U.S. Department of Transportation
Research and
Special Programs
Administration

Lowell National Historical Park
Alternative Transportation System
Historic Trolley Planning Study

Final Report

December, 2002

Prepared for:
National Park Service
Northeast Region
200 Chestnut Street
Philadelphia, PA 19106

Prepared by:
John A. Volpe
National Transportation
Systems Center
Kendall Square
Cambridge, MA 02142

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
December 2002	Planning Study	NA

4. TITLE AND SUBTITLE

Lowell National Historical Park
Alternative Transportation System
Historic Trolley Planning Study

5a. CONTRACT NUMBER
NA

5b. GRANT NUMBER
NA

5c. PROGRAM ELEMENT NUMBER
NA

6. AUTHOR(S)

Terence Sheehan; John Boiney, Bob Brodesky, Jeff Bryan, Randy Clarke, Frank Ford, Ross Gill, Bob Hallett, Emmett Harris, Mike Jacobs, Mary Lawler, Barry Mickela, Scott Peterson, Eric Plosky, Richard Porcaro, Gary Ritter, Eran Segev, Anusha Seetharaman, Terrence F. Smith, and Paul Vallahura.

5d. PROJECT NUMBER
PMIS 55358

5e. TASK NUMBER
NPS TIC No. D-80

5f. WORK UNIT NUMBER
NA

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

US Department of Transportation, Research and Special Programs Administration
John A. Volpe National Transportation Systems Center
55 Broadway
Cambridge, MA 02142

8. PERFORMING ORGANIZATION REPORT NUMBER
DOT-VNTSC-NPS-02-03

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

National Park Service
Alternative Transportation Program
1201 Eye St. NW
Washington, DC 20005

10. SPONSOR/MONITOR'S ACRONYM(S)
WASO/ATP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
(see 5d. and 5e. above)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Public distribution/availability.

13. SUPPLEMENTARY NOTES

This report addresses alternative transportation decision factors as indicated below (Y/N/NA):
(N) Non-construction options; (Y) park carrying capacity; (Y) life-cycle/ops. & maintenance costs; (N) cost-effectiveness.

14. ABSTRACT

This report assesses opportunities for expanding Lowell National Historical Park's historic trolley line by implementing a light rail system reminiscent of late 19th/early 20th Century trolley lines. This is in line with the Park Service's Transportation Mission to preserve and protect resources while providing safe and enjoyable access within the National Parks by using sustainable, appropriate, integrated transportation solutions.

This Plan uses as a starting point the existing trolley system, the Park Service and the LNHP commitment to Alternative Transportation Systems (ATS), and the on-going efforts to revitalize the City of Lowell. Objectives relate to mobility for visitors and residents, reducing traffic congestion, intra-regional connectivity, economic development, and maintaining and interpretive and educational context. Four major routes are identified and options for these routes evaluated, using the Objectives and Route Selection Criteria.

15. SUBJECT TERMS

Lowell National Historic Park, Alternative Transportation Systems, Historic Trolley, Light Rail, Economic Revitalization/Development, Traffic Congestion, Regional Connectivity

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Gary Ritter
None	None	None	NA	113	19b. TELEPHONE NUMBER *(Include area code)*: 617-494-2716, ritter@volpe.dot.gov

Reset

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

PREFACE

The Lowell National Historical Park (LNHP) and the City of Lowell (the City) are considering expansion of the LNHP's historic trolley line. The impetus for this study is a June 1999 Memorandum of Understanding (MOU) between the National Park Service, the City of Lowell, the Lowell Regional Transportation Authority (LRTA), the Northern Middlesex Council of Governments (NMCOG), and the New England Electric Railway Historical Society (Seashore Trolley Museum). The United States Department of Transportation's Volpe National Transportation Systems Center examined the feasibility of implementing a light rail system reminiscent of late 19th/early 20th Century trolley lines that is consistent with the National Park Service's mission, and supports the City's transportation, economic, and redevelopment objectives.

The proposed system is designed to improve mobility in downtown Lowell where streets are narrow and auto congestion is common. It will connect sites operated by the LNHP, and provide access to the City's major activity centers, each of which has been influential in the City's economic turnaround: the Gallagher Intermodal Transportation Center (Gallagher Center), the Paul E. Tsongas Arena (Arena), LeLacheur Baseball Park (Ballpark), and the University of Massachusetts Lowell (UMASS-Lowell) campus. An integral component is the construction of a combination Operations and Maintenance facility/National Street Car Museum at Lowell. The museum will house vehicles and artifacts from the Seashore Trolley Museum collection, and possibly transit artifacts from other streetcar museums nationwide.

Vintage trolley systems are making a comeback in many cities across the nation, and have had a substantial positive economic development impacts in several cases. In Lowell, the proposed routes present the opportunity to enhance development goals at several key sites suffering from access and parking constraints, among them the Boott, Massachusetts, Lawrence, and Appleton Mills, the Dutton Yarn Co., and the site adjacent to the Arena.

This report provides a starting point in the expansion of the Lowell Historic Trolley system. Moving from the conceptual design outlined in this report to construction and operation will require cooperation by a large number of stakeholders, and will also require identifying funding and addressing regulatory requirements.

ACKNOWLEDGEMENTS

This Lowell National Historical Park (LNHP) Alternative Transportation System Historic Trolley Planning Study was prepared by the U.S. Department of Transportation John A. Volpe National Transportation Systems Center under the supervision of Terrence M. Sheehan, through the guidance and critical review of Christina Briggs and Peter Aucella of the Lowell National Historical Park. Additional review and comment came from members comprising the Lowell Trolley Task Force. The following is a listing of the Task Force members and their affiliation(s).

- Lowell Regional Transportation Authority - Robert Kennedy, Administrator
- Northern Middlesex Council of Governments (NMCOG) – