels along US 441, and stops only at the Dollywood parking lot. No other stops by the Gatlinburg Trolley service within the City limits of Pigeon Forge have been approved by the Pigeon Forge City government. The Dollywood (a theme park in central Pigeon Forge) parking lot is also served by the Pigeon Forge Trolley and therefore serves as a transfer point between the two Trolley systems. Fare for the Red Line is 50¢ per person.

The Yellow Line of the Gatlinburg Trolley circulates through the "Arts and Crafts Community", a district of specialty shops, in the eastern part of Gatlinburg. The route forms a triangular loop along Glades Road, Buckhorn Road, and East Parkway. On East Parkway (US 321), the Yellow Line serves the Gatlinburg City Hall-Post Office buildings and the East park-and-ride lot. For a \$1.00 fare per person per day, riders have unlimited access to the Yellow Line.

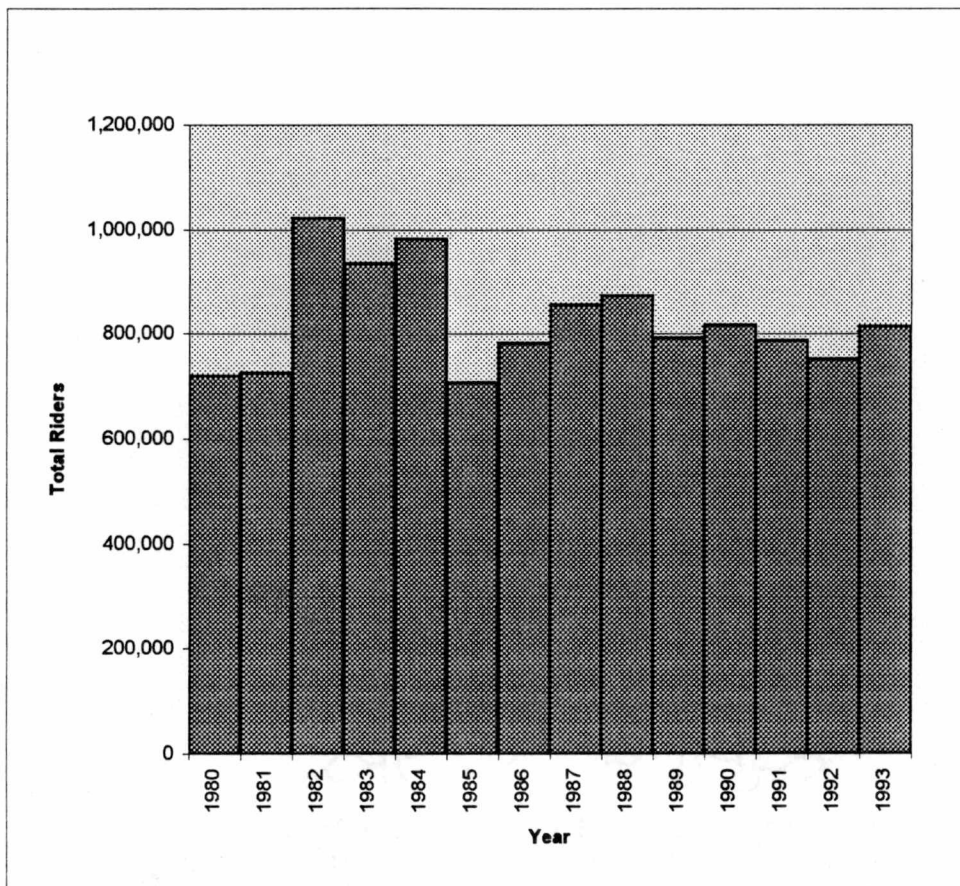
Use of the two park-and-ride lots is free to motorists. The North park-and-ride lot is located off US 441 behind the Gatlinburg/Smoky Mountains Welcome Center. The lot can accommodate about 116 vehicles and is served by the Green and Red Trolley Lines. The East park-and-ride lot lies along US 321 beside the Gatlinburg City Hall-Post Office buildings. This lot can hold up to 80 vehicles and is served by both the Orange and Yellow Trolley Lines.

Historical Ridership

Trolley ridership exceeded the expectations of the local and State governments initially and generated further support for the system from

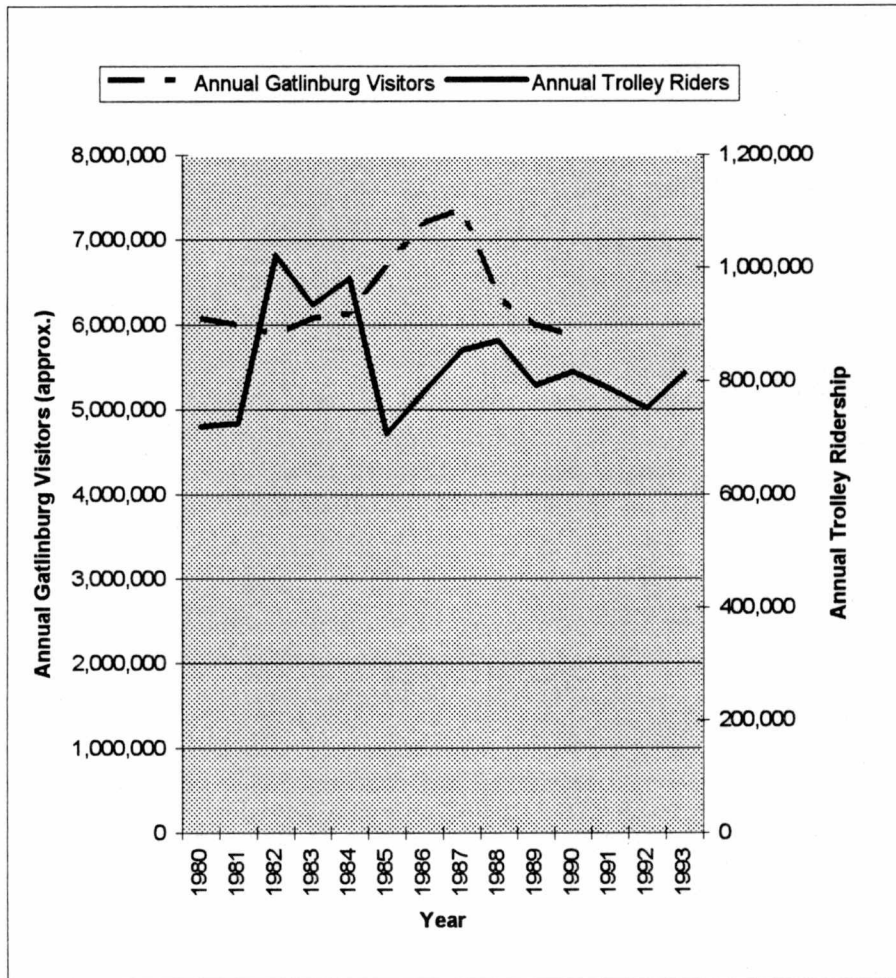
local officials. Annual ridership has remained relatively consistent as the fifth largest public transportation provider in the State behind Tennessee's major urban areas: Memphis, Nashville, Knoxville, and Chattanooga (Davis, 1994). However, ridership during two distinct periods since 1980 was likely affected as a result of outside circumstances. Due largely to the World's Fair being held in nearby Knoxville, Tennessee in 1982, regional tourism boomed that year causing total Trolley ridership to exceed one million in 1982. Use of the Trolley remained high for the succeeding years. In 1985, however, ridership dropped from 982,235 the previous year to an all-time annual low of 702,462--a year-to-year decrease of almost 29%. This slack in demand can be attributed to a fare increase from 10¢ to 25¢. Figure 11 shows the total annual ridership (including all Trolley Lines) from 1980 to 1993.

As expected, Trolley ridership is very seasonal and is dependent on the amount of tourism supported by the City. Gatlinburg consistently hosts approximately three quarters of the number of tourists that visit GSMNP annually. Likewise, the Gatlinburg Trolley's annual ridership (Gatlinburg Mass Transit Department, 1980-1994) has ranged between 10.5% and 17.4% of the number of total annual visitors to Gatlinburg (1981 Community Facilities Plan). The relationship of these quantities appears in Figure 12. In recent years, local tourism has declined somewhat which may reflect the weak national economic health during that time period. As a result of recent "low" tourism rates, a reliable



Source: Gatlinburg Trolley System Performance Reports, 1980-1993

Figure 11. Historical Trolley Ridership



Source: Gatlinburg Trolley System Performance Reports, 1980-1993; 1981 Community Facilities Plan; and 1991 Gatlinburg Land Use Plan

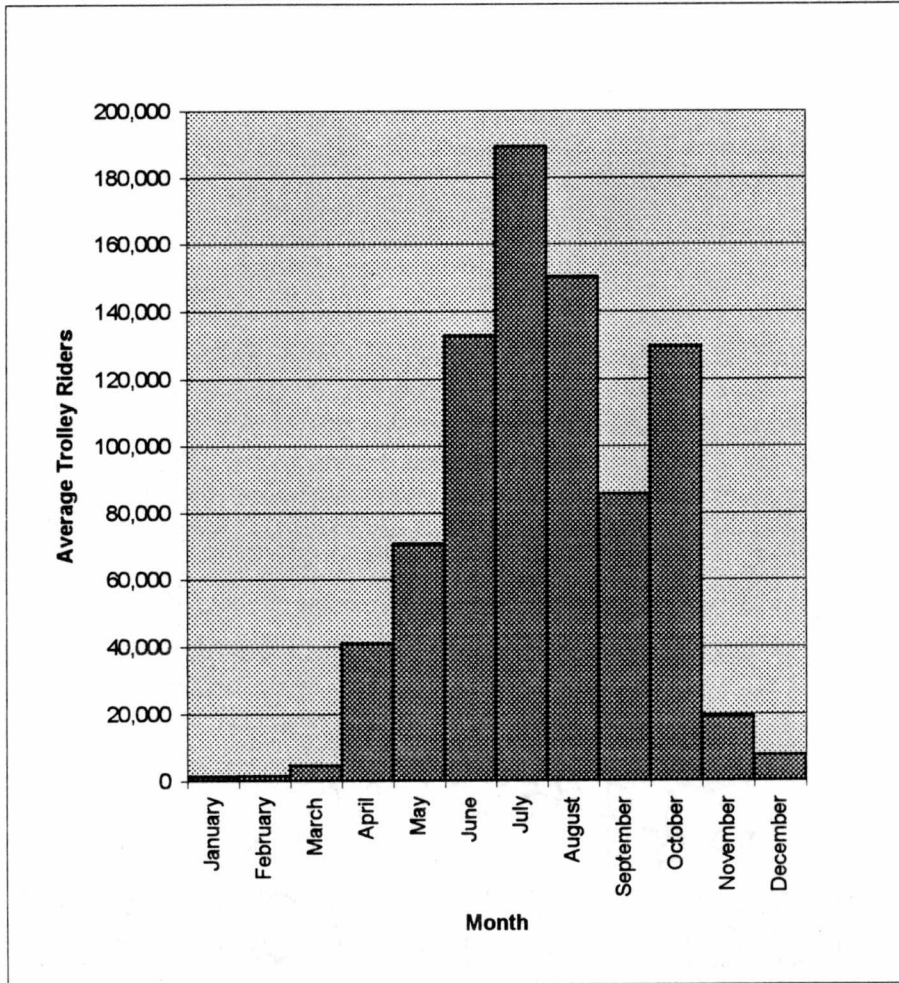
Figure 12. Annual Gatlinburg Tourists and Annual Trolley Ridership

estimation of a minimum demand for the Trolley service can be assumed at around 750,000 riders annually.

Trolley ridership, which is reflected by local tourism, peaks in the summer months as shown in Figure 13 (Gatlinburg Mass Transit Department, 1980-1994). On average, the months of June through October account for 83.5% of annual ridership. As mentioned, the Trolley service is often operated on a limited basis if it is operated at all during the months of January, February, and March. Individual holiday year. Independence Day and Labor Day are typical days when such peaking occurs (Gatlinburg Mass Transit Department, 1980-1994). Most ridership during the non-holiday or non-special event periods occur on Saturdays and Sundays. Although hourly ridership information is not available, some indications may be available from traffic volumes. For example, traffic counts were conducted at the intersection of North Parkway-East Parkway in July of 1993 (University of Tennessee Transportation Center, 1993). The data, from a typical twenty-four-hour weekday period during the peak season, indicates that travel demand is highest and remains relatively constant between the hours of 9:00 AM and 7:00 PM. Six to seven percent of the day's traffic occurs each hour for the entire ten-hour period (Figure 14).

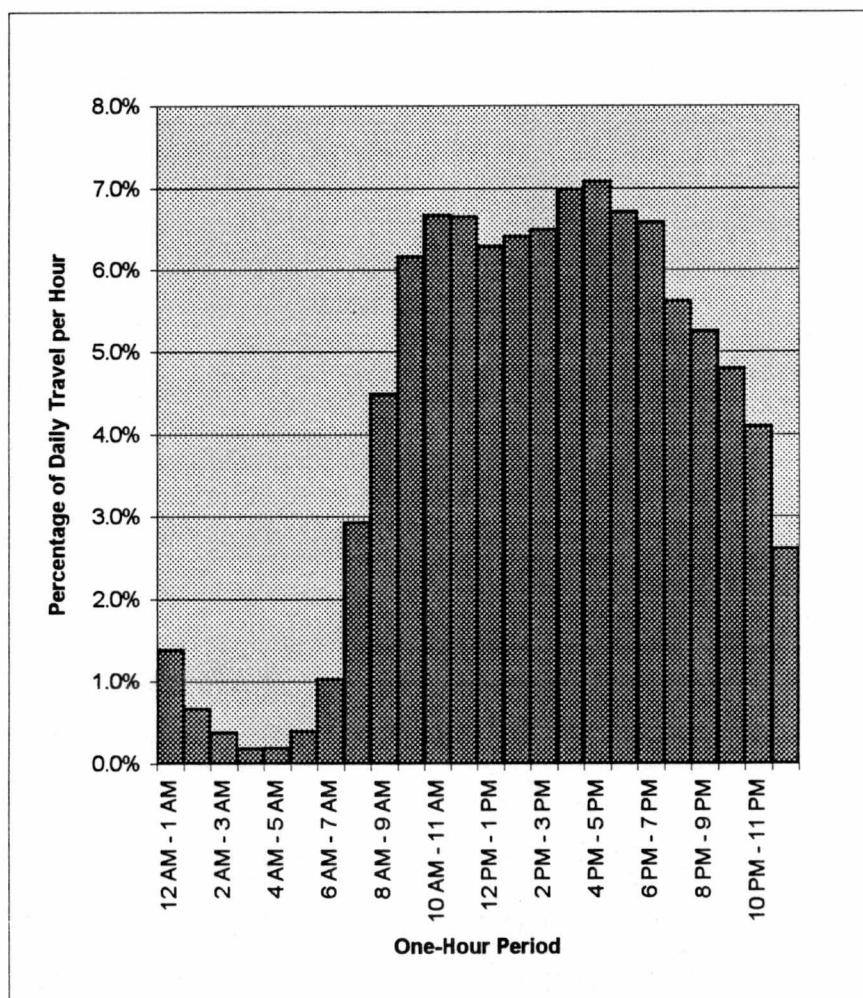
Transit Resources

When the Trolley service began in 1980, the fleet consisted of six Trolleys. The fleet then increased by two in 1985 and by six in 1993



Source: Gatlinburg Trolley System Performance Reports, 1980-1993

Figure 13. Average Trolley Ridership per Month from 1980-1993



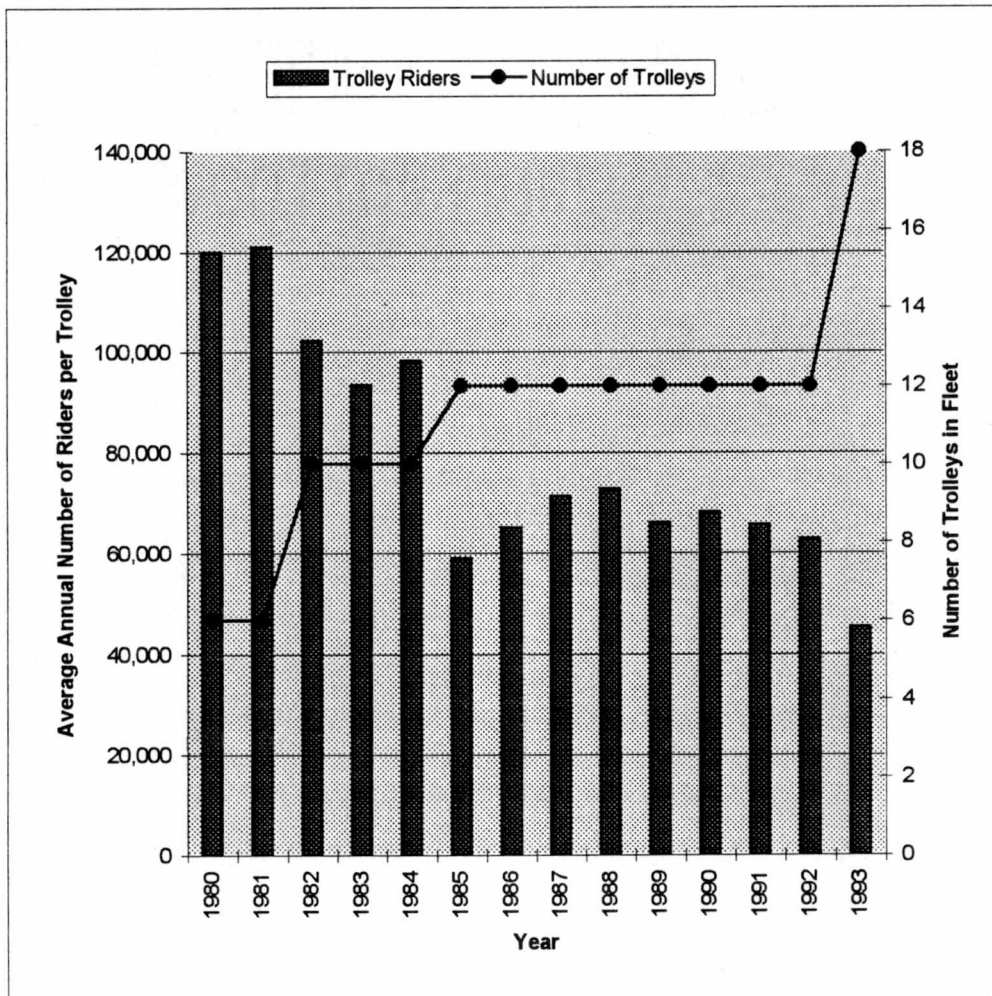
Source: University of Tennessee Transportation Center, 1993

Figure 14. Hourly Travel Distribution at the North Parkway-East Parkway Intersection for July 26-27, 1993

for a total of eighteen vehicles currently including mini-Trolleys which have a seating capacity of sixteen as opposed to a full-size Trolley which has a seating capacity of twenty-eight (Gatlinburg Mass Transit Department 1980-1994). During peak demand periods it is necessary for many riders to stand in the aisles. The increasing fleet size has better accommodated the number of Trolley riders by reducing the ratio of annual passengers per Trolley (Figure 15), but demand continues to exceed seating capacity during peak travel.

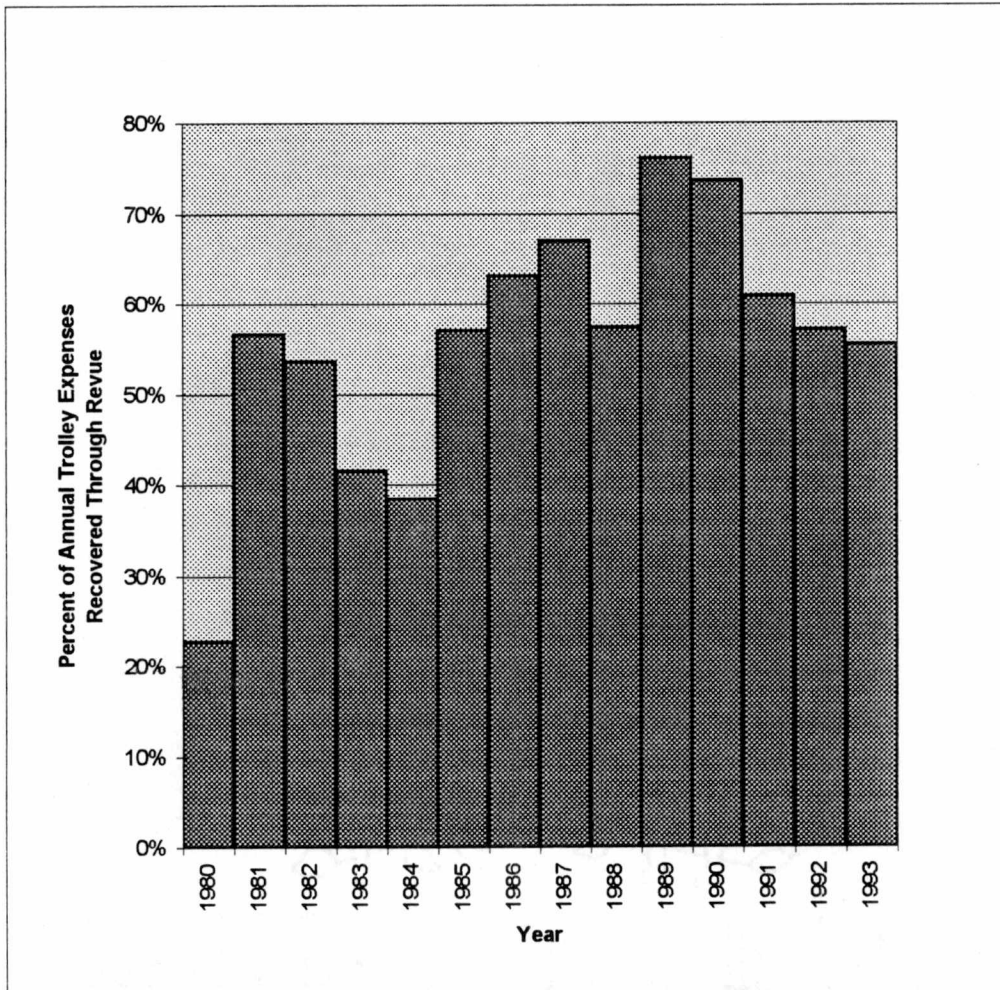
Operational expenses for the Trolley include staff (administrative and driver) salaries, vehicle maintenance and operation, and promotional and informational signing and literature. Trolley service revenue is generated by fare collection, the renting of advertising space onboard the Trolleys, and chartering the Trolley service upon request to touring groups. Figure 16 shows the trend of the percentage of annual operational expenses recovered by annual revenues (Gatlinburg Mass Transit Department, 1980-1994). The local portion of Trolley subsidy is generated mainly through the Parking Lot Department and from the local budget when parking revenues alone are insufficient (Parton, 1993). The total cost per passenger-trip served by the Trolley has increased as presented in Figure 17. The historical financial data for the Trolley service is discussed in the following chapter.

The Gatlinburg Trolley System is operated from the City's joint Mass Transit/Parking Lot Department. A Mass Transit director oversees the daily activities and responsibilities of the service. Operation of



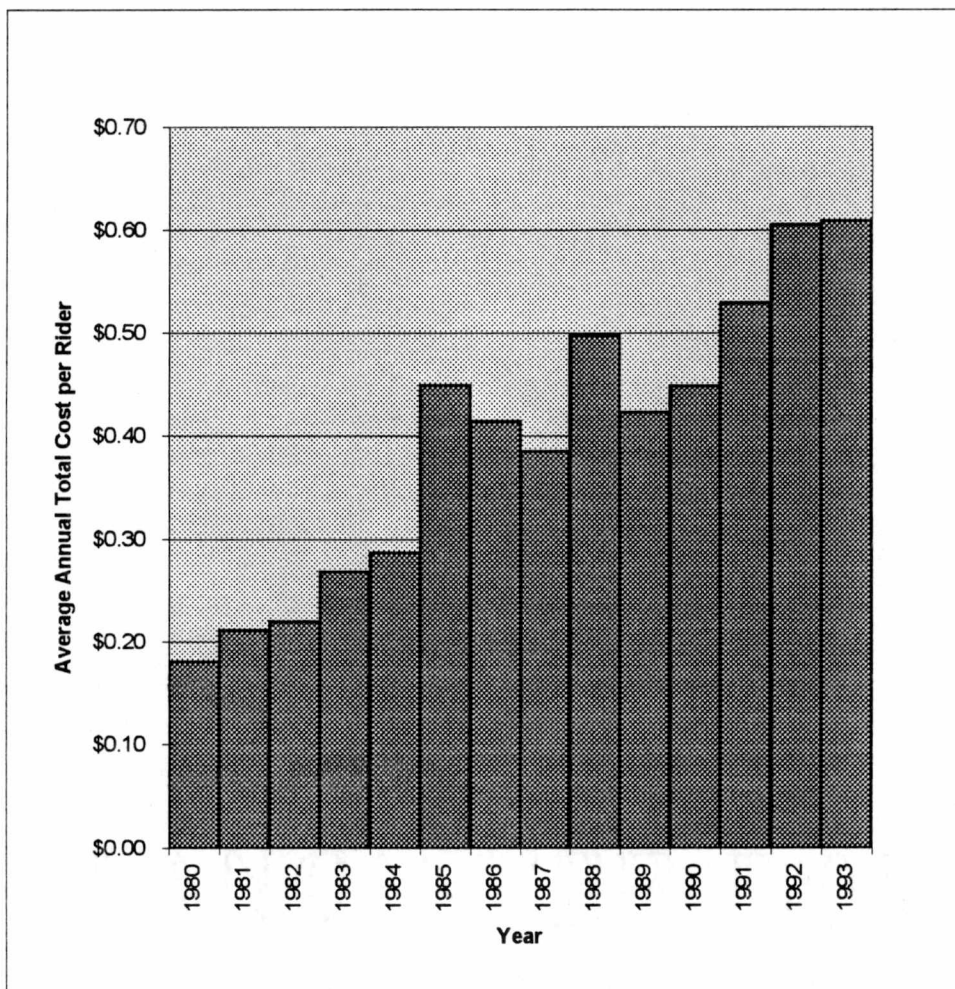
Source: Gatlinburg Trolley Performance Reports, 1980-1993

Figure 15. Historical Trolley Fleet Size and Average Annual Trolley Riders per Trolley



Source: Gatlinburg Trolley System Performance Reports, 1980-1993

Figure 16. Percentage of Annual Trolley Operation Expenses Recovered by Fares, Advertising, and Charter Service



Source: Gatlinburg Trolley System Performance Reports, 1980-1993

Figure 17. Average Annual Total Cost per Trolley Ride

the Trolleys are funded locally and by TDOT. Federal funding is used only for capital expenses.

As mentioned in Chapter 2, the traffic conditions are very poor based on LOS and are expected to worsen if no major improvements are implemented. Traffic conditions expected in the future without transportation improvements will make travel very unattractive to tourists and could severely impact the local tourism industry on which the City and citizens of Gatlinburg thrive. The State of Tennessee also could experience financial loss because of the significant tax base provided by the City. The alternatives available to avoid the extreme conditions are limited to expansion of the existing transportation facilities as recommended in the previously mentioned planning documents or continued investment in the Trolley service. These alternatives are the topic of the comparison in the following chapters.

Chapter 5

Analysis Procedure

The methodology adopted for defining the impact which the Trolley service has had on the local transportation system in Gatlinburg consists of an economic comparison analysis as well as an observation of non-monetary benefits related to the Trolley service. The cost and benefit terms are defined in this chapter which is followed by detailed descriptions of the procedures used to complete the analysis.

Definition of Terms

For this study "benefits", B_i , are defined as economic and other costs which are avoided as a result of the Trolley service. Generally benefits are a function of reduced traffic congestion:

$$B_i = f(\text{congestion reduction}) \qquad \text{Equation 1.}$$

These costs include those associated with the overall in-vehicle delay time at critical intersections. The costs are reduced as a result of removing vehicles from the traffic stream in congested areas which can be accomplished through the Trolley service or by other alternatives to driving private automobiles. It is assumed that, at a minimum, passengers traveling aboard the Trolley would travel the same number of vehicle-miles in private automobiles if the Trolley were not available.

Other benefits of the Trolley system to the City of Gatlinburg are intangible. Environmental, social, and other factors are improved when

vehicle congestion is reduced. The community experiences less air pollution largely as a result of less automobile idle time due to reduced delay at critical intersections and fewer automobiles on the road. Reduced congestion, in general, also has positive psychological and social impacts as well as stress and anxiety reduction for travelers and citizens. Fewer automobiles also reduce the frequency of road repairs and increase pedestrian safety. Though outside research may be available to quantify or more nearly define these statements, they are considered intangible (not quantifiable) for this report.

Next, the "cost" terms, C_1 , in the analysis are defined as the expenses which are required as a result of operating the Trolley system:

$$C_1 = f(\text{Trolley operation}) \quad \text{Equation 2.}$$

Trolley costs include capital and operational expenses which are necessary to maintain the Trolley service. Capital expenses are used to purchase a wide variety of resources for the expansion and replacement of Trolley facilities such as electronic equipment (e.g. radio communications), infrastructure needs (e.g. pullouts, maintenance and storage facilities), and the Trolley fleet. These capital costs have not been consistent from year to year, while operating expenses (e.g. salaries, fuel, maintenance) have been recorded throughout the life of the Trolley and can be averaged for an assumed annual value. These operational expenses, which are shared on the local, State, and Federal levels of government, can be analyzed for the existing Level-of-Service (LOS) provided by the Trolley and for projected Levels-of-Service.

Level-of-Service can be defined by several methods, but the method used in this analysis reflects the magnitude of average vehicle delay experienced at a particular intersection in the CBD due to the traffic congestion as defined by the Highway Capacity Manual.

Costs also include infrastructure improvements expenses which would be necessary to reduce delay without a public transportation service in place. These costs consist of such items as increasing roadway capacity and parking supply. For the purposes of this report, it is assumed that without the Trolley or a similar public transportation service, such investments would be essential to avoid a breakdown of the local transportation system brought about by the travel demand created by tourists and local traffic in Gatlinburg.

Benefit Items

The following section individually identifies various benefit items used in this analysis. To quantify the benefit items, independent research and analysis was conducted to develop a basic understanding of the existing Trolley service characteristics. The research methodology and the subsequent conclusions used to develop this understanding are described in the following paragraphs.

Delay at Critical Intersections

The Trolley service provides an opportunity to manage the amount of delay to travelers by offering an alternative to driving private automobiles. When travelers utilize the Trolley, it is assumed vehicles and hence congestion are removed from the streets, however a base delay

associated with the present street network will exist independent of the Trolley service. The Trolley or other alternative to driving private automobiles has the opportunity to minimize this cost to the users of the transportation facilities in the City of Gatlinburg.

These vehicle trips removed from the roadways by the Trolley decrease congestion which in turn reduce overall delay time during travel. The magnitude of that decrease in delay time can be approximated with information about existing travel conditions and public transportation resources, and, in turn, the public transportation resources necessary to obtain an improved Level-of-Service can be projected. For example, assuming the rate of travel per bus remains constant, by adding more Trolley buses to the service fleet, more Trolley trips would be made and more vehicles would be removed from the roads which would further reduce the overall traffic delay. To calculate the delay, the existing traffic patterns must be considered.

Daily Traffic Patterns During the Peak Period

North Parkway, South Parkway, East Parkway, and Airport Road are the major thoroughfares in the City on which most of the vehicle traffic travels in Gatlinburg. Practically all vehicles must travel through the segment of road between the intersections of North Parkway-East Parkway and South Parkway-River Road-Cherokee Orchard Road (Figure 18) for most all trips within the City. During the peak travel months, this segment remains congested with through traffic and turning movements which cause near gridlock conditions on a regular basis. Though the intersections

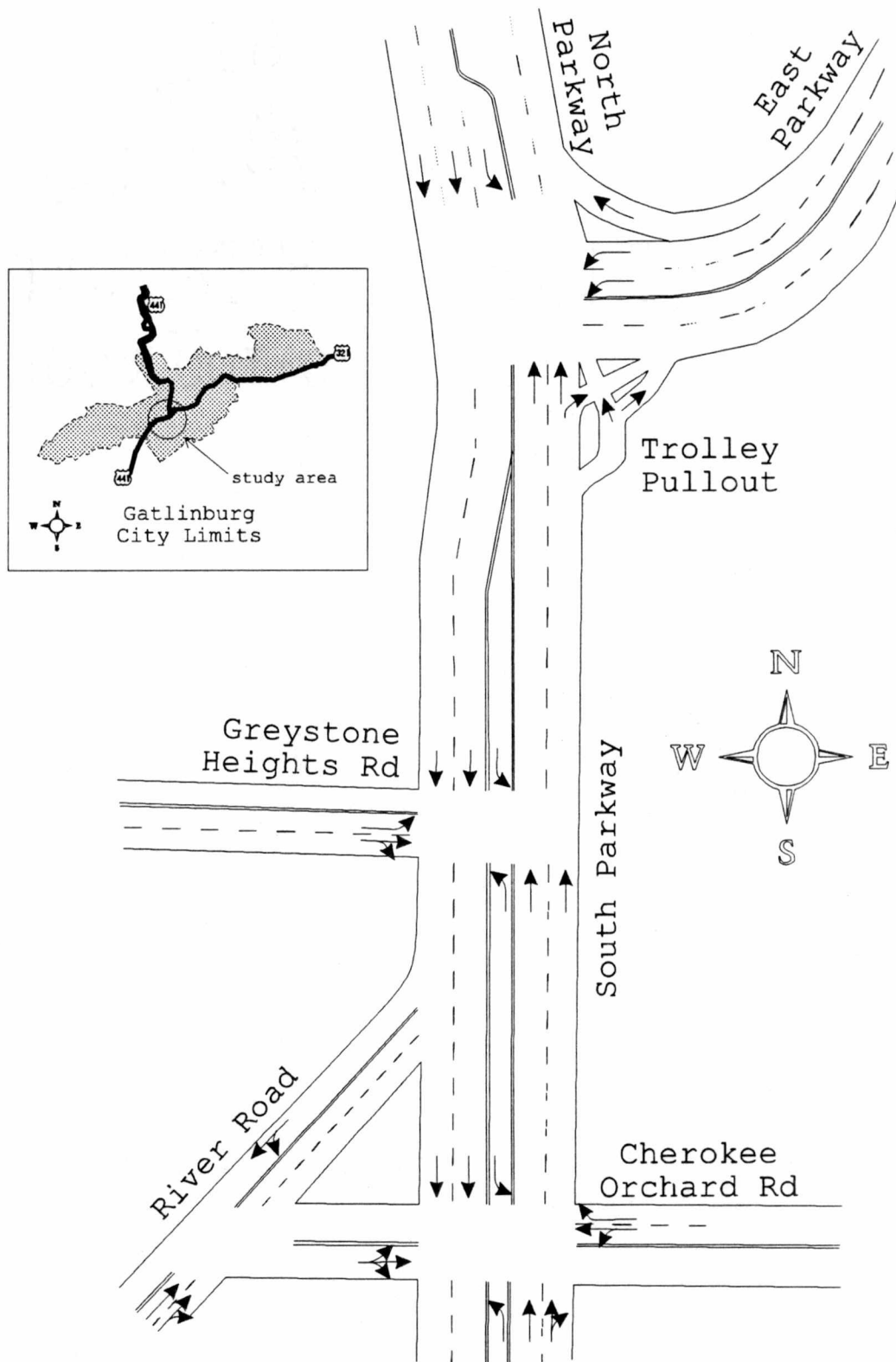
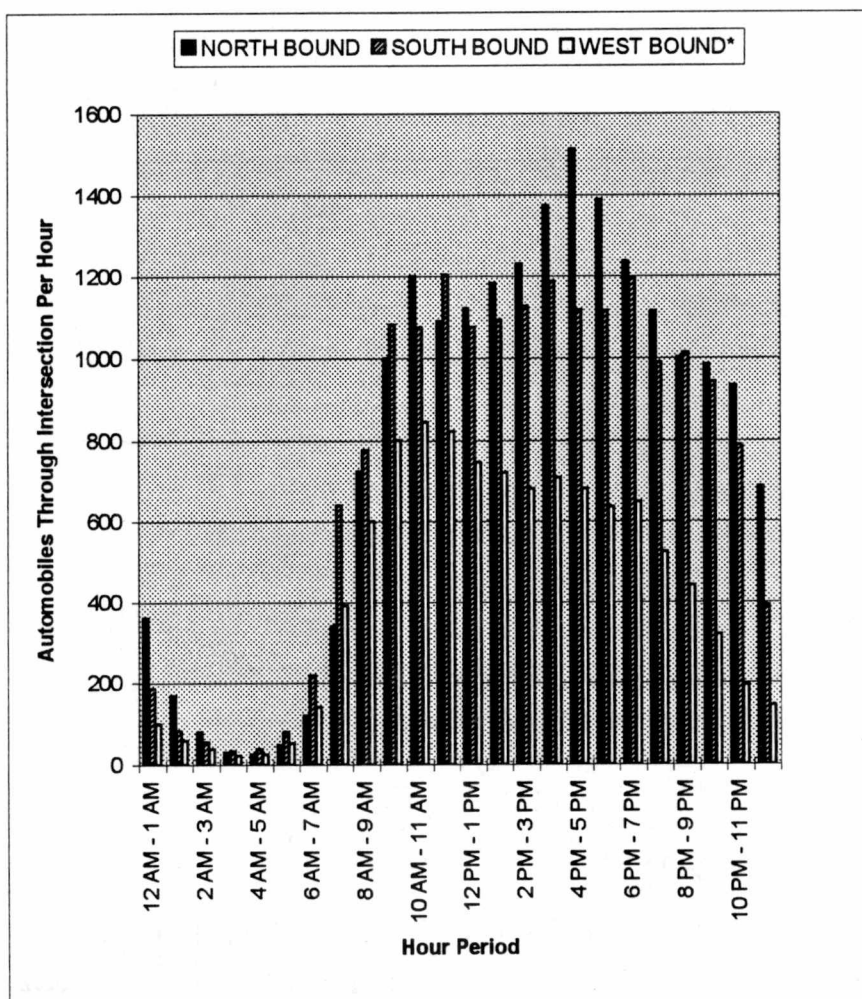


Figure 18. Lane Configuration at the North Parkway-East Parkway & South Parkway-River Road-Cherokee Orchard Road Intersections

are signalized, the backup of traffic frequently spills into the adjacent intersections blocking side-street traffic movement. This has prompted the City police department to hire cadets each summer season to override the traffic signals and control the flow of traffic manually when congestion becomes too severe for the signals to effectively accommodate. Congestion reaches this level several times each day during the peak season.

The delay at these two intersections initiates much of the City's overall congestion experienced by motorists because of the central location of the intersections relative to City-wide travel patterns. Directional traffic count (Figure 19) and turning movement (Table 1) data at the intersection of North Parkway-East Parkway were collected by the University of Tennessee Transportation Center on July 26 and July 27, 1993. Analysis of this location (the major of the two intersections) would reflect the existing LOS for the intersection which will be used to determine the overall delay for the local road network in the next chapter.

As mentioned earlier, transit ridership is directly proportional to overall travel which peaks in the summer, particularly the month of July. The dates on which the traffic counts and turning movements were taken represent what is assumed to be a typical 24-hour period for the month of July (a non-holiday weekday). Once travel conditions for July are established, the remaining months' travel values can be prorated



Source: University of Tennessee Transportation Center, 1993.

* Westbound traffic volumes between 2:00 AM and 11:00 AM were not available but were estimated based on the ratio of westbound traffic to the northbound plus southbound traffic during hours where data was available.

Figure 19. Traffic Counts by Direction at the North Parkway-East Parkway Intersection from July 26-27, 1993

*Table 1. Turning Movement Counts for the
North Parkway-East Parkway Intersection*

	SOUTHBOUND		WESTBOUND		NORTHBOUND		
HOUR	LEFT	THROUGH	LEFT	RIGHT	THROUGH	RIGHT	TOTAL
10:00 AM - 11:00 AM	204	856	469	290	775	260	2,854
11:00 AM - 12:00 PM	247	967	491	276	689	276	2,946
12:00 PM - 1:00 PM	241	827	416	230	680	299	2,693
1:00 PM - 2:00 PM	170	618	325	185	541	227	2,066
4:00 PM - 5:00 PM	337	715	365	328	833	498	3,076
5:00 PM - 6:00 PM	281	684	333	256	832	451	2,837
6:00 PM - 7:00 PM	262	688	317	232	708	296	2,503

assumed to represent all days of the year based on several personal observations of traffic patterns.

Delay Reduction at the Critical Intersections Due to the Trolley

In order to determine the impact of the Trolley on relieving some of the downtown congestion, the traffic counts and turning movements were analyzed using the Highway Capacity Software (HCS) (*Special Report 210*, 1985). HCS produces the LOS and the average stop delay time per vehicle for an intersection and its approaches based on travel and physical characteristics of the intersection as outlined in Appendix B from the Highway Capacity Manual.

Among the traffic conditions at the North Parkway-East Parkway intersection, traffic counts, turning movement counts, and the traffic signal timings are needed for input for HCS. The traffic signal utilized at the subject intersection currently operates with four phases per cycle as shown in Figure 20 (Marine, 1994). Phase 1 allows US 441 southbound through and northbound through and right-turning traffic to proceed through the intersection over a forty-second phase. Phase 2 is a twenty-three-second actuated phase for US 441 southbound left-turning and through traffic. During the peak travel period being analyzed, left turning traffic is assumed to be present at all times causing Phase 2 to engage during each cycle. Phase 3 allows two movements: a fourteen-second all pedestrian phase including a seven-second clear time followed by the advance of US 321 westbound traffic for an additional thirty-second period. Since the intersection is three-legged, westbound

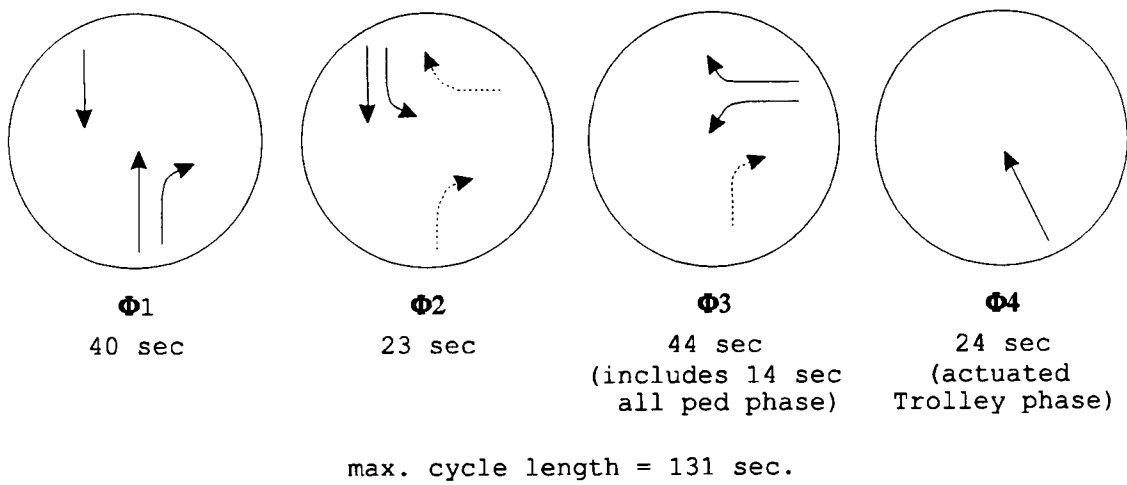


Figure 20. Existing Parkway Intersection Signal Phasing

traffic can only move right or left as presented in Figure 18. Phase 4 is another actuated phase which is controlled by the Trolleys as they leave the pullout area in front of the Gatlinburg Chamber of Commerce. This "Trolley phase" consists of twenty seconds of green time plus a four-second yellow and all-red time (all phases except Phase 4 include a five-second yellow and all-red period). Phase 4 is an actuated Trolley phase which does not occur during each cycle. It is estimated to approximately engage once every seven and one half minutes or every ten cycles based on Trolley headways. The maximum cycle length for the existing phase scheme is 131 seconds.

In the HCS analysis, Phase 2 was expected to occur during each cycle due to the high demand for southbound left turns, and Phase 3 was divided into two new phases: The "new" Phase 3 became the all-pedestrian phase and the "new" Phase 4 consisted of the vehicular movements of the "old" Phase 3. The "old" Phase 4 was eliminated as a phase, but the time of the old Phase 4 was prorated and equally distributed over each remaining phase within the yellow and all-red times. Figure 21 shows the equivalent phasing scheme used in the HCS. An overall cycle length of 109.5 seconds was used which is equivalent to approximately thirty-three cycles per hour. An estimated four vehicles per cycle for the northbound and westbound traffic were assumed to turn right during the red times giving an hourly right-on-red volume of 132. Based on the turning movement analysis performed by the University of Tennessee Transportation Center on the turning movement data, a peak

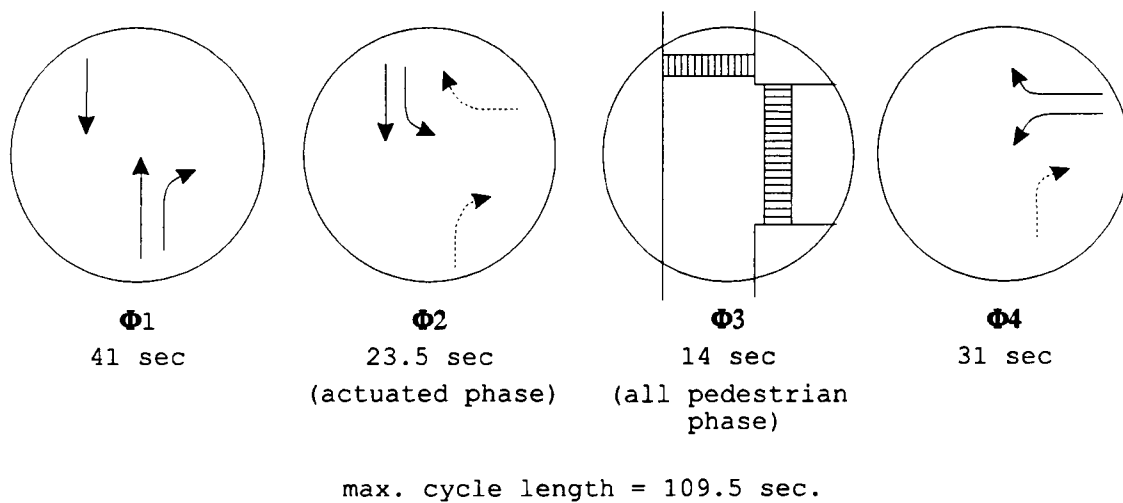


Figure 21. Equivalent Existing Parkway Intersection Signal Phasing Used in HCS

hour factor of 0.93 was used throughout the model. Also, pedestrian volumes were estimated at 200 pedestrians per hour per direction. A 5% heavy vehicle factor was also used. Turning count data also collected by the University of Tennessee Transportation Center for the 11:00 AM to 12:00 PM hour at the subject intersection were used in the analysis. The HCS model estimated an overall delay per vehicle of 29.4 seconds for the existing conditions which corresponds to a LOS "D". The volume-to-capacity (V/C) ratio equaled 0.651 (HCS output for all existing and estimated cases is presented in Appendix C).

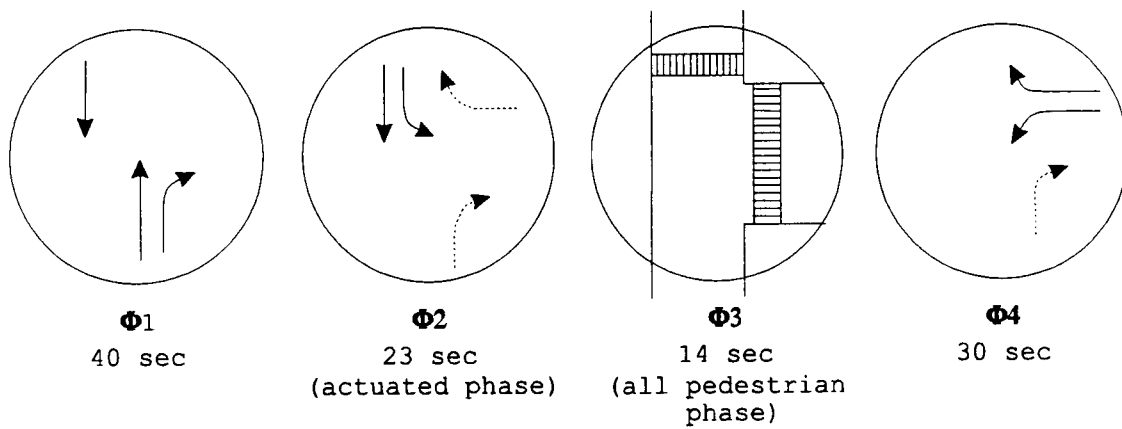
The traffic service levels at the existing conditions can be compared to the LOS conditions estimated if no Trolley service existed. The 106 vehicles per hour removed by the Trolley fleet were equally distributed across all traffic movements at the intersection for a volume distribution shown in Table 2. The 2.5 seconds per cycle that accounted for the "Trolley phase" (the "old" Phase 4) were eliminated because no Trolley service is assumed in this scenario (Figure 22). Analyzing these modified traffic volumes and modified signal phasing yielded an increase of over ten seconds in average delay for the intersection for a delay of 33.4 seconds per vehicle, and the LOS remained at "D". The V/C ratio rose to 0.670. As indicated by this analysis, even a relatively small increase in traffic at this intersection during peak travel conditions degrades the travel environment for motorists. Thus, the importance of removal of any vehicles from the critical area during peak travel should not be

*Table 2. Vehicles per Hour Removed from the
North Parkway-East Parkway Intersection by Trolley*

data from July 26-27, 1993		EXISTING CONDITIONS DURING HOURS OF TROLLEY OPERATION		ESTIMATED CONDITIONS WITHOUT TROLLEY	
BEGIN HOUR	END HOUR	TOTAL VEHICLES THROUGH INTERSECTION	PERCENTAGE DISTRIBUTION	VMT REDUCED DUE TO TROLLEY ¹	VEHICLES REDUCED DUE TO TROLLEY ²
8:00 AM	9:00 AM	2,099	4.83%	128	71
9:00 AM	10:00 AM	2,883	6.63%	176	98
10:00 AM	11:00 AM	3,120	7.18%	191	106
11:00 AM	12:00 PM	3,116	7.17%	191	106
12:00 PM	1:00 PM	2,942	6.77%	180	100
1:00 PM	2:00 PM	2,997	6.90%	183	102
2:00 PM	3:00 PM	3,039	6.99%	186	103
3:00 PM	4:00 PM	3,268	7.52%	200	111
4:00 PM	5:00 PM	3,311	7.62%	203	113
5:00 PM	6:00 PM	3,139	7.22%	192	107
6:00 PM	7:00 PM	3,081	7.09%	188	105
7:00 PM	8:00 PM	2,625	6.04%	161	89
8:00 PM	9:00 PM	2,454	5.65%	150	83
9:00 PM	10:00 PM	2,244	5.16%	137	76
10:00 PM	11:00 PM	1,915	4.41%	117	65
11:00 PM	12:00 PM	1,223	2.81%	75	42
TOTAL		43,456	100.00%	2,658	1,477

¹ The VMT reduced from the Gatlinburg street network due to the Trolley are based on the 2,658 VMT calculated in Table 4 which are distributed using the hourly percentages of total vehicle through the North Parkway-East Parkway intersection. All vehicle removed by the Trolley are assumed to have traveled through this intersection.

² The vehicles reduced from the Gatlinburg street network due to the Trolley is equivalent to the VMT reduced due to the Trolley divided by the average trip length of 1.80 miles.



max cycle length = 107 sec.

Figure 22. Equivalent Parkway Intersection Signal Phasing Used in HCS without Trolley

underestimated. Other values of delays are estimated in the next chapter to determine annual delay cost values based on the hourly and monthly travel distributions (travel during each day of the week is assumed to remain constant).

To achieve a more acceptable LOS near "C", the number of vehicles to be removed from the intersection was determined assuming the existing signal timing scheme is maintained. The 106 vehicles per hour currently removed from the North Parkway-East Parkway intersection during the hour of 11:00 AM to 12:00 PM for the average July day requires a fleet of eighteen Trolleys. To achieve a LOS of "C" as determined by HCS, removal of almost 480 vehicles per hour from the intersection is necessary which would require a Trolley fleet of at least eighty vehicles assuming the rate of automobile removal per Trolley remains constant. This is not practical for the City of Gatlinburg, however a LOS "D" or better can be achieved during the peak hours with a doubled fleet size. For analysis purposes, a Trolley fleet that is doubled the existing size for a total of thirty-six Trolleys will be used to represent a level of upgraded Trolley service to investigate the economic justification of investing further resources in the Trolley system. The magnitude and cost of Trolley service improvement to achieve this LOS is determined in the next chapter.

Cost Items

This section individually identifies the cost items used in this analysis. To quantify the cost items, traffic data was collected and analyzed from the subject Gatlinburg street intersection at North

Parkway and East Parkway. Also, operating costs for the Gatlinburg Trolley were collected from the Gatlinburg Mass Transit Department and the Tennessee Department of Transportation to obtain a basic understanding of the existing Trolley service characteristics. Cost items also include any costs associated with an alternative to operating the Trolley service for the purpose of improving mobility such as roadway and parking improvements.

Survey of Trip Characteristics

A survey, which appears as Figure 23, was developed and administered to Trolley riders on a voluntary basis to gauge various trip characteristics (survey results are shown in Appendix D). In general, the information obtained from the ridership survey determined the Trolley users, the trip purpose, and how frequently the Trolley was used for substitution of private automobile travel. When comparing the full time population of Gatlinburg to the peak day population which consists largely of visitors, it can be assumed that many of the Trolley riders are visitors to the City. A visitor, or tourist, to Gatlinburg is defined as one who does not live or work in Sevier County, Tennessee.

Trip purpose for Trolley trips were determined based on the destination identified by each group of passengers. Classifications of trip purposes were divided between specific and general destinations. A specific destination included the return trip home or to the hotel, trip to the private automobile, or other known location for a specific reason. A general destination involved a trip with multiple or

nonspecific purposes such as that of shopping and/or sightseeing. This latter group will be referred to as "casual" trips.

In this research, it is also important to establish the number of automobile trips replaced by the Trolley. In order to do this, information was gathered on the following: travel group size, automobile availability, automobile parking location, trip origin and destination, length of stay in Gatlinburg, and number of daily Trolley trips made at the time of the survey. A separate observation was performed in which the average Trolley trip length was determined. This information was also used to develop assumptions on the travel patterns of tourists.

Results of Trip Observation

The survey of Trolley riders was conducted during the summer of 1993. One hundred eighty-eight riders were randomly selected to participate in the survey. Two-thirds of the survey results were collected from the Green Line riders and the remainder of results were based on riders from the Orange Line. The time periods during which the surveys were administered included weekday AM (31% of surveys), weekday PM (29%), and weekend (40%).

Ninety-two percent of the Trolley riders were identified to be tourists. The travel group size (Figure 24) averaged 3.12 person per group which is consistent with demographic data provided from the Gatlinburg Chamber of Commerce ("Gatlinburg, Tennessee Demographic

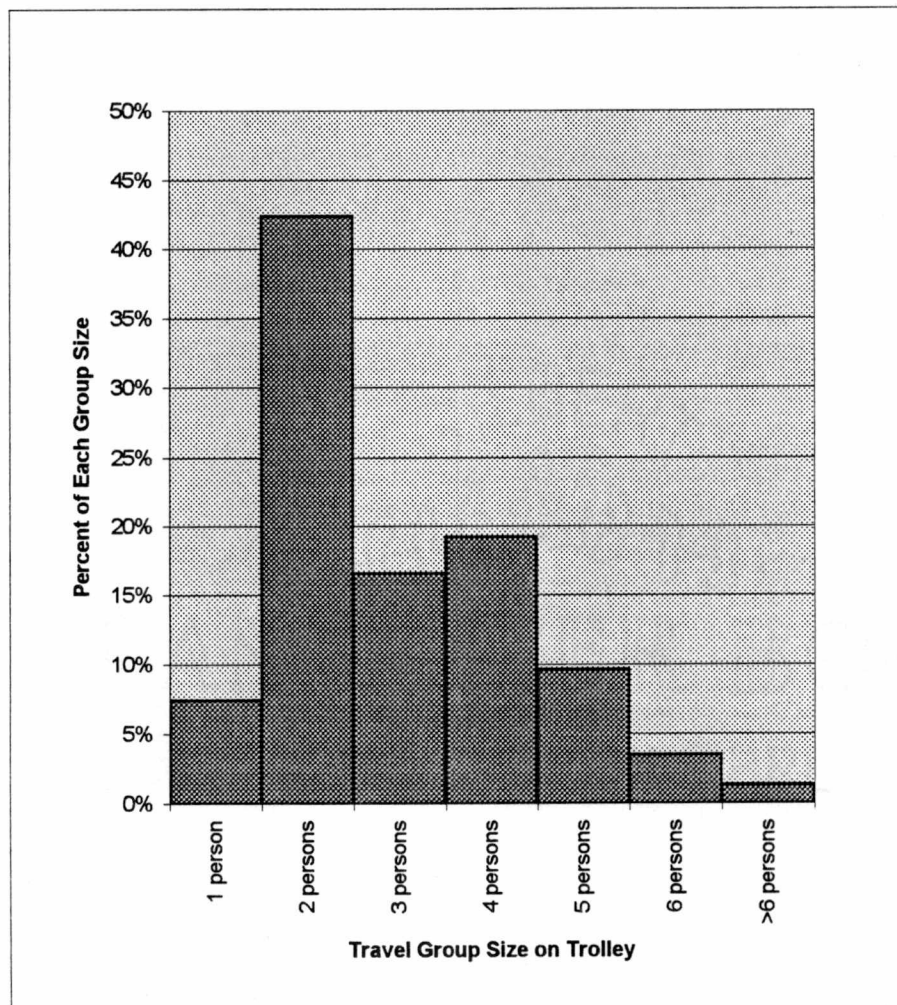


Figure 24. Trolley Travel Group Size Distribution Based on Survey

Profile", 1993). Some parties were too large to travel in a single automobile, therefore 1.02 automobiles on average were required per group for non-Trolley automobile travel according to the survey. Ninety percent of riders stated they could have made the particular trip by using a private automobile instead of riding the Trolley.

The lengths of Trolley trips were well distributed between very short trips and long trips (Figure 25). Again, two-thirds of the trip length data were collected from the Green Line and the remaining one-third from the Orange Line. Fifty-one pairs of trip ends were identified on maps, and the road distances from origin to destination were measured. Many of the Trolley riders, particularly on the Green Line, backtrack over part of the route during a Trolley trip. In other words, many riders: board the Trolley at a location, "A"; ride to the end of the Trolley route, "B", where the Trolley turns around to travel toward the other end of the route; and alight at a location, "C", which has been served on the same trip between "A" and "B". This distance of "overlap" was not represented in the trip length data unless a complete loop of the route was made during the trip. For example, two of the observed Green Line trips boarded and alighted the Trolley at the same location after traveling the entire route for a measured travel distance of 6.63 miles; the remaining trip lengths on the Green Line were defined and recorded as the road distance along the Trolley route between the Trolley trip origin and the Trolley trip destination, excluding any overlap distance. The overall average Trolley trip length was 1.80 miles.

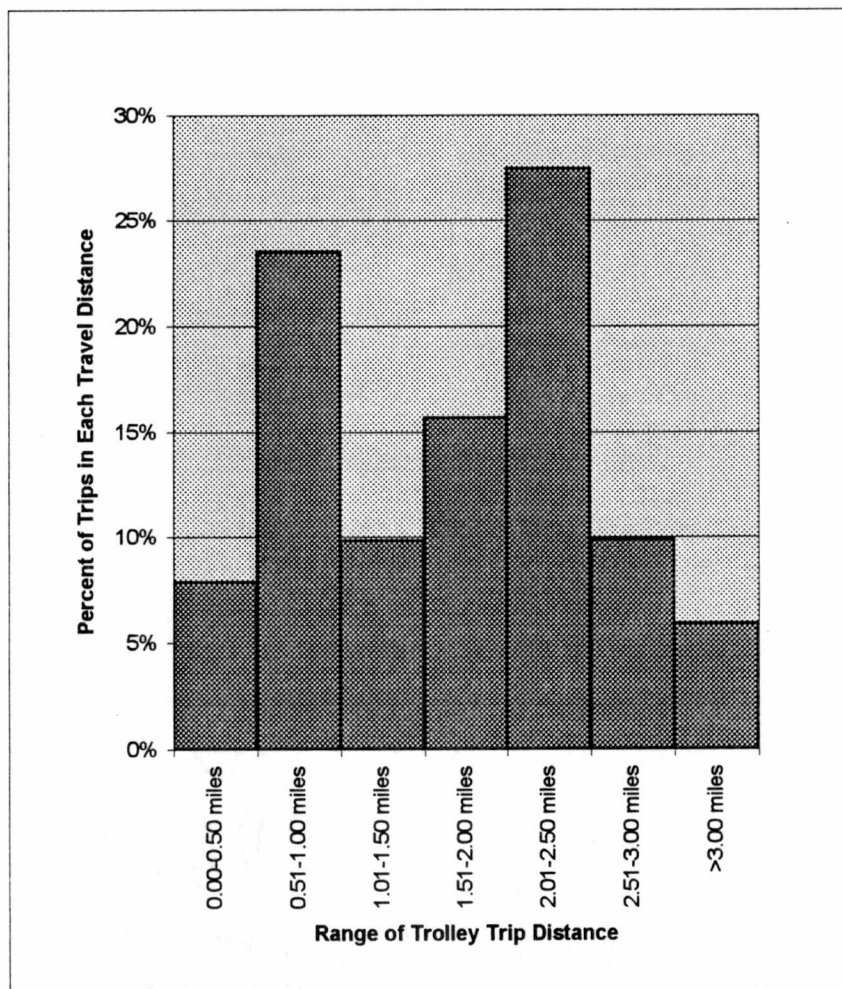


Figure 25. Trolley Trip Length Distribution Based on Observation

Those Trolley riders with available automobiles were asked where their vehicles were parked. Fifty percent indicated their automobiles were parked at the place of lodging, 35% were parked at one of the two park-and-ride lots, and the remaining 15% were parked either at a pay-parking lot, on-street, or at a local business. Trip origins were almost equally distributed among: the place of lodging, the private automobile, or a street location where Trolley patrons changed travel mode from walking to transit (37%, 34%, and 29%, respectively). Trip destinations were used to determine the purposes of the trips. The majority (74%) of trip purposes were for shopping or sightseeing, or were "casual" as described earlier; the remaining trips alighted at specific locations such as the place of lodging (8.5%), the private automobile (8.5%), or other defined location (9.0%). Approximately two thirds of Trolley riders were staying overnight during their trip to Gatlinburg, the remaining one third are referred to as "day visitors". Finally, 73% of riders were making their first Trolley trip of the day at the time of answering the survey.

Several conclusions can be made from these tabulations. Due to the high number of "casual" trips, it can be assumed that many Trolley trips were made in order to familiarize riders with the layout of downtown Gatlinburg, perhaps to select a destination or destinations during their visit. Two other facts support this hypothesis. First, the tendency of Trolley riders to overlap part of the route during a single Trolley trip. This may indicate destinations are not determined until mid-trip or later. Second, a high number of riders indicated

making no previous Trolley trips during the day at the time of the survey. Once travelers become familiar with the City, some may walk or drive for succeeding trips instead of using the Trolley.

To obtain further information on groups of Trolley riders with specific characteristics, two comparisons were made. Table 3 contrasts certain characteristics of Trolley riders who parked their private automobile(s) in a park-and-ride lot versus those who parked at other locations. Table 4 compares similar characteristics of Trolley riders who visited Gatlinburg overnight versus those who were only day visitors to Gatlinburg. Other observations included:

- 63.7% of tourists who rode the Trolley and were visiting Gatlinburg overnight (n=113) were parked at their place of lodging during Trolley rides;
- 66.7% of local residents who rode the Trolley (n=15) did not have an auto available;
- average group size by time period was:

weekday AM	3.38
weekday PM	3.48
weekend	2.91
- average group size by Trolley Line was:

Green Line	3.44
Orange Line	2.74

Table 3. Trolley Rider Characteristics by Parking Location

	Did Park in Park-and-Ride Lot (n = 59)	Did Park in Other Lot (n = 112)
percent of local residents	3.4% (2/59)	1.8% (2/112)
percent of non-local residents	96.6% (57/59)	98.2% (110/112)
TOTAL	100.0%	100.0%
percent who were not visiting Gatlinburg overnight	61.0% (36/59)	15.2% (17/112)
percent who were visiting Gatlinburg overnight	39.0% (23/59)	84.8% (95/112)
TOTAL	100.0%	100.0%
average group size	3.39	3.31
average number of vehicles per group	1.09	1.07

Table 4. Trolley Rider Characteristics by Length of Stay in Gatlinburg

	Did Stay in Gatlinburg Overnight (n = 114)	Did Not Stay Overnight (n = 55)
percent with a non- specific (shopping or sightseeing) trip purpose	80.7% (92/114)	78.2% (43/55)
percent with a specific (shopping or sightseeing) trip purpose	19.3% (22/114)	21.8% (12/55)
TOTAL	100.0%	100.0%
percent of survey responses collected during a weekend	39.5% (45/114)	36.4% (20/55)
percent of survey responses collected during a weekdays	60.5% (69/114)	63.6% (35/55)
TOTAL	100.0%	100.0%
average group size	3.32	3.38
average number of vehicles per group	1.03	1.16

These rider characteristics show the Trolley is providing a service to both captive riders (riders without access to a private automobile) as well as choice riders who travel in small groups of about three persons with some variations by of time of week and route choice.

The main conclusion obtained from these trip and rider characteristics is that little uniformity can be established among trip origins and destinations other than the significant number of casual trips made by tourists and that most of these Trolley trips were replacing private automobile trips. Trip length, group size, and origin-destination patterns vary from trip to trip.

Roadway Capacity Additions

Trip patterns consist of three identifiable groups: home-based work (HBW), home-based other (HBO), and non-home-based (NHB). Home-based trips have at least one trip end within a residential area. Land use patterns in most cities, including Gatlinburg, locate most residential areas outside the CBD. Home-based trips which penetrate the CBD may be best served by arterial corridors leading through residential areas. However, NHB trips may have their origins, destinations, or both origins and destinations within a CBD. Since almost all Trolley trips are non-home-based during the peak travel season, the roadway network in Gatlinburg must be designed to accommodate many origin-destination combinations within a small area. Without a public transportation service which serves most of the potential origins and destinations, a comprehensive road network must be provided to meet the travel demands.

Without public transportation, automobile travel would increase in the CBD requiring construction of additional roads and the provision of new links between existing roads. A hypothetical improved road network configuration is described based on previous recommendations. As suggested repeatedly in the aforementioned local planning documents, a one-way pair should be implemented on South Parkway and River Road. The two major East-West roads, East Parkway and Airport Road, should be extended to River Road in order to be accessible to travelers from either direction on the one-way pair. Maple Lane which is parallel to Airport Road should be converted to a pedestrian only street for improved vehicle and pedestrian flow. Figure 26 presents these recommendations for a hypothetical road network on a map while cost estimates are calculated in the next chapter.

VMT Removed by the Trolley

Many of the effects of traffic congestion generally are a direct result of vehicle-miles of travel (VMT). To determine the VMT removed from the road network, the number of vehicles removed from the North Parkway-East Parkway intersection due to the Trolley service were calculated and converted to VMT. This intersection was used for analysis due to data availability and its earlier classification as a critical intersection with significant volumes of vehicle and Trolley travel through the area. July conditions were used because of the available data and because of the extreme traffic conditions experienced around the City during this time.

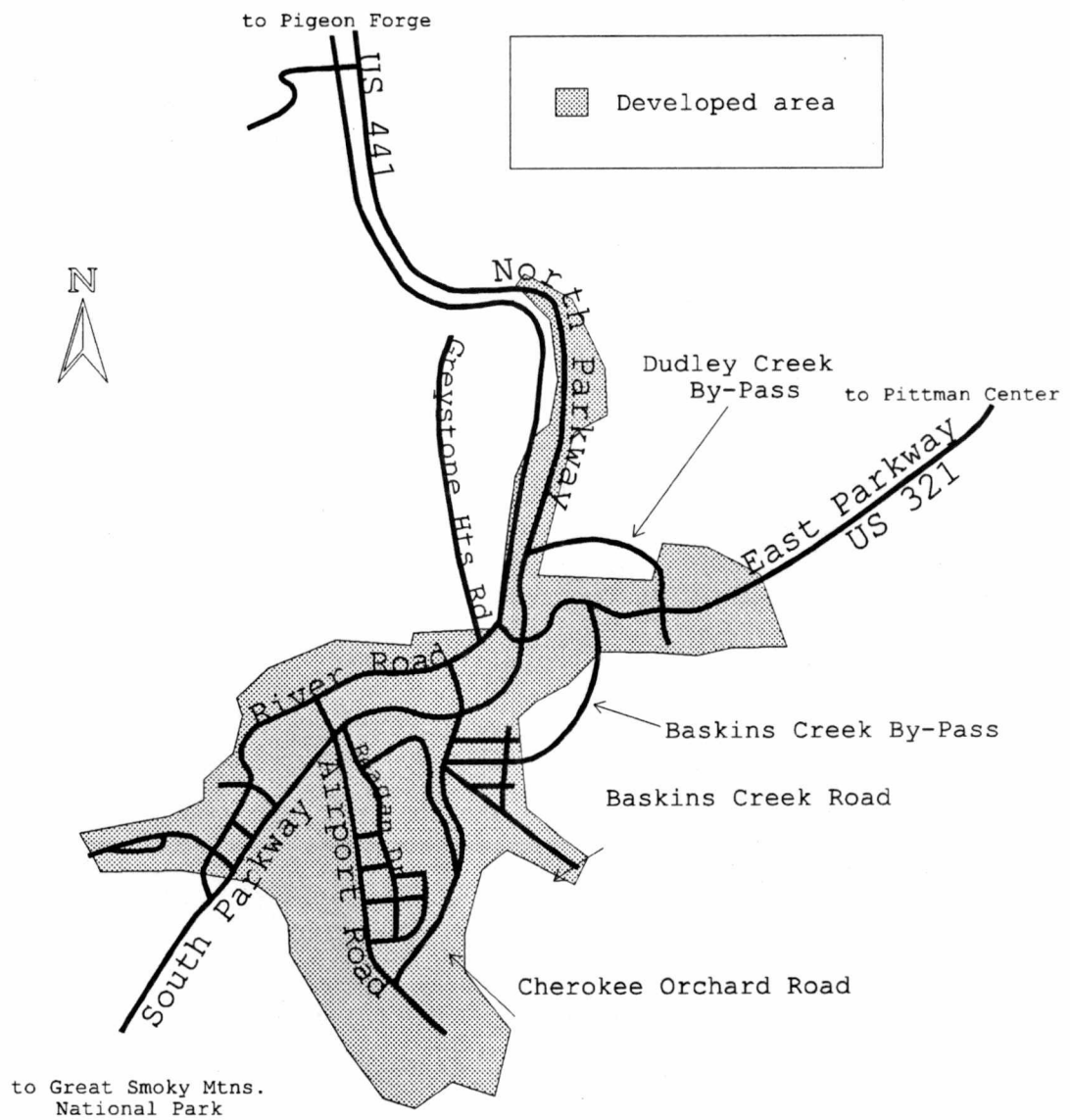
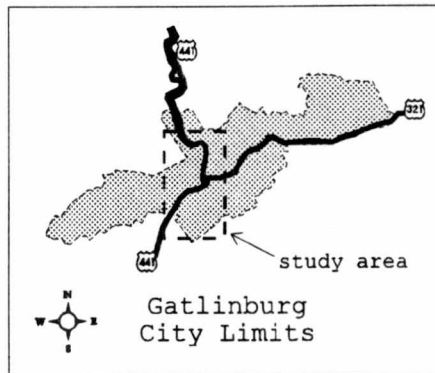
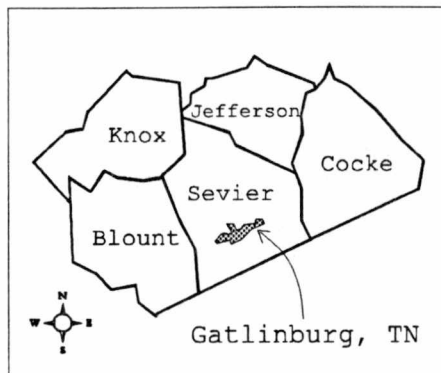


Figure 26. Hypothetical Road Network for Downtown Gatlinburg

From 1980 to 1993, the average Trolley ridership for the month of July is 189,340 which is equivalent to 6,108 riders per day. After applying average factors obtained from the trip observation and survey (1.02 vehicles per group, 3.1 riders per group, and 1.80 miles per trip), it was estimated that approximately 3,618 automobile VMT are removed per day in July (Table 5). However, the VMT attributed to the Trolley must be incorporated in the overall VMT calculations. The Green and Orange Line Trolleys account for most of the Trolley trips in the City either directly or indirectly because riders on the secondary Lines must transfer from the Green and Orange Lines. Therefore, only these Lines are considered in this calculation. The Trolleys operate sixteen hours per day in July. To achieve the desired headway of twenty minutes, an average of 2.5 Trolleys per Line are assumed to be in operation at any given time throughout the day of operation. The length of the Green Line loop is approximately six miles, and the length of the Orange Line loop is approximately twelve miles. Despite the difference in distance, the loop travel time for each Line is approximately 45 minutes. With this information, the Trolley VMT calculations yielded roughly 320 and 640 vehicle-miles daily for the Green and Orange Lines respectively for a total of 960 VMT per day (Table 6). The difference in the automobile VMT removed from the roads (3,618) and the Trolley VMT added to the roads (960) yield a cumulative removal of about 2,658 VMT daily.

Table 5. Calculation of Automobile Peak Daily VMT Removed by the Trolley

<u>189,340 average Trolley riders/July</u> =		6,108 riders/day
31 days/July		
<u>6,108 riders</u> *	<u>1.02 vehicle/group</u> *	<u>1.80 miles</u> =
day	3.1 riders/group	trip
		3,618 VMT/day removed

Table 6. Calculation of Net Peak Daily VMT Removed by the Trolley

Green Line Trolley			
2.5 Trolleys * operating	<u>16 hours operation</u> * Trolley	<u>6 miles/loop</u> = 0.75 hours/loop	320 VMT/day
Orange Line Trolley			
2.5 Trolleys * operating	<u>16 hours operation</u> * Trolley	<u>12 miles/loop</u> = 0.75 hours/loop	640 VMT/day
Trolley VMT =		320 VMT + 640 VMT =	960 VMT/day
Net VMT Removed by Trolley =		3,618 VMT - 960 VMT =	2,658 VMT/day

Many of the trips that are assumed to be removed, in actuality, would simply not take place because of the added inconvenience of driving due to the added congestion if the Trolley did not exist. However, without a public transportation system, additional vehicle trips would be created to replace trips that were too long to walk, and many of the automobile trips would increase in length due to circuitous travel resulting from unknown trip destinations. These effects are assumed to offset each other. For these reasons it assumed that the calculated number of VMT removed from the local road network adequately represents conditions which would occur if there were no Trolley service. These VMT are used later in this report to quantify the magnitude of other benefits such as delay reduction.

Downtown Parking Inventory

By increasing the percentage of overall trips in Gatlinburg carried by the Trolley, the total number of vehicle trips in the area can be reduced. Increased Trolley ridership implies that vehicles are remaining in one location while travelers walk and ride the Trolley more frequently. This reduces the number of multiple parking spaces around the City required per vehicle, and, consequently, less total parking spaces are required in the CBD. However, if additional parking supply were necessary, garage facilities at existing lot locations would be needed due to a lack of available vacant land.

An inadequate supply of parking in Gatlinburg can be seen as a travel disincentive to tourists resulting in a potential loss of tourism

dollars to the City. Though the parking supply in Gatlinburg is currently low and additional parking would be beneficial, the Trolley service provides a greater flexibility to motorists by allowing tourist travel to continue without reliance on automobiles and the need to find parking in the downtown. However, the parking deficiency would be critical without a public transportation service and necessitate additional parking supply.

To determine the need for additional parking, an inventory of the existing parking facilities in downtown Gatlinburg was conducted for this report. Although land uses such as residential areas, motels, public institutions (such as schools and hospitals), and automobile repair shops are required to provide customer parking; commercial developments, which compose the majority of the CBD, are not required to provide parking as defined by the local planning regulations (Owenby, 1994). Due to the extreme fluctuation in demand for parking spaces from a few thousand individuals to tens of thousands during the course of the year, determining the number of spaces required to satisfy the needs of the tourists is a difficult task, but the peak demand period is chosen for analysis.

The number of spaces is not the only issue concerning parking availability, but the location of the spaces is also a function of their utility. Some of the existing lots are located outside the main corridor of activity and are not directly served by transit. Due to this lower visibility, many travelers are unable to locate these parking facilities and the spaces go unused. It was observed that the lots

located on or within clear visibility of the South Parkway-River Road corridor fill up daily in the summer peak tourism season, while lots located off the corridor may fill up only one or two times per year.

While spaces are available, the tourists appear to feel the supply of parking is inadequate based on informal observations of trip patterns and comments made during the survey process. In an effort to find convenient parking, drivers often circulate through the downtown streets causing additional congestion. From the perspective of the parking providers, however, the unused parking is an indication that an adequate supply of parking is currently available and no new parking facilities are required.

An inventory of the available downtown parking is shown in Table 7 and a map of these locations on Figure 27. The City of Gatlinburg owns and operates six of the twenty public parking facilities. Two of these City-owned facilities provide 196 spaces at the two park-and-ride lots mentioned earlier. These park-and-ride facilities are free to travelers and encourage parking at the City fringe and using the Trolley as an alternative to driving and parking in the CBD. Other City-owned lots are located at the Chamber of Commerce, the Anna Porter Library, on Reagan Drive, and on North Parkway. All of these City-owned lots provide a total of 683 parking spaces (Cole, 1993).

There are fourteen other lots located throughout the CBD that are privately owned and operated, plus approximately 200 free on-street parking spaces are available on River Road. An approximate 1,471 spaces

Table 7. Downtown Gatlinburg Public Parking Inventory

	LOT NAME AND LOCATION	# OF SPACES	OWNER
1	Meter Park North Parkway	34	City
2	Greystone Parking Greystone Heights Road	216	private
3	Downtown Parking River Road	46	private
4	Old Smoky Candy Kitchen Parking South Parkway	75 approx.	private
5	(name not known) Airport Road	90 approx.	private
6	Meter Park River Road	62	private
7	Bearskin Parking South Parkway	150 approx.	private
8	Mill Creek Restaurant South Parkway	75 approx.	private
9	Ober Gatlinburg Parking Long Branch Road	200 approx.	private
10	Skyline Park and Lock South Parkway	150 approx.	private
11	Shade Tree Parking Lot Airport Road	108	private
12	(name not known) Airport Road	60 approx.	private
13	(name not known) Airport Road	107	private
14	City of Gatlinburg Parking Reagan Road	180	City
15	City of Gatlinburg (Anna Porter Library) Baskins Creek/Cherokee Orchard Road	82	City
16	Gatlinburg Middle School Cherokee Orchard Road	48	semi-private
17	Midtown Parking South Parkway	84	private
18	City of Gatlinburg (Chamber of Commerce) South Parkway	183	City
19	East Park-and-Ride Lot East Parkway	80	City
20	North Park-and-Ride Lot North Parkway	116	City
	on-street parking	200 approx.	
	TOTAL	2,350 approx.	

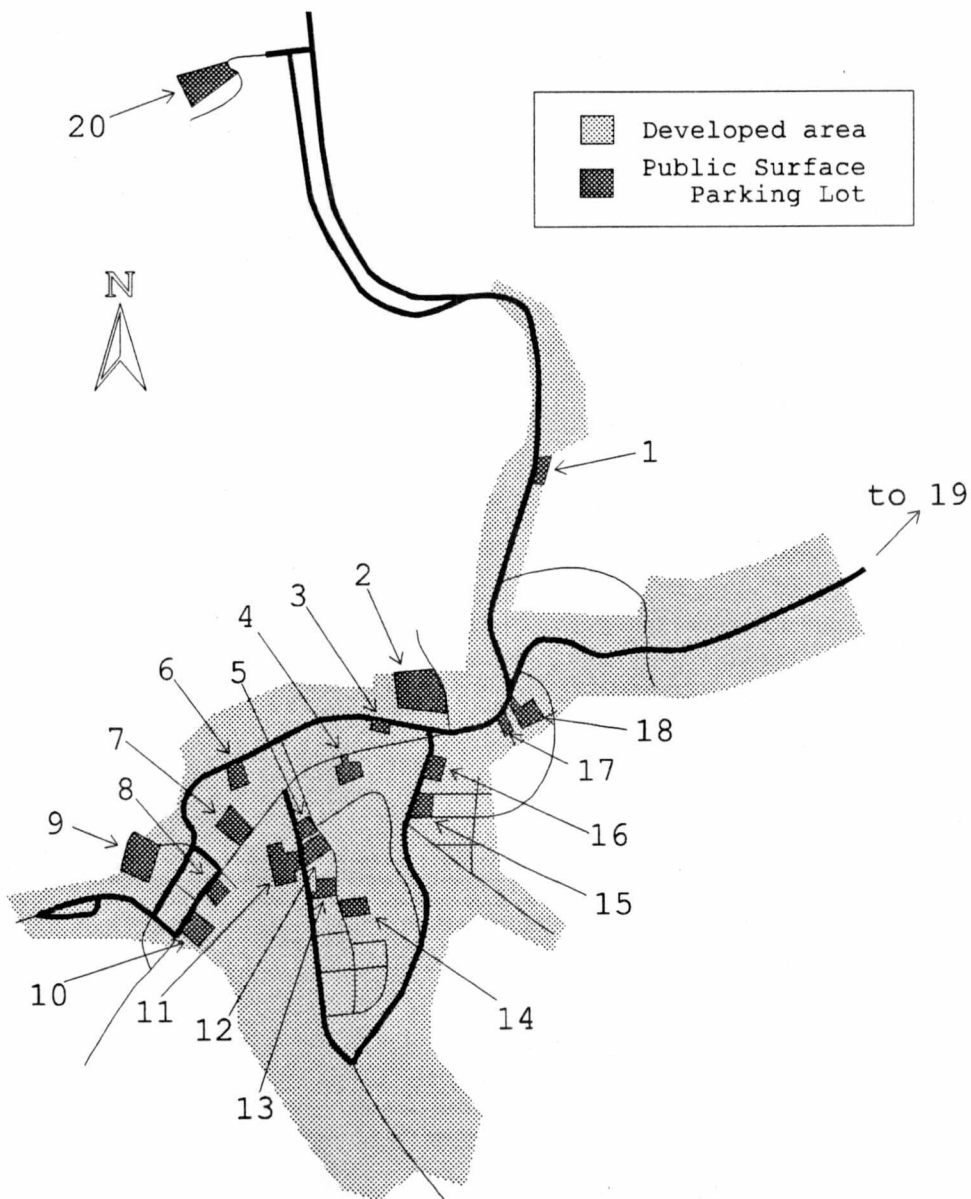
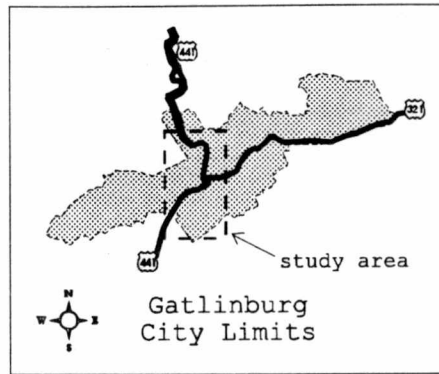
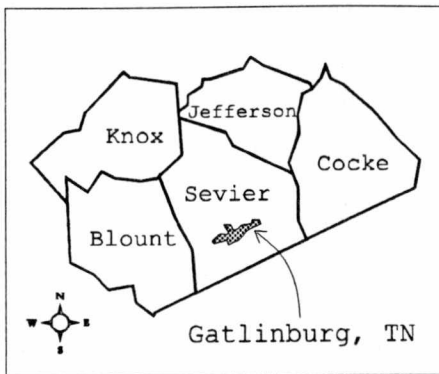


Figure 27. Downtown Gatlinburg Public Parking Supply

are available at the privately-owned facilities for a City-wide total of about 2,350 spaces. Most of the lots, including the City-owned lots, charge 50¢ to 75¢ per hour or \$2 to \$3 for all-day parking. Few of the lots accommodate large recreational vehicle or buses, but when they can, they may charge a higher rate. Most lots were not intended for overnight use, and attendants were available at most sites.

Parking Deficiency

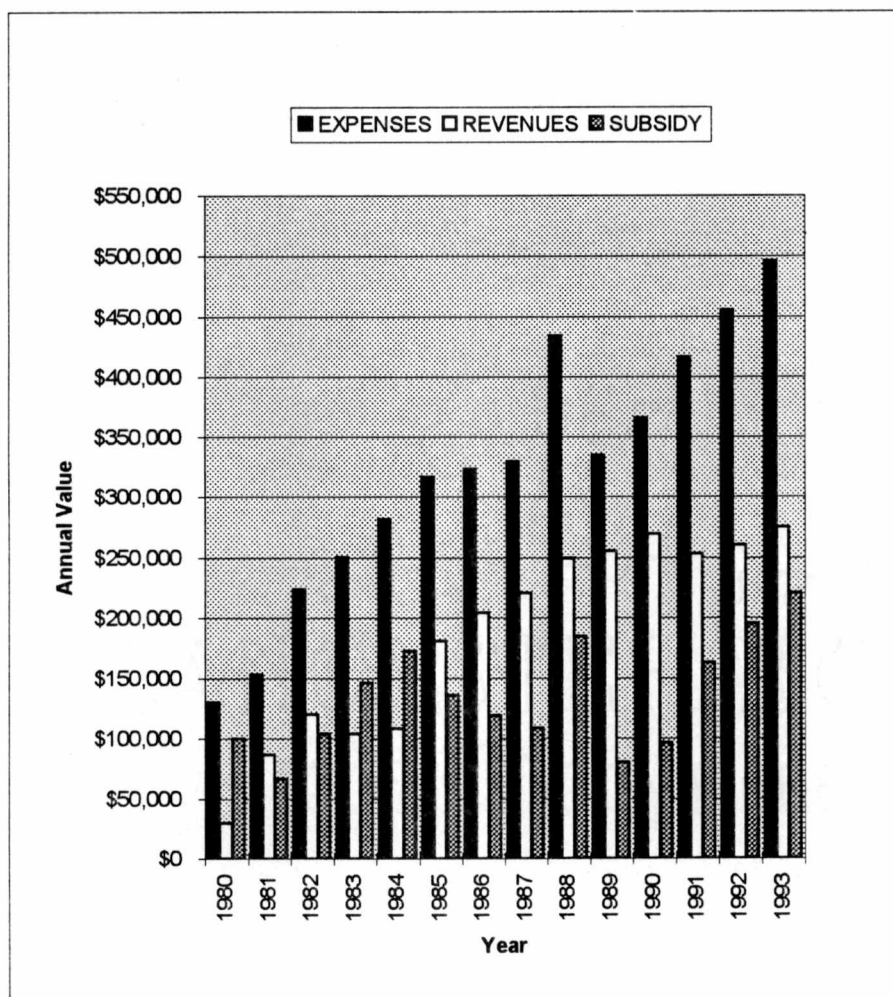
One way to determine the number of parking spaces needed in the CBD is to consider the daytime population of the CBD, including workers and visitors. The latest estimation of the daily peak population in Gatlinburg is 60,000. According to the "Gatlinburg, Tennessee Demographic Profile", there are approximately 8,000 lodging units including hotels, condominiums, and chalets available, and each unit is occupied by an average of three persons. Since lodging units do provide parking, it may be assumed approximately 24,000 individuals have access to parking at their place of lodging as do the 4,000 full-time residents. Parking for the remaining 32,000 individuals must be accommodated in public lots. In order to determine the number of spaces desired to accommodate the peak population, it is possible to compare the parking needs of cities with a similar population as that of Gatlinburg or by making assumptions.

For cities with an urbanized population of 25,000 to 50,000, the average number of total spaces to be provided in the zone of activity such as the CBD is 3,990 according to the 1971 Highway Research Board Special Report 125 Parking Principles. This number is likely to have

increased in the past twenty years, but a more accurate estimation is not essential for these comparison purposes. By these estimates, the Gatlinburg CBD is deficient by at least 40% the recommended total of parking spaces for a typical city of similar size. Though the parking demand in Gatlinburg is seasonal, the peak demand does exist for several months each year, and without a public transportation service, it is assumed that the parking demand would become an essential need which should be satisfied. The potential cost for meeting this parking demand will be calculated in the next chapter.

Trolley Operational Expenses

Because the City of Gatlinburg is not located within an urbanized area, the Federal Transit Administration does not classify the Gatlinburg Trolley as a traditional public transportation service. Therefore, Federal funds for the operation of the Trolley are not directly available. Hence, TDOT and the local government provide operational subsidy for the service. Figure 28 shows a plot of the historical revenue, expense, and subsidy generated by the Trolley service since it began in 1980 (Gatlinburg Mass Transit Department, 1980-1994). From this information, a historical annual average for each operating value can be determined: average annual expense equals \$321,191.49; average annual revenue equals \$181,621.32; and average annual subsidy equals \$129,600.87. Much of the local portion of Trolley operating subsidy is generated from the revenues of the City-owned parking lots which are managed by the Gatlinburg Parking Lot/Mass Transit Department (Parton, 1993).



Source: Gatlinburg Trolley System Performance Reports, 1980-1993

Figure 28. Average Annual Trolley Revenue, Expenses, and Subsidy

Trolley Capital Expenses

Though the Federal government does not contribute funds toward daily operation of the Gatlinburg Trolley, capital funds are directly available for projects such as the purchase of new buses and actuated signal installation. The percent of the purchase costs provided by the Federal government varies depending on the project, but the State and local governments equally contribute half of the remaining costs. The most regular expense requiring capital funds is bus replacement. The average useful life for a bus such as the Trolleys in Gatlinburg is about seven years; the average cost of a new Trolley bus is about \$150,000 for an ADA-equipped full-size Trolley; and the salvage value of a full-size ADA-equipped bus is about \$50,000 (Welch, 1994). The estimated average annual cumulative capital and operational costs on the local, State, and Federal levels are given in the following chapter.

The purpose of this chapter was to define the impact which the Trolley service has on the condition of the local transportation system of Gatlinburg in terms of costs and benefits. From the survey results, it was determined that the trips made on the Trolleys were mostly replacing trips which are consistently difficult to classify by distance, specific origin, or specific destination due to the trips often being non-premeditated. The survey results also indicated however, that travel groups are usually similar in size ranging between two and five which usually could be accommodated in a single automobile.

By quantifying these impacts and characteristics which the Trolley has on the intracity trips in Gatlinburg, dollar values for both the costs and benefits can be calculated and compared as performed in the next chapter. From that information, a value judgment can be made which represents the importance of operation of the Trolley to the citizens and tourists of Gatlinburg.

Chapter 6

Results

The previous chapter defined the cost and benefit terms which are effected by the implementation of the Gatlinburg Trolley System. This chapter calculates the benefits and costs in terms of monetary values for comparison of four scenarios:

- I. the base case (the traffic conditions expected to exist at the present time if no Trolley service were in place),
- II. the existing traffic conditions and Trolley service as they exist presently,
- III. the existing traffic conditions plus an expanded Trolley service, and
- IV. the existing traffic conditions and a hypothetical series of roadway improvements and no Trolley service.

These scenarios can be compared to determine the most cost effective combination of transportation services based on the assumptions used in this document. Costs and benefits are unequally distributed on the local, State, or Federal levels. For this study however, the benefits and costs will be calculated from two perspectives: the "local" perspective (which includes the costs and benefits of the State, the City, and the transportation users and citizens of Gatlinburg) and the "overall" perspective (which includes the local perspective plus the Federal costs and benefits). To simplify the parameters used to determine annual dollar values, all costs and benefits (where

applicable) are based on a twenty-year analysis period at an assumed interest rate of ten percent unless otherwise indicated.

Benefit Items

The benefit items outlined previously include the difference in vehicle delay costs which are achievable through Trolley service or other transportation alternative. Each benefit is quantified below.

Traffic Congestion Delay Cost

In the previous chapter, the existing delay in peak travel periods due to congestion at the North Parkway-East Parkway intersection was evaluated using HCS. Delay is considered to be a cost to travelers which can be reduced by implementing various levels of Trolley service or by other strategies. Delays were estimated for the base case (no Trolley) and for the existing and proposed levels of Trolley service.

Turning volume data for only seven hours were available for input into the HCS software. Therefore, three four-hour analysis periods were developed so that all hours of Trolley service were considered: 8:00 AM to 12:00 PM, 12:00 PM to 4:00 PM, and 4:00 PM to 8:00 PM³. Data from one hour within each of the three periods were evaluated using HCS to yield an average hourly delay⁴ time for each of the three periods. Hourly traffic volumes were multiplied by the delay per vehicle for the respective period from which total hourly delay values were calculated.

³ No turning count data were available to analyze the 8:00 PM to 12:00 PM period, so the delay saved during this period was not considered.

⁴ This is the average stop delay which is directly given by HCS. Average overall delay, which is used to calculate the monetary value of delay is equal to average stop delay * 1.3 (Special Report 209, 1985).

The first delay calculation (the base case) considered no Trolley service and determined an average daily delay for the month of July to be 349.0 hours (Table 8). The same calculations for conditions with the existing Trolley service yielded an reduced average daily delay for July of 295.0 hours (Table 9), a difference of 54.0 hours per day and 1,674.0 hours per month for average July conditions. A doubled Trolley fleet improves the LOS from "D" to "C" and reduces average daily July delay an average of 111.5 hours per day over the base case (Table 10). These values were extrapolated for an annual delay reduction for each case using the average monthly Trolley ridership distribution (Table 11).

The "Gatlinburg Demographic Profile" indicates the average annual salary of tourists is \$39,600 which is equivalent to an hourly value of approximately \$19.00⁵. Considering this information, the annual cost savings were calculated for the North Parkway-East Parkway intersection. It is assumed that the delay at this intersection is the most critical within the City due to its central location among the major traffic corridors. However, delay at other intersections such as the South Parkway-River Road-Cherokee Orchard Road and the South Parkway-Airport Road are also significant. The City-wide delay at these and other major intersections is assumed to be, at a minimum, equivalent to the delay created at the North Parkway-East Parkway intersection. Therefore, the cumulative delay and cost savings are estimated to be twice that

⁵ The following conversion was used to calculate the dollar value of one hour for this document: \$39,600 salary/year ÷ 52 weeks/year ÷ 40 hours/week.

*Table 8. Estimated Delay in Hours at the North Parkway-East Parkway Intersection
for Case I. (without Trolley service)*

HOURS OF TROLLEY OPERATION (* INDICATES THE HOUR USED TO DETERMINE THE PERIOD DELAY)	SECONDS OF AVERAGE DELAY PER VEHICLE BASED ON REPRESENTATIVE PERIOD HOUR	VEHICLES THROUGH INTERSECTION EACH HOUR BASED ON TRAFFIC COUNTS	HOURS OF DELAY PER HOUR OF TRAVEL FOR THE INTERSECTION
Period 1			
8:00 AM - 9:00 AM	33.4	2170	20.1
9:00 AM - 10:00 AM	33.4	2981	27.7
10:00 AM - 11:00 AM	33.4	3226	29.9
11:00 AM - 12:00 PM*	33.4	3222	29.9
Period 2			
12:00 PM - 1:00 PM	32.9	3042	27.8
1:00 PM - 2:00 PM*	32.9	3099	28.3
2:00 PM - 3:00 PM	32.9	3142	28.7
3:00 PM - 4:00 PM	32.9	3379	30.9
Period 3			
4:00 PM - 5:00 PM	36.0	3424	34.2
5:00 PM - 6:00 PM	36.0	3246	32.5
6:00 PM - 7:00 PM*	36.0	3186	31.9
7:00 PM - 8:00 PM	36.0	2714	27.1
Period 4			
8:00 PM - 9:00 PM	not available	2537	--
9:00 PM - 10:00 PM	not available	2320	--
10:00 PM - 11:00 PM	not available	1980	--
11:00 PM - 12:00 AM	not available	1265	--
TOTAL			349.0 hours

total hours of vehicle stop stopped delay for July
= 349.0 hours/day * 31 days/July
= 10,819.0 hours/July

total hours of overall vehicle delay for July
= 10,819.0 * 1.3
= 14,064.7 hours/July

*Table 9. Estimated Delay in Hours at the North Parkway-East Parkway Intersection
for Case II (existing Trolley service)*

HOURS OF TROLLEY OPERATION (* INDICATES THE HOUR USED TO DETERMINE THE PERIOD DELAY)	SECONDS OF AVERAGE DELAY PER VEHICLE BASED ON REPRESENTATIVE PERIOD HOUR	VEHICLES THROUGH INTERSECTION EACH HOUR BASED ON TRAFFIC COUNTS	HOURS OF DELAY PER HOUR OF TRAVEL FOR THE INTERSECTION
Period 1			
8:00 AM - 9:00 AM	29.4	2099	17.1
9:00 AM - 10:00 AM	29.4	2883	23.5
10:00 AM - 11:00 AM	29.4	3120	25.5
11:00 AM - 12:00 PM*	29.4	3116	25.4
Period 2			
12:00 PM - 1:00 PM	29.2	2942	23.9
1:00 PM - 2:00 PM*	29.2	2997	24.3
2:00 PM - 3:00 PM	29.2	3039	24.6
3:00 PM - 4:00 PM	29.2	3268	26.5
Period 3			
4:00 PM - 5:00 PM	30.9	3311	28.4
5:00 PM - 6:00 PM	30.9	3139	26.9
6:00 PM - 7:00 PM*	30.9	3081	26.4
7:00 PM - 8:00 PM	30.9	2625	22.5
Period 4			
8:00 PM - 9:00 PM	not available	2454	--
9:00 PM - 10:00 PM	not available	2244	--
10:00 PM - 11:00 PM	not available	1915	--
11:00 PM - 12:00 AM	not available	1223	--
TOTAL			295.0 hours

total hours of vehicle stopped delay for July
= 295.0 hours/day * 31 days/July
= 9,145.0 hours/July

total hours of overall vehicle delay for July
= 9,145.0 * 1.3
= 11,888.5 hours/July

*Table 10. Estimated Delay at the North Parkway-East Parkway Intersection
for Case III. (upgraded Trolley service)*

HOURS OF TROLLEY OPERATION (* INDICATES THE HOUR USED TO DETERMINE THE PERIOD DELAY)	SECONDS OF AVERAGE DELAY PER VEHICLE BASED ON REPRESENTATIVE PERIOD HOUR	VEHICLES THROUGH INTERSECTION EACH HOUR BASED ON TRAFFIC COUNTS ⁶	HOURS OF DELAY PER HOUR OF TRAVEL FOR THE INTERSECTION
Period 1			
8:00 AM - 9:00 AM	24.8	2028	14.0
9:00 AM - 10:00 AM	24.8	2785	19.2
10:00 AM - 11:00 AM	24.8	3014	20.8
11:00 AM - 12:00 PM*	24.8	3010	20.7
Period 2			
12:00 PM - 1:00 PM	24.7	2842	19.5
1:00 PM - 2:00 PM*	24.7	2895	19.9
2:00 PM - 3:00 PM	24.7	2936	20.1
3:00 PM - 4:00 PM	24.7	3157	21.7
Period 3			
4:00 PM - 5:00 PM	25.0	3198	22.2
5:00 PM - 6:00 PM	25.0	3032	21.1
6:00 PM - 7:00 PM*	25.0	2976	20.7
7:00 PM - 8:00 PM	25.0	2536	17.6
Period 4			
8:00 PM - 9:00 PM	not available	2371	--
9:00 PM - 10:00 PM	not available	2168	--
10:00 PM - 11:00 PM	not available	1850	--
11:00 PM - 12:00 AM	not available	1181	--
TOTAL			237.5 hours

total hours of vehicle stopped delay for July
= 237.5 hours/day * 31 days/July
= 7,362.5 hours/July

total hours of overall vehicle delay for July
= 7,362.5 * 1.3
= 9,571.3 hours/July

⁶ This quantity of total vehicles through the North Parkway-East Parkway intersection is equal to the number of vehicles through the intersection without Trolley service minus two times the number of vehicles removed by the Trolley.

Table 11. Estimated Annual Delay Values
at the North Parkway-East Parkway Intersection

	Distribution of Monthly Travel ⁷	Hours of Monthly Delay ⁸ -- Base Case (without Trolley)	Hours of Monthly Delay ⁸ -- Condition I. (existing Trolley service)	Hours of Monthly Delay ⁸ -- Condition II. (upgraded Trolley service)
January	0.1%	61.4	51.9	41.8
February	0.1%	61.4	51.9	41.8
March	0.3%	184.3	155.7	125.4
April	4.6%	2,825.2	2,388.1	1,922.6
May	8.5%	5,220.5	4,412.8	3,552.7
June	16.1%	9,888.3	8,358.3	6,729.2
July	22.9%	14,064.7	11,888.5	9,571.3
August	18.2%	11,178.1	9,448.5	7,606.9
September	10.4%	6,387.5	5,399.1	4,346.8
October	15.7%	9,642.6	8,150.6	6,562.0
November	2.3%	1,412.6	1,194.0	961.3
December	0.8%	491.3	415.3	334.4
TOTAL	100.0%	61,417.9	51,914.7	41,796.2

⁷ Monthly travel is assumed to be directly proportional to average monthly Trolley ridership.

⁸ These are monthly overall delay values which are extrapolated over each month based on the calculated value for July which equals 31 (days/July) * the July average overall daily vehicle delay.

calculated for the North Parkway-East Parkway intersection. The results are shown in Table 12.

Cost Items

The cost items consist of costs incurred during daily operation of a particular transportation strategy. These strategies include roadway and parking improvements which require annual payments for the construction and operating and capital costs for the Trolley. Funding sources vary for each cost as described below.

Cost for Additional Parking

Based on cost data from recent parking garage construction projects and existing operation of parking facilities, a construction cost of \$5,000 per space and an annual administrative and maintenance cost of \$200 per space are assumed in order to determine an average annual cost for the construction and operation of a parking structure (Whalen, 1994). However, revenue would be collected at an assumed \$3 per space per day in the peak season which would decrease the overall yearly costs for a parking garage. To meet the estimated parking demand in Gatlinburg over the next several years, two 1,000-space parking structures built on sites currently occupied by City-owned parking lots would be necessary based on the analysis in the previous chapter⁹. The estimated annual cost for these facilities are calculated below:

⁹ The previous chapter indicates a need for 1,600 additional parking spaces, but 2,000 spaces are recommended to replace those parking spaces which would be removed to accommodate the garages.

Table 12. Annual Cost Savings as a Result of Reduced Delay

	Hours of Annual Delay at the North Parkway- East Parkway intersection	Hours of Annual Delay at the North Parkway- East Parkway intersection	Annual Delay Cost to Gatlinburg Travelers @ \$19/hour
Case I. Base Case	61,418	122,836	\$2,333,884
Case II. Existing Case	51,915	103,830	\$1,972,770
Case III. Improved Case	41,796	83,592	\$1,588,240

present construction cost
 = 2,000 spaces * \$5,000 per space
 = \$10,000,000
 annual construction cost (using capital recovery factor)
 = \$10,000,000(0.1175)
 = \$1,175,000 per year
 annual administrative and maintenance costs
 = 2,000 spaces * \$200 per space per year
 = \$400,000 per year
 annual parking revenue (assuming \$3/day charge and a full garage for
 150 days/year)
 = 2,000 spaces * \$3 per space * 150 days/year
 = \$900,000 per year
 annual overall cost (construction plus administrative minus revenue)
 = \$1,175,000 + \$400,000 - \$900,000
 = \$675,000 per year

Cost for Roadway Reconfiguration and Additional Road Capacity

The proposed roadway improvements shown previously as Figure 21
 have been presented in earlier planning documents as needed in order to
 reduce congestion. It is assumed the Trolley is presently deferring
 this need to add roadway capacity by diverting trips otherwise made by
 private automobiles to trips on the Trolley. Here, each individual road
 project is adjusted to a 1994 value before being annualized over a 20-
 year period at an assumed interest rate of 10%:

A) Implementation of One-Way Pair on South Parkway and River Road

1978 estimated cost
 = \$75,000
 1994 value (using compound amount factor over 16-year period)
 = \$75,000(4.5950)
 = \$344,625
 annual cost (using capital recovery factor)
 = \$344,625(0.1175)
 = **\$40,493 per year**

B) Construction of Additional Lanes on North Parkway

1978 estimated cost
= \$8,000,000
1994 value (using compound amount factor over 16-year period)
= \$8,000,000(4.5950)
= \$36,760,000
annual cost (using capital recovery factor)
= \$36,760,000(0.1175)
= **\$4,319,300 per year**

C) Extension of Airport Road to River Road

1978 estimated cost
= \$243,000 plus land acquisition
estimated 1994 right-of-way acquisition cost
= \$500,000¹⁰
1994 value (using compound amount factor over 16-year period)
= \$243,000(4.5950)
= \$1,116,585
plus estimated land acquisition cost
= \$1,116,585 + \$500,000
= \$1,616,585
annual cost (using capital recovery factor)
= \$1,616,585(0.1175)
= **\$189,949 per year**

¹⁰ Based on the current real estate market (e.g. a single vacant lot of 0.3 acres in downtown Gatlinburg as of April 1, 1994 was selling for \$500,000), this is a conservative estimate because the proposed right-of-way is already occupied by commercial establishments which would require demolition (Stevens, 1994).

D) Extension of East Parkway to River Road

estimated 1978 cost
= \$350,000¹¹ plus land acquisition
estimated 1994 right-of-way acquisition cost
= \$600,000
1994 value (using compound amount factor over 16-year period)
= \$350,000(4.5950)
= \$1,608,250
plus land acquisition cost
= \$1,608,250 + \$600,000
= \$2,208,250
annual cost (using capital recovery factor)
= \$2,108,250(0.1175)
= **\$259,469 per year**

The total annual cost for the proposed road construction projects over a twenty year period equals:

\$40,493	for one-way pair implementation
\$4,319,300	for added capacity to North Parkway
\$189,949	for extension of Airport Road to River Road
+ \$259,469	for extension of East Parkway to River Road

\$4,809,211	per year

It is assumed that the costs for all road projects would be financed by the Federal, State, and local government, in the traditional proportions--90%, 5%, and 5% respectively.

Trolley Operational Costs

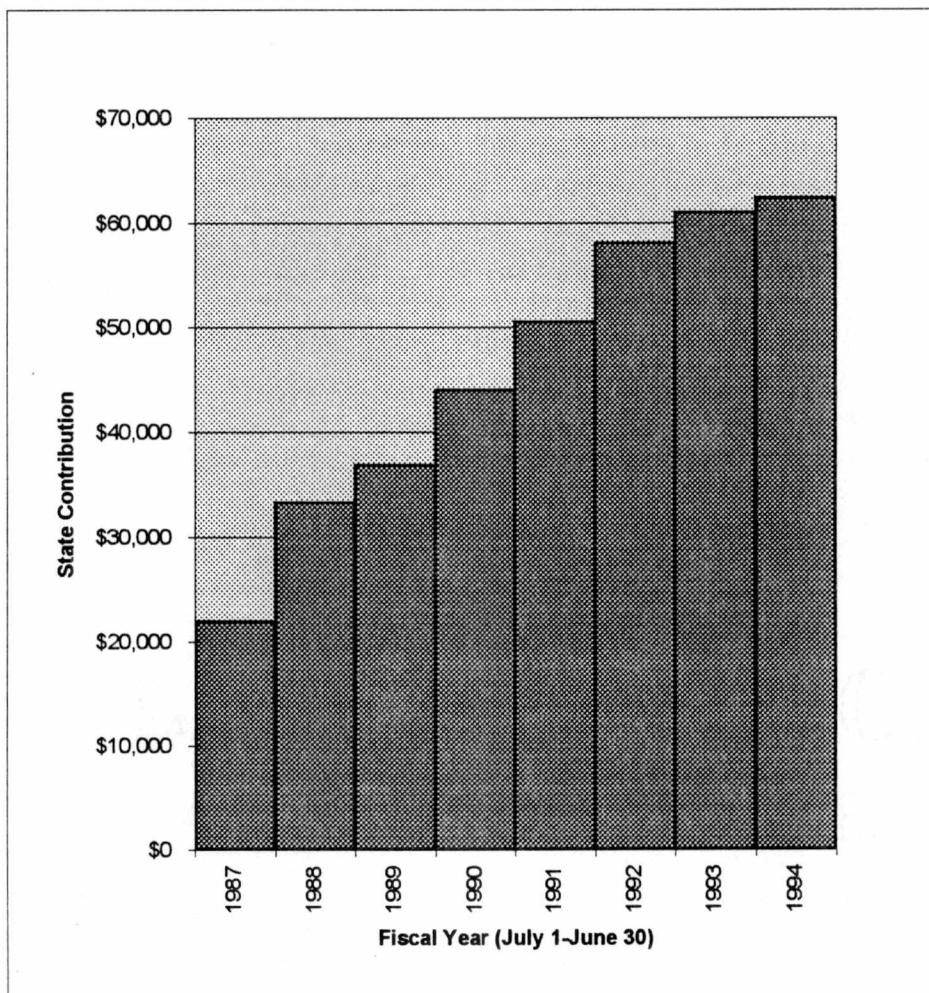
Due to funding obligations, Federal funds (which are distributed by the State) available for rural public transportation operation in Tennessee, are not sufficient to assist in the operation of the

¹¹ No estimated cost was provided for this project, but an approximation was developed based on the Airport Road project. East Parkway would require a similar amount of work, but the cost would be slightly higher than the Airport Road extension because East Parkway is a four-lane road as opposed to the two-lane Airport Road.

Gatlinburg Trolley. Therefore, the Trolley operating subsidy is shared between the local government and by TDOT with the largest portion coming from the local government. The State budget for public transportation operating funds are divided among the public transit agencies within the State based on population or, in the case of Gatlinburg (due to a low full-time Census population), the amount of annual transit ridership. These State funds cannot exceed 40% of any agency's operating costs. Figure 29 shows the TDOT contributions for Trolley operating expenses since the existing funding structure was established in 1986. For fiscal year (FY) 1994, the State funding allocation rate has been partially updated and will be further updated to reflect the 1990 Census population data and the initiation of a new public transportation service within the State in FY 1994 (Davis, 1994). Considering these facts, an estimation of annual State contribution for operational expenses is assessed at approximately **\$65,000 per year** for the next several years. The average operational subsidy required over the past four years was \$168,780. From this information, an average local contribution for operating expenses over the next several years is estimated at approximately **\$100,000 per year** for this analysis.

Trolley Capital Costs

Capital costs mainly include monies necessary to buy buses and hardware, build related infrastructure, and improve other facilities which assist in the operation of the public transportation service. For simplicity, the cost of purchasing new buses is the only capital cost considered in this analysis because of the regularity and predictability



Source: Davis, 1994

Figure 29. Tennessee DOT Annual Financial Contributions to Subsidize Trolley Operating Expenses

of such an expense. Due to the recent passage of the Americans with Disabilities Act (ADA) in 1990 which requires all public transportation fleets to accommodate handicapped passengers, only the price of ADA equipped Trolleys are considered. The primary cost of Trolley replacement is annualized below:

- approximate cost of a new Trolley
 - = \$150,000
- average useful life of a Trolley
 - = 7 years
- approximate salvage value of a Trolley at end of useful life
 - = \$50,000
- present value of a single Trolley purchase (using single payment present worth factor for 7-year period)
 - = \$150,000 - \$50,000(0.5132)
 - = \$124,340 per bus
- average buying rate to maintain fleet of 18 Trolleys
 - = 2.5 Trolleys per year
- average annual cost
 - = 2.5 Trolleys/year * \$124,340 per Trolley
 - = **\$310,850 per year**

The Federal government contributes 83% of the cost for ADA equipped buses (80% for non-ADA buses), and the State of Tennessee and the City of Gatlinburg equally provide the remaining costs.

Benefit-Cost Ratio

An incremental benefit-cost analysis is used to compare the transportation alternatives outlined at the beginning of this chapter. The scenarios developed for the comparison analysis represent a general guideline for evaluation of the Gatlinburg Trolley Service as compared to alternative transportation strategies. The scenarios used are defined and described below:

Scenario A: Case I. Base Case versus Case II. Existing Case
(existing traffic and existing level of Trolley service)

The distinction should be made that this scenario is considered a short-term comparison. Values representing these alternatives would not apply if long-term strategies were applied. For example, the existing traffic volumes and the existing usage of the Trolley would differ once long-term projects such as the addition of parking, roadway capacity, or expanded Trolley service took place. See Tables 13 and 14 for the monetary values of the Cases represented in Scenario A.

Scenario B: Scenario A. versus Case III. - Expanded Trolley
(existing traffic demands plus expanded Trolley service)

The benefit-cost ratio calculated in this scenario evaluates a greater availability of Trolley service to travelers which would further reduce traffic delay over the most effective strategy from Scenario A. It is also assumed that the demand for overall transportation within Gatlinburg is constant and that the rate of Trolley usage is also constant (i.e. increasing the number of Trolleys in operation by 50% would increase the Trolley ridership by 50%). See Table 15 for the monetary values of Case III.

Scenario C: Scenario B. versus Case IV. - Roadway Improvements
(existing traffic demand with past recommended improvements to the roadway network and with no Trolley service)

This scenario considers the travel conditions without a Trolley service and with the implementation of the major recommendations to improve the roadway network. These recommendations are based on historical studies

Table 13. Case I. - Base Case Benefits and Costs

BENEFITS (totals rounded to the nearest 100)

	FUNDING SOURCE				
	System Users	Local Government	State Government	Federal Government	TOTAL
Delay Costs	\$2,333,884	\$0	\$0	\$0	\$2,333,900
TOTAL	\$2,333,900	\$0	\$0	\$0	\$2,333,900

COSTS (totals rounded to the nearest 100)

	FUNDING SOURCE				
	System Users	Local Government	State Government	Federal Government	TOTAL
Parking Garage Construction	\$0	\$0	\$0	\$0	\$0
One-Way Pair Implementation	\$0	\$0	\$0	\$0	\$0
North Parkway Extension	\$0	\$0	\$0	\$0	\$0
Airport Road Extension	\$0	\$0	\$0	\$0	\$0
East Parkway Extension	\$0	\$0	\$0	\$0	\$0
Operating Costs for Trolley	\$0	\$0	\$0	\$0	\$0
Capital Costs for Trolley	\$0	\$0	\$0	\$0	\$0
TOTAL	\$0	\$0	\$0	\$0	\$0

Table 14. Case II. - Existing Case Benefits and Costs

BENEFITS (totals rounded to the nearest 100)

	FUNDING SOURCE				
	System Users	Local Government	State Government	Federal Government	TOTAL
Delay Savings	\$1,972,770	\$0	\$0	\$0	\$1,972,800
TOTAL	\$1,972,800	\$0	\$0	\$0	\$1,972,800

COSTS (totals rounded to the nearest 100)

	FUNDING SOURCE				
	System Users	Local Government	State Government	Federal Government	TOTAL
Parking Garage Construction	\$0	\$0	\$0	\$0	\$0
One-Way Pair Implementation	\$0	\$0	\$0	\$0	\$0
North Parkway Extension	\$0	\$0	\$0	\$0	\$0
Airport Road Extension	\$0	\$0	\$0	\$0	\$0
East Parkway Extension	\$0	\$0	\$0	\$0	\$0
Operating Costs for Trolley	\$0	\$100,000 @ 60%	\$65,000 @ 40%	\$0	\$165,000
Capital Costs for Trolley	\$0	\$26,422 @ 8.5%	\$26,422 @ 8.5%	\$258,006 @ 83%	\$310,900
TOTAL	\$0	\$126,400	\$91,400	\$258,000	\$475,900

Table 15. Case III. - Improved Trolley Service Benefits and Costs

BENEFITS (totals rounded to the nearest 100)

	FUNDING SOURCE				
	System Users	Local Government	State Government	Federal Government	TOTAL
Delay Savings	\$1,588,248	\$0	\$0	\$0	\$1,588,200
TOTAL	\$1,588,200	\$0	\$0	\$0	\$1,588,200

COSTS (totals rounded to the nearest 100)

	FUNDING SOURCE				
	System Users	Local Government	State Government	Federal Government	TOTAL
Parking Garage Construction	\$0	\$0	\$0	\$0	\$0
One-Way Pair Implementation	\$0	\$0	\$0	\$0	\$0
North Parkway Extension	\$0	\$0	\$0	\$0	\$0
Airport Road Extension	\$0	\$0	\$0	\$0	\$0
East Parkway Extension	\$0	\$0	\$0	\$0	\$0
Operating Costs for Trolley	\$0	\$200,000 @ 60%	\$130,000 @ 40%	\$0	\$330,000
Capital Costs for Trolley	\$0	\$52,844 @ 8.5%	\$52,844 @ 8.5%	\$516,012 @ 83%	\$621,700
TOTAL	\$0	\$252,800	\$182,800	\$516,000	\$951,700

which were reviewed earlier in this document. This alternative is compared to the most effective strategy determined from Scenario B. See Table 16 for the monetary values of Case IV.

The general methodology used to determine the benefit-cost ratios for this analysis is the following:

$$\frac{b}{c} \text{ ratio} = \frac{\text{user cost}_{\text{base}} - \text{user cost}_{\text{alternative}}}{C_{\text{alternative}} - C_{\text{base}}} \quad \text{Equation 3.}$$

where:

- b = the overall benefit of the comparison,
- c = the overall cost of the comparison,
- user cost_{base} = the cost of vehicle delay to users for the base condition,
- user cost_{alternative} = the cost of vehicle delay to users for the alternative condition,
- C_{alternative} = the cost of the alternative condition, and
- C_{base} = the cost of the base condition.

When the overall benefit, *b*, exceeds the overall cost, *c*, the value of the ratio is greater than one and the alternative is considered economically justifiable.

Two separate analyses are conducted for this report: Analysis 1 includes the benefits and costs associated with the State and local governments and the local residents and users of the transportation services in Gatlinburg, Analysis 2 is determined from a more overall perspective which includes those economic perspectives from Analysis 1 in addition to that of the Federal government. The analyses in this report utilize an incremental approach in which the Alternatives, in

Table 16. Case IV. - Road Improvements Benefits and Costs

BENEFITS (totals rounded to the nearest 100)

	FUNDING SOURCE				
	System Users	Local Government	State Government	Federal Government	TOTAL
Delay Costs	\$0	\$0	\$0	\$0	\$0
TOTAL	\$0	\$0	\$0	\$0	\$0

COSTS (totals rounded to the nearest 100)

	FUNDING SOURCE				
	System Users	Local Government	State Government	Federal Government	TOTAL
Parking Garage Construction	\$0	\$675,000 @ 100%	\$0	\$0	\$675,000
One-Way Pair Implementation	\$0	\$2,025 @ 5%	\$2,025 @ 5%	\$36,443 @ 90%	\$40,500
North Parkway Extension	\$0	\$215,965 @ 5%	\$215,965 @ 5%	\$3,887,370 @ 90%	\$4,319,300
Airport Road Extension	\$0	\$9,497 @ 5%	\$9,497 @ 5%	\$170,955 @ 90%	\$189,900
East Parkway Extension	\$0	\$12,973 @ 5%	\$12,973 @ 5%	\$233,523 @ 90%	\$259,500
Operating Costs for Trolley	\$0	\$0	\$0	\$0	\$0
Capital Costs for Trolley	\$0	\$0	\$0	\$0	\$0
TOTAL	\$0	\$915,500	\$240,500	\$4,328,300	\$5,484,200

order of least to most costly, are directly compared against one another in order to determine the most economically acceptable.

Analysis 1

Analysis 1 is included in this study to accommodate the State and local interests. Table 17 presents the tabulated benefits and costs for each Alternative, and Tables 18 presents the results of the benefit-cost analyses for Scenarios A, B, C, and D of Analyses 1 utilizing Equation 3. The results of each Scenario are described below.

Scenario A.

A benefit-cost ratio of 1.66 indicates that investment in the Trolley service in Gatlinburg is economically justifiable for the State and local governments. In essence the costs of delay to travelers in Gatlinburg without a Trolley service would exceed the State and local costs of operating the existing Trolley system and the consequent delay costs.

Scenario B.

Because Trolley operation at its existing level is justified, a resulting analysis to investigate if further investment in the Trolley service is logical. By increasing the fleet size of the existing Trolley service by 100% (and consequently doubling the operating and capital costs), the vehicle delay costs are reduced. When compared to the costs of the existing Trolley service, the benefit-cost ratio of 1.77 indicates that this alternative is also justified on the State and

*Table 17. Summary of Monetary Values for Analysis 1
(including Federal Government costs)*

Alternative	Delay Costs	Annual Construction Costs	Annual Trolley Costs
I.	\$2,333,900	\$0	\$0
II.	\$1,972,800	\$0	\$217,800
III.	\$1,588,200	\$0	\$435,700
IV.	\$0	\$1,155,900	\$0

Table 18. Results of Benefit-Cost Analysis 1

Scenario A. Case II. Versus Case I.

$$\frac{\$2,333,900 - \$1,972,800}{\$217,800 - \$0} = \frac{\$361,100}{\$217,800} = 1.66:1$$

→ Accept Alternative (Case II.), Reject Base (Case I.)

Scenario B. Case III. Versus Case II.

$$\frac{\$1,972,800 - \$1,588,200}{\$435,700 - \$217,800} = \frac{\$384,600}{\$217,900} = 1.77:1$$

→ Accept Alternative (Case III.), Reject Base (Case II.)

Scenario C. Case IV. Versus Case III.

$$\frac{\$1,588,200 - \$0}{\$1,155,900 - \$435,700} = \frac{\$1,588,200}{\$720,200} = 2.21:1$$

→ Accept Alternative (Case IV.), Reject Base (Case III.)

local levels assuming the usage of the Trolley is proportional to the availability (fleet size) of the Trolley service.

Scenario C.

A second option available to the City of Gatlinburg to improve transportation conditions for visitors and residents is to improve the roadway and parking facilities so that more efficient travel would be achieved. The improvements outlined previously would not require a Trolley service to supplement travel supply. Therefore, a benefit-cost comparison of the roadway and parking improvements with the most cost efficient level of Trolley service (Case III.) was conducted and yielded a benefit-cost ratio of 2.21. This fact supports any decision on the local level to implement the proposed series of improvements to the transportation infrastructure. It should be noted that the improvements analyzed in this study are grouped together as a single expense and not as individual projects. Investigation of these individual alternatives would require further assumptions regarding delay costs by the analyst.

Summary of Analysis 1

In order to provide an appropriate environment for tourists, merchants, and residents in Gatlinburg, City officials must consider, among many factors, the adequacy of mobility within the City. When selecting a strategy or strategies, the local officials should obtain the financial and other support of the State government. The Alternatives outlined in Analysis 1 include the do-nothing alternative, providing a Trolley service as it exists currently, providing an

increased level of Trolley service, and providing no Trolley service but an improved road network.

Based on the amount of in-vehicle delay costs reduced by each Alternative compared to the costs of the local and State governments for implementation of each Alternatives, the do-nothing option was the least attractive overall. Further investment in the Trolley service at a level greater than that of the existing level of investment is more economically attractive than financially supporting the existing level of Trolley service. From the local and State perspective, more spending is also justified for such measures as implementing parking and road improvements based on the reductions in delay costs created by the expanded facilities.

Analysis 2

Analysis 2 reflects the overall costs for the alternatives described above. Though the local and State budgets are of primary concern to the citizens and officials of Gatlinburg, the impact of these decisions encompass a broader economic scope. The Federal government is the primary contributor to any either alternative with the exception of the do-nothing alternative. Table 19 presents the tabulated benefits and costs for each Alternative, and Tables 20 presents the results of the benefit-cost analyses for Scenarios A, B, C, and D of Analyses 2 utilizing Equation 3. The results of each Scenario are described below.

*Table 19. Summary of Monetary Values for Analysis 2
(not including Federal Government costs)*

Alternative	Delay Costs	Annual Construction Costs	Annual Trolley Costs
I.	\$2,333,900	\$0	\$0
II.	\$1,972,800	\$0	\$475,900
III.	\$1,588,200	\$0	\$951,700
IV.	\$0	\$5,484,200	\$0

Table 20. Results of Benefit-Cost Analysis 2

Scenario A. Case II. Versus Case I.

$$\frac{\$2,333,900 - \$1,972,800}{\$475,900 - \$0} = \frac{\$361,100}{\$475,900} = 0.76:1$$

⇒ Reject Alternative (Case II.), Accept Base (Case I.)

Scenario B. Case III. Versus Case I.

$$\frac{\$2,333,900 - \$1,588,200}{\$951,700 - \$0} = \frac{\$745,700}{\$951,700} = 0.78:1$$

⇒ Reject Alternative (Case III.), Accept Base (Case I.)

Scenario C. Case IV. Versus Case I.

$$\frac{\$2,333,900 - \$0}{\$5,484,200 - \$0} = \frac{\$2,333,900}{\$5,484,200} = 0.43:1$$

⇒ Reject Alternative (Case IV.), Accept Base (Case I.)

Scenario A.

A benefit-cost ratio of 0.76 indicates that investment in the Trolley service in Gatlinburg is not justified economically when considering the overall costs. It should be noted for this and the remaining Scenarios that no benefit is applied to the Federal level which may or may not be representative of the actual conditions. The Federal government contributes to many public transit systems across the country at a greater rate (dollars to riders) than to Gatlinburg's service. The Gatlinburg Trolley may be considered an effective investment on the Federal level which is not reflected in the values used in this study.

Scenario B.

As the level of Trolley service increases, justification for the investment does not improve based on the benefit-cost ratio of 0.78. The do-nothing alternative is again the most acceptable Case.

Scenario C.

Improving the roadway and parking capacity in Gatlinburg is not justified in Gatlinburg from the overall cost perspective. The benefit-cost ratio for this Alternative was 0.43 which is clearly below the acceptable range. The level of Federal investment required to implement the proposed improvements exceeds \$4,000,000 annually which is significant compared to other costs in this study.

Summary of Analysis 2

The same Alternatives considered in Analysis 1 are considered in Analysis 2 only the Federal costs are applied to the cost values. When

the Federal perspective is considered, costs values greatly increase. As a result, the do-nothing Alternative appears to be the most justifiable option. However, all affects (benefits) of implementing a Trolley system or constructing a roadway/parking system are unable to be fully determined for the Federal level. This Analysis can provide general values to consider for decision making regarding Gatlinburg mobility Alternatives but are not intended to reflect absolute conditions.

Study Limitations

The data used to determine the benefits and costs were estimated based on the information and resources available during the analysis. The limitations associated with these values are identified in the following paragraphs.

Vehicle delay costs due to congestion were determined using a single intersection in the City of Gatlinburg. The extent of delay caused by congestion at the North Parkway-East Parkway intersection may be actually affected by factors not identified in this analysis. Delay calculations were based solely on the output of the Highway Capacity Software. City-wide delay was estimated at twice the delay which occurs the subject intersection. The actual City-wide delay value was not determined. The value of this delay was determined solely on the value of time based on the average salary of Gatlinburg tourists. This method of estimation may not consider all applicable factors.

Trolley operating costs are based on actual data reported to TDOT. A slight variation in numbers was discovered during their confirmation, however a consistent reference was used when possible and any error is minimal. Trolley capital costs were obtained from "order of magnitude" estimates based on interviews with professionals in the transportation field.

Road and parking construction costs were also obtained from estimated economic factors which attempted to reflect the original estimated value in current dollars. Factors which may have changed the actual value of these projects other than time were not considered.

Chapter 7

Conclusions

Two goals were attempted to be achieved by this study. The first goal was to identify the transportation-related issues which exists in Gatlinburg, Tennessee. The City is a nationally-known tourism market which is adjacent to the Great Smoky Mountains National Park. As a result of these facts, millions of visitors visit and/or travel through the City each year. Due to the regional topography, the City, and consequently its roadways and developable areas, lie in a narrow valley making transportation and parking facilities very limited.

The second goal for this study was to acknowledge the Gatlinburg Trolley service, which has operated since 1980, as a successful and even essential component of the transportation network in the City. The Trolley system operates two main routes (Orange and Green Lines) and two secondary routes and accommodates about 800,000 passenger trips each year--most of them (eighty-three percent) served during the peak summer tourism season of June through October. Steady utilization and growth of the Trolley service has afforded the City of Gatlinburg the opportunity to indefinitely postpone any major roadway and/or parking construction.

Observations collected by the author and used in this study include various Trolley service characteristics and characteristics of the existing City facilities. These include:

- Approximately ninety percent of the Trolley riders are tourists;
- The average group size for those traveling on the Trolley is approximately three persons and ranges between one and five usually;
- Travel distance on the Trolley ranges from very short distances (one or two blocks) to over six miles (the length of one complete loop on the Orange Line Trolley) and averages approximately 1.80 miles;
- Approximately 2,650 vehicle-miles of travel are estimated to be removed daily from the local street network as a result of the Trolley; and
- The City of Gatlinburg operates six public parking lots and on-street parking which provide approximately 900 parking spaces and privately-owned parking lots provide approximately 1,450 additional parking spaces, this number of parking spaces in addition to a limited supply of private parking spaces currently accommodates an estimated peak-day population of 60,000 individuals.

Benefit-cost analyses were conducted to attempt to quantify the impacts and justification of the Trolley service. The results indicate that from the local and State economic perspective, the existing level of Trolley service is economically justified over the do-nothing alternative with a benefit-cost ratio of 1.66. A greater level of investment in the Trolley system is also justifiable for the City and State. Roadway and parking improvements yielded an acceptable benefit-cost ratio as well when compared to Trolley service investment, however,

the roadway improvements considered may not be physically feasible and may cost significantly more than the amounts indicated in this study due to the maturity of the development in the Gatlinburg which did not exist at the time the roadway improvements were initially recommended.

A series of benefit-cost analyses were also conducted which consider the overall cost perspectives including Federal investments. These results yielded the do-nothing approach as the most economically justifiable alternative. Limitations in these analyses may exist however which would overestimate the desirability of the do-nothing alternative. These limitations are due to the inability to quantify all benefits associated with reducing vehicle congestion (particularly intangible benefits--environmental, social, and others) which exist on the local, State, and Federal levels. These benefits would offset the costs which appear to be somewhat disproportionately represented in this study.

In the event of further study on this topic, some information which was not readily available during this study should be considered. The passenger survey conducted for this document could be broadened in its scope to obtain a more thorough database of passenger and trip characteristics. A larger sample size for the survey than that of this study would also be more desirable. Traffic data should also be collected more extensively than what was available for this study. Namely, historical, existing, and projected turning volumes and link volumes for all major locations would allow a more comprehensive

understanding of the local traffic patterns and allow network computer modeling.

The Trolley complements the tourism industry in Gatlinburg as well as serves a definite mobility purpose for travelers and local residents. Vehicle delay on the local streets which would occur without the Trolley could create a near break down of mobility in the City during peak travel periods. It is the opinion of the author that the Trolley system in Gatlinburg is a highly effective tool in improving mobility in the City, yet potential exists to make service more efficient. Many of the options available are cost inhibitive such as various Intelligent Vehicle-Highway Systems technologies. These may include:

- real-time information to users at Trolley stops (route information, wait-time information, etc.), and
- real-time parking information (assigning available parking spaces to motorists just before entering the City, or changeable message signs indicating parking availability).

Other strategies would not require significant investment, such as:

- implementing a one-way pair street system on South-Parkway and River Road which would incorporate a bus-lane in each direction, and
- coordinating public transportation service with the neighboring communities of Pigeon Forge and Sevierville to provide a more regional service which serves regional park-and-ride facilities and

would reduce the need for driving private automobiles between communities.

At a minimum, Trolley service in Gatlinburg should continue to be a local and State priority. Without the Gatlinburg Trolley, travel in the City for local residents and highly valued tourists is estimated to reach critically severe conditions as a result of traffic congestion.

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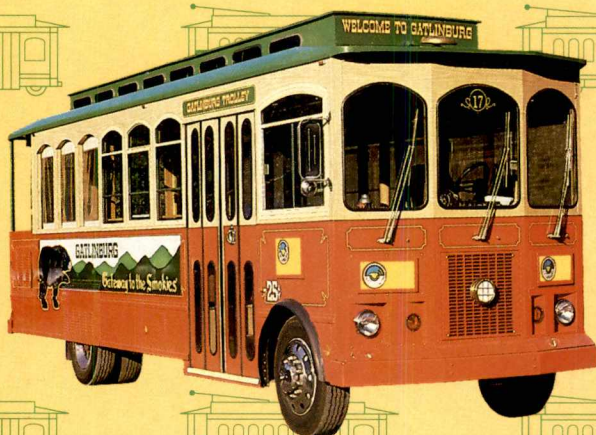
APPENDICES

APPENDIX A.

GATLINBURG TROLLEY SYSTEM

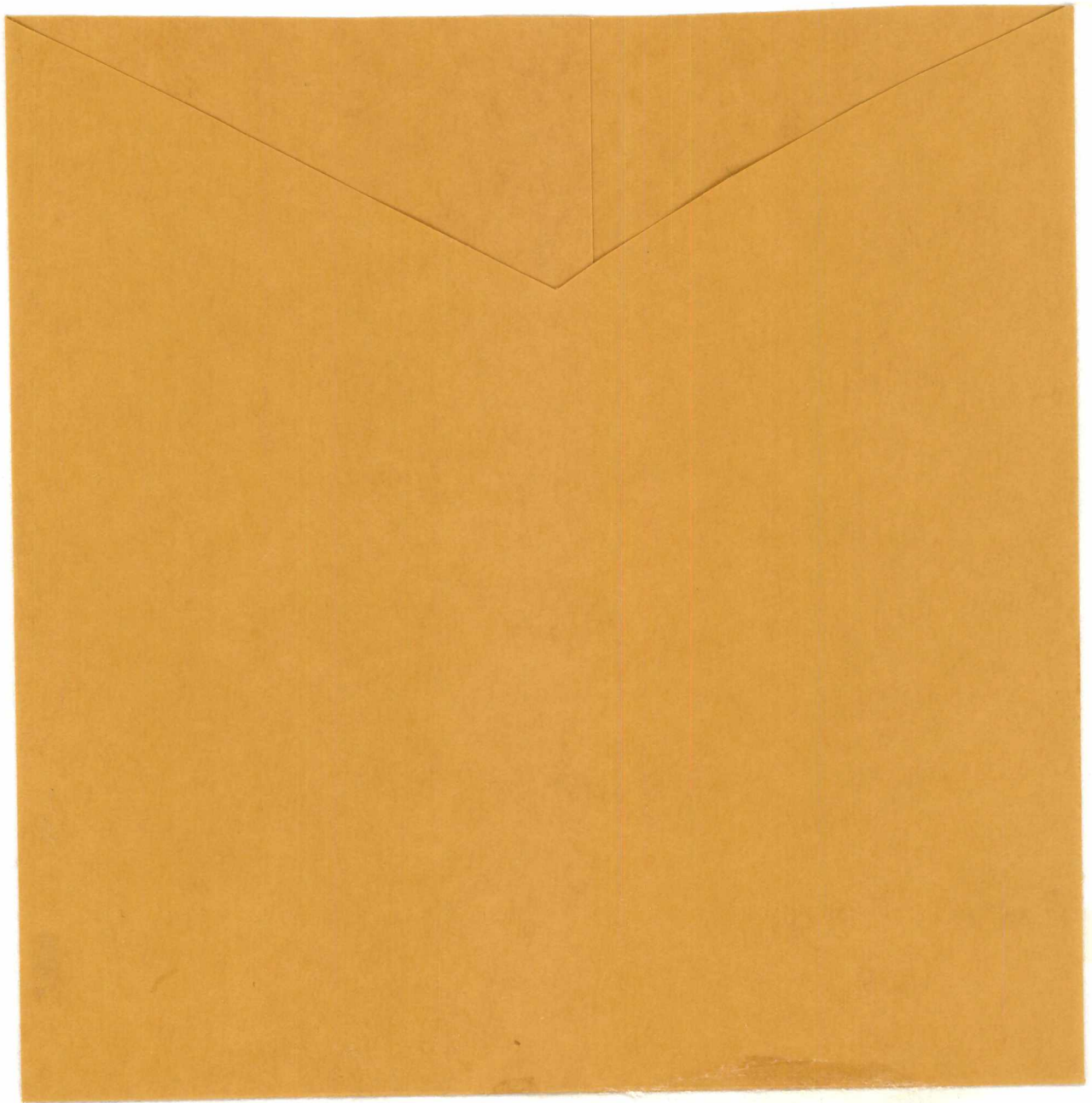
SERVICE AREA MAP

ALL ABOARD THE TROLLEY



**PARK AND RIDE
THE GATLINBURG
TROLLEY
THE EASIEST
WAY TO GET
AROUND**

Steve Eric Stoner
1994



APPENDIX B.

HIGHWAY CAPACITY MANUAL

INTERSECTION LEVEL-OF-SERVICE DEFINITIONS

1985 Highway Capacity Manual Intersection Level-of-Service Definitions:

Level-of-Service	Stopped Delay per Vehicle (seconds)
A	≤ 5.0
B	5.1 to 15.0
C	15.1 to 25.0
D	25.1 to 40.0
E	40.1 to 60.0
F	> 60.0

Level-of-service A describes operations with very low delay, i.e., less than 5.0 seconds per vehicle. This occurs when progression is extremely favorable, and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.

Level-of-service B describes operations with delay in the range of 5.1 to 15.0 seconds per vehicle. This generally occurs with good progression and/or short cycle lengths. More vehicles stop than for LOS A, causing higher levels of average delay.

Level-of-service C describes operations with delay in the range of 15.1 to 25.0 seconds per vehicle. These higher delays may result from fair progression and/or longer cycle lengths. Individual cycle failures may begin to appear in this level. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.

Level-of-service D describes operations with delay in the range of 25.1 to 40.0 seconds per vehicle. At level D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high v/c ratios. Many vehicles stop, and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.

Level-of-service E describes operations with delay in the range of 40.1 to 60.0 seconds per vehicle. This is considered to be the limit of acceptable delay. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are frequent occurrences.

Level-of-service F describes operations with delay in excess of 60.0 seconds per vehicle. This is considered to be unacceptable to most drivers. This condition often occurs with oversaturation, i.e., when arrival flow rates exceed the capacity of the intersection. It may also occur at high v/c ratios below 1.00 with many individual cycle failures. Poor progression and long cycle lengths may also be major contributing causes to such delay levels.

APPENDIX C.

HIGHWAY CAPACITY SOFTWARE INTERSECTION LEVEL-OF-SERVICE RESULTS

1985 HCM: SIGNALIZED INTERSECTIONS

SUMMARY REPORT

INTERSECTION..US 321/US 441

AREA TYPE.....CBD

ANALYST.....STEVE STONER

DATE.....04-28-94

TIME.....11:00 AM TO 12:00 PM

COMMENT.....PERIOD1.SIG

VOLUMES					GEOMETRY						
	EB	WB	NB	SB	:	EB	WB	NB	SB		
LT	0	491	0	247	:	12.0	L	12.0	T	12.0	L
TH	0	0	689	967	:	12.0	L	12.0	TR	12.0	T
RT	0	276	276	0	:	12.0	R	12.0		12.0	T
RR	0	132	132	0	:	12.0		12.0		12.0	
					:	12.0		12.0		12.0	
					:	12.0		12.0		12.0	

	ADJUSTMENT FACTORS										
	GRADE	HV	ADJ	PKG	BUSES	PHF	PEDS	PED.	BUT.	ARR.	TYPE
	(%)	(%)	Y/N	Nm	Nb			Y/N	min T		
EB	0.00	5.00	N	0	0	0.93	200	N	17.5		3
WB	0.00	5.00	N	0	0	0.93	200	N	17.5		3
NB	0.00	5.00	N	0	0	0.93	200	N	11.5		3
SB	0.00	5.00	N	0	0	0.93	200	N	11.5		3

SIGNAL SETTINGS								CYCLE LENGTH = 109.5			
	PH-1	PH-2	PH-3	PH-4		PH-1	PH-2	PH-3	PH-4		
EB LT					NB LT						
TH					TH	X					
RT					RT	X					
PD	X				PD				X		
WB LT		X			SB LT		X				
TH					TH	X	X				
RT		X			RT						
PD	X				PD				X		
GREEN	7.0	25.0	0.0	0.0	GREEN	35.0	18.0	7.0	0.0		
YELLOW	0.0	6.0	0.0	0.0	YELLOW	6.0	5.5	0.0	0.0		

LEVEL OF SERVICE							
	LANE GRP.	V/C	G/C	DELAY	LOS	APP. DELAY	APP. LOS
WB	L	0.915	0.256	43.4	E	39.8	D
	R	0.451	0.256	26.7	D		
NB	TR	0.881	0.347	31.8	D	31.8	D
SB	L	0.945	0.187	61.8	F	22.3	C
	T	0.615	0.562	12.7	B		

INTERSECTION: Delay = 29.4 (sec/veh) V/C = 0.651 LOS = D

1985 HCM: SIGNALIZED INTERSECTIONS

SUMMARY REPORT

INTERSECTION..US 321/US 441

AREA TYPE.....CBD

ANALYST.....STEVE STONER

DATE.....04-28-94

TIME..... 1:00 PM TO 2:00 PM

COMMENT.....PERIOD2.SIG

VOLUMES					GEOMETRY						
	EB	WB	NB	SB	EB	L	WB	T	NB	L	SB
LT	0	433	0	227	12.0	L	12.0	T	12.0	L	12.0
TH	0	0	721	824	12.0	L	12.0	TR	12.0	T	12.0
RT	0	247	303	0	12.0	R	12.0		12.0	T	12.0
RR	0	132	132	0	12.0		12.0		12.0		12.0
					12.0		12.0		12.0		12.0
					12.0		12.0		12.0		12.0

ADJUSTMENT FACTORS										
	GRADE	HV	ADJ	PKG	BUSES	PHF	PEDS	PED.	BUT.	ARR. TYPE
	(%)	(%)	Y/N	Nm	Nb			Y/N	min T	
EB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
WB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
NB	0.00	5.00	N	0	0	0.93	200	N	11.5	3
SB	0.00	5.00	N	0	0	0.93	200	N	11.5	3

SIGNAL SETTINGS										CYCLE LENGTH = 109.5			
		PH-1	PH-2	PH-3	PH-4			PH-1	PH-2	PH-3	PH-4		
EB	LT					NB	LT						
	TH						TH	X					
	RT						RT	X					
	PD	X					PD			X			
WB	LT		X			SB	LT		X				
	TH						TH	X	X				
	RT		X				RT						
	PD	X					PD			X			
GREEN		7.0	25.0	0.0	0.0	GREEN		35.0	18.0	7.0	0.0		
YELLOW		0.0	6.0	0.0	0.0	YELLOW		6.0	5.5	0.0	0.0		

LEVEL OF SERVICE							
	LANE GRP.	V/C	G/C	DELAY	LOS	APP. DELAY	APP. LOS
WB	L	0.807	0.256	34.6	D	32.8	D
	R	0.360	0.256	25.7	D		
NB	TR	0.946	0.347	38.3	D	38.3	D
SB	L	0.869	0.187	49.4	E	19.4	C
	T	0.524	0.562	11.6	B		

INTERSECTION: Delay = 29.2 (sec/veh) V/C = 0.562 LOS = D

1985 HCM: SIGNALIZED INTERSECTIONS

SUMMARY REPORT

INTERSECTION..US 321/US 441

AREA TYPE.....CBD

ANALYST.....STEVE STONER

DATE.....04-28-94

TIME.....6:00 PM TO 7:00 PM

COMMENT.....PERIOD3.SIG

VOLUMES					GEOMETRY						
	EB	WB	NB	SB	:	EB	WB	NB	SB		
LT	0	317	0	262	:	12.0	L	12.0	T	12.0	L
TH	0	0	708	688	:	12.0	L	12.0	TR	12.0	T
RT	0	232	296	0	:	12.0	R	12.0		12.0	T
RR	0	132	132	0	:	12.0		12.0		12.0	
					:	12.0		12.0		12.0	
					:	12.0		12.0		12.0	

ADJUSTMENT FACTORS										
	GRADE	HV	ADJ	PKG	BUSES	PHF	PEDS	PED.	BUT.	ARR. TYPE
	(%)	(%)	Y/N	Nm	Nb			Y/N	min T	
EB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
WB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
NB	0.00	5.00	N	0	0	0.93	200	N	11.5	3
SB	0.00	5.00	N	0	0	0.93	200	N	11.5	3

SIGNAL SETTINGS										CYCLE LENGTH = 109.5
	PH-1	PH-2	PH-3	PH-4		PH-1	PH-2	PH-3	PH-4	
EB LT					NB LT					
TH					TH	X				
RT					RT	X				
PD	X				PD			X		
WB LT		X			SB LT		X			
TH					TH	X	X			
RT		X			RT					
PD	X				PD			X		
GREEN	7.0	25.0	0.0	0.0	GREEN	35.0	18.0	7.0	0.0	
YELLOW	0.0	6.0	0.0	0.0	YELLOW	6.0	5.5	0.0	0.0	

LEVEL OF SERVICE							
	LANE GRP.	V/C	G/C	DELAY	LOS	APP. DELAY	APP. LOS
WB	L	0.591	0.256	28.3	D	27.6	D
	R	0.313	0.256	25.2	D		
NB	TR	0.924	0.347	35.6	D	35.6	D
SB	L	1.003	0.187	75.9	F	28.1	D
	T	0.438	0.562	10.7	B		

INTERSECTION: Delay = 30.9 (sec/veh) V/C = 0.446 LOS = D

1985 HCM: SIGNALIZED INTERSECTIONS

SUMMARY REPORT

INTERSECTION..US 321/US 441

AREA TYPE.....CBD

ANALYST.....STEVE STONER

DATE.....04-28-94

TIME.....11:00 AM TO 12:00 PM

COMMENT.....PERIOD1A.SIG

VOLUMES					GEOMETRY						
	EB	WB	NB	SB	EB	WB	NB	SB	EB	WB	SB
LT	0	509	0	265	12.0	L	12.0	T	12.0	L	12.0
TH	0	0	707	985	12.0	L	12.0	TR	12.0	T	12.0
RT	0	294	294	0	12.0	R	12.0		12.0	T	12.0
RR	0	132	132	0	12.0		12.0		12.0		12.0
					12.0		12.0		12.0		12.0
					12.0		12.0		12.0		12.0

ADJUSTMENT FACTORS										
	GRADE (%)	HV (%)	ADJ Y/N	PKG Nm	BUSES Nb	PHF	PEDS	PED. Y/N	BUT. min T	ARR. TYPE
EB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
WB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
NB	0.00	5.00	N	0	0	0.93	200	N	11.5	3
SB	0.00	5.00	N	0	0	0.93	200	N	11.5	3

SIGNAL SETTINGS										CYCLE LENGTH = 107.0	
	PH-1	PH-2	PH-3	PH-4		PH-1	PH-2	PH-3	PH-4		
EB LT					NB LT						
TH					TH	X					
RT					RT	X					
PD	X				PD			X			
WB LT		X			SB LT		X				
TH					TH	X	X				
RT		X			RT						
PD	X				PD			X			
GREEN	7.0	25.0	0.0	0.0	GREEN	35.0	18.0	7.0	0.0		
YELLOW	0.0	5.0	0.0	0.0	YELLOW	5.0	5.0	0.0	0.0		

LEVEL OF SERVICE							
	LANE GRP.	V/C	G/C	DELAY	LOS	APP. DELAY	APP. LOS
WB	L	0.961	0.252	50.2	E	44.8	E
	R	0.514	0.252	27.2	D		
NB	TR	0.924	0.346	35.1	D	35.1	D
SB	L	1.016	0.187	79.1	F	26.2	D
	T	0.628	0.561	12.6	B		

INTERSECTION: Delay = 33.4 (sec/veh) V/C = 0.670 LOS = D

1985 HCM: SIGNALIZED INTERSECTIONS

SUMMARY REPORT

 INTERSECTION..US 321/US 441
 AREA TYPE.....CBD
 ANALYST.....STEVE STONER
 DATE.....04-28-94
 TIME..... 1:00 PM TO 2:00 PM
 COMMENT.....PERIOD2A.SIG

VOLUMES					GEOMETRY						
	EB	WB	NB	SB	EB	WB	NB	SB			
LT	0	450	0	244	12.0	L	12.0	T	12.0	L	12.0
TH	0	0	738	841	12.0	L	12.0	TR	12.0	T	12.0
RT	0	264	320	0	12.0	R	12.0		12.0	T	12.0
RR	0	132	132	0	12.0		12.0		12.0		12.0
					12.0		12.0		12.0		12.0
					12.0		12.0		12.0		12.0

ADJUSTMENT FACTORS										ARR. TYPE
	GRADE (%)	HV (%)	ADJ Y/N	PKG Nm	BUSES Nb	PHF	PEDS	PED. Y/N	BUT. min T	
EB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
WB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
NB	0.00	5.00	N	0	0	0.93	200	N	11.5	3
SB	0.00	5.00	N	0	0	0.93	200	N	11.5	3

SIGNAL SETTINGS										CYCLE LENGTH = 107.0			
		PH-1	PH-2	PH-3	PH-4			PH-1	PH-2	PH-3	PH-4		
EB	LT					NB	LT						
	TH						TH	X					
	RT						RT	X					
	PD	X					PD			X			
WB	LT		X			SB	LT		X				
	TH						TH	X	X				
	RT		X				RT						
	PD	X					PD			X			
GREEN		7.0	25.0	0.0	0.0	GREEN		35.0	18.0	7.0	0.0		
YELLOW		0.0	5.0	0.0	0.0	YELLOW		5.0	5.0	0.0	0.0		

LEVEL OF SERVICE							
	LANE GRP.	V/C	G/C	DELAY	LOS	APP. DELAY	APP. LOS
WB	L	0.850	0.252	36.8	D	34.4	D
	R	0.419	0.252	25.9	D		
NB	TR	0.987	0.346	44.9	E	44.9	E
SB	L	0.935	0.187	59.1	E	21.8	C
	T	0.536	0.561	11.5	B		

INTERSECTION: Delay = 32.9 (sec/veh) V/C = 0.580 LOS = D

1985 HCM: SIGNALIZED INTERSECTIONS
SUMMARY REPORT

INTERSECTION..US 321/US 441
AREA TYPE.....CBD
ANALYST.....STEVE STONER
DATE.....04-28-94
TIME.....6:00 PM TO 7:00 PM
COMMENT.....PERIOD3A.SIG

VOLUMES					GEOMETRY					
	EB	WB	NB	SB	EB	WB	NB	SB		
LT	0	335	0	280	12.0	L	12.0	T	12.0	L
TH	0	0	726	706	12.0	L	12.0	TR	12.0	T
RT	0	250	314	0	12.0	R	12.0		12.0	T
RR	0	132	132	0	12.0		12.0		12.0	
					12.0		12.0		12.0	
					12.0		12.0		12.0	

ADJUSTMENT FACTORS										
	GRADE (%)	HV (%)	ADJ Y/N	PKG Nm	BUSES Nb	PHF	PEDS	PED. Y/N	BUT. min T	ARR. TYPE
EB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
WB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
NB	0.00	5.00	N	0	0	0.93	200	N	11.5	3
SB	0.00	5.00	N	0	0	0.93	200	N	11.5	3

SIGNAL SETTINGS										CYCLE LENGTH = 107.0
	PH-1	PH-2	PH-3	PH-4		PH-1	PH-2	PH-3	PH-4	
EB LT					NB LT					
TH					TH	X				
RT					RT	X				
PD	X				PD			X		
WB LT		X			SB LT		X			
TH					TH	X	X			
RT		X			RT					
PD	X				PD			X		
GREEN	7.0	25.0	0.0	0.0	GREEN	35.0	18.0	7.0	0.0	
YELLOW	0.0	5.0	0.0	0.0	YELLOW	5.0	5.0	0.0	0.0	

LEVEL OF SERVICE							
	LANE GRP.	V/C	G/C	DELAY	LOS	APP. DELAY	APP. LOS
WB	L	0.633	0.252	28.6	D	27.8	D
	R	0.374	0.252	25.4	D		
NB	TR	0.967	0.346	41.2	E	41.2	E
SB	L	1.073	0.187	99.7	F	35.1	D
	T	0.450	0.561	10.6	B		

INTERSECTION: Delay = 36.0 (sec/veh) V/C = 0.464 LOS = D

1985 HCM: SIGNALIZED INTERSECTIONS

SUMMARY REPORT

INTERSECTION..US 321/US 441

AREA TYPE.....CBD

ANALYST.....STEVE STONER

DATE.....04-28-94

TIME.....6:00 PM TO 7:00 PM

COMMENT.....PERIOD3C.SIG

VOLUMES					GEOMETRY						
	EB	WB	NB	SB	:	EB	WB	NB	SB		
LT	0	281	0	226	:	12.0	L	12.0	T	12.0	L
TH	0	0	672	652	:	12.0	L	12.0	TR	12.0	T
RT	0	196	260	0	:	12.0	R	12.0		12.0	T
RR	0	132	132	0	:	12.0		12.0		12.0	
					:	12.0		12.0		12.0	
					:	12.0		12.0		12.0	

ADJUSTMENT FACTORS										
	GRADE (%)	HV (%)	ADJ Y/N	PKG Nm	BUSES Nb	PHF	PEDS	PED. Y/N	BUT. min T	ARR. TYPE
EB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
WB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
NB	0.00	5.00	N	0	0	0.93	200	N	11.5	3
SB	0.00	5.00	N	0	0	0.93	200	N	11.5	3

SIGNAL SETTINGS										CYCLE LENGTH = 109.5
	PH-1	PH-2	PH-3	PH-4		PH-1	PH-2	PH-3	PH-4	
EB LT					NB LT					
TH					TH	X				
RT					RT	X				
PD	X				PD			X		
WB LT		X			SB LT		X			
TH					TH	X	X			
RT		X			RT					
PD	X				PD			X		
GREEN	7.0	25.0	0.0	0.0	GREEN	35.0	18.0	7.0	0.0	
YELLOW	0.0	6.0	0.0	0.0	YELLOW	6.0	5.5	0.0	0.0	

LEVEL OF SERVICE							
	LANE GRP.	V/C	G/C	DELAY	LOS	APP. DELAY	APP. LOS
WB	L	0.524	0.256	27.3	D	26.8	D
	R	0.200	0.256	24.3	C		
NB	TR	0.844	0.347	29.6	D	29.6	D
SB	L	0.865	0.187	49.0	E	20.1	C
	T	0.415	0.562	10.5	B		

INTERSECTION: Delay = 25.0 (sec/veh) V/C = 0.412 LOS = C

1985 HCM: SIGNALIZED INTERSECTIONS
SUMMARY REPORT

INTERSECTION..US 321/US 441
AREA TYPE.....CBD
ANALYST.....STEVE STONER
DATE.....04-28-94
TIME..... 1:00 PM TO 2:00 PM
COMMENT.....PERIOD2C.SIG

VOLUMES					:	GEOMETRY						
	EB	WB	NB	SB	:	EB		WB		NB		SB
LT	0	399	0	193	:	12.0	L	12.0	T	12.0	L	12.0
TH	0	0	687	790	:	12.0	L	12.0	TR	12.0	T	12.0
RT	0	213	269	0	:	12.0	R	12.0		12.0	T	12.0
RR	0	132	132	0	:	12.0		12.0		12.0		12.0
					:	12.0		12.0		12.0		12.0
					:	12.0		12.0		12.0		12.0

ADJUSTMENT FACTORS											
	GRADE	HV	ADJ	PKG	BUSES	PHF	PEDS	PED.	BUT.	ARR.	TYPE
	(%)	(%)	Y/N	Nm	Nb			Y/N	min T		
EB	0.00	5.00	N	0	0	0.93	200	N	17.5		3
WB	0.00	5.00	N	0	0	0.93	200	N	17.5		3
NB	0.00	5.00	N	0	0	0.93	200	N	11.5		3
SB	0.00	5.00	N	0	0	0.93	200	N	11.5		3

SIGNAL SETTINGS									
					CYCLE LENGTH = 109.5				
	PH-1	PH-2	PH-3	PH-4		PH-1	PH-2	PH-3	PH-4
EB LT					NB LT				
TH					TH	X			
RT					RT	X			
PD	X				PD			X	
WB LT		X			SB LT		X		
TH					TH	X	X		
RT		X			RT				
PD	X				PD			X	
GREEN	7.0	25.0	0.0	0.0	GREEN	35.0	18.0	7.0	0.0
YELLOW	0.0	6.0	0.0	0.0	YELLOW	6.0	5.5	0.0	0.0

LEVEL OF SERVICE							
	LANE GRP.	V/C	G/C	DELAY	LOS	APP. DELAY	APP. LOS
WB	L	0.744	0.256	31.9	D	30.7	D
	R	0.254	0.256	24.7	C		
NB	TR	0.870	0.347	31.1	D	31.1	D
SB	L	0.739	0.187	38.6	D	16.5	C
	T	0.503	0.562	11.3	B		

INTERSECTION: Delay = 24.7 (sec/veh) V/C = 0.531 LOS = C

1985 HCM: SIGNALIZED INTERSECTIONS

SUMMARY REPORT

INTERSECTION..US 321/US 441

AREA TYPE.....CBD

ANALYST.....STEVE STONER

DATE.....04-28-94

TIME.....11:00 AM TO 12:00 PM

COMMENT.....PERIOD1C.SIG

VOLUMES					GEOMETRY						
	EB	WB	NB	SB	EB	WB	NB	SB			
LT	0	455	0	211	12.0	L	12.0	T	12.0	L	12.0
TH	0	0	653	931	12.0	L	12.0	TR	12.0	T	12.0
RT	0	240	240	0	12.0	R	12.0		12.0	T	12.0
RR	0	132	132	0	12.0		12.0		12.0		12.0
					12.0		12.0		12.0		12.0
					12.0		12.0		12.0		12.0

ADJUSTMENT FACTORS										
	GRADE (%)	HV (%)	ADJ Y/N	PKG Nm	BUSES Nb	PHF	PEDS	PED. Y/N	BUT. min T	ARR. TYPE
EB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
WB	0.00	5.00	N	0	0	0.93	200	N	17.5	3
NB	0.00	5.00	N	0	0	0.93	200	N	11.5	3
SB	0.00	5.00	N	0	0	0.93	200	N	11.5	3

SIGNAL SETTINGS										CYCLE LENGTH = 109.5
	PH-1	PH-2	PH-3	PH-4		PH-1	PH-2	PH-3	PH-4	
EB LT					NB LT					
TH					TH	X				
RT					RT	X				
PD	X				PD			X		
WB LT		X			SB LT		X			
TH					TH	X	X			
RT		X			RT					
PD	X				PD			X		
GREEN	7.0	25.0	0.0	0.0	GREEN	35.0	18.0	7.0	0.0	
YELLOW	0.0	6.0	0.0	0.0	YELLOW	6.0	5.5	0.0	0.0	

LEVEL OF SERVICE							
	LANE GRP.	V/C	G/C	DELAY	LOS	APP. DELAY	APP. LOS
WB	L	0.848	0.256	37.1	D	34.9	D
	R	0.338	0.256	25.5	D		
NB	TR	0.801	0.347	27.7	D	27.7	D
SB	L	0.808	0.187	43.2	E	17.8	C
	T	0.592	0.562	12.4	B		

INTERSECTION: Delay = 24.8 (sec/veh) V/C = 0.617 LOS = C

APPENDIX D.

SURVEY RESULTS

1993 Gatlinburg Trolley Rider Survey Results

weekday AM 58
weekday PM 54
weekend 75

green line 124
orange line 61

1. Are you a a.) resident of Sevier County 15
 b.) other 173

2. How many persons are in your party?

0... --
1... 15
2... 72
3... 31
4... 33
5... 17
>5... 18

(if party is more than 3 or 4, how many vehicles would you use if
your party were riding in a private automobile?)

0... 10
1... 169
2... 4
3... 5

3. Could you have used a private automobile to make this same trip?

a.) yes 161 b.) no 17

4. Where is your car(s) parked currently?

86 a.) your lodging (or home if local resident)
59 b.) a park-and-ride lot
23 c.) other public parking lot
1 d.) local business _____
2 e.) other _____

5. Where did you board the Trolley for this trip?

69 a.) your lodging/home
64 b.) your car
54 c.) other _____

6. Where are you going on this trip?

16 a.) your lodging/home
16 b.) your car
138 c.) sightseeing/shopping
17 d.) other _____

7. How long is your stay in Gatlinburg (not Pigeon Forge)?

55 a.) just today (not overnight)
67 b.) two or three days (including overnight)
47 c.) more than three days

8. How many other times have you ridden the Trolley today? _____
(not including this trip) (each time boarding counts as one trip)

0... 137
1... 38
2... 10
>2... 3

Vita

Steve Eric Stoner was born in McMinnville, Tennessee on April 15, 1970. There he lived with his family--parents, Glen and Jannette, and brothers, Allen and Chris. Steve began college in 1988 at the University of Tennessee in Knoxville. There he received his Bachelor of Science degree in civil engineering in December of 1992 and his Master of Science degree in civil engineering with a concentration in transportation engineering and planning in December 1994.

In May of 1994, Steve accepted a position with the consulting firm of DeShazo, Tang & Associates in Dallas, Texas where he now lives.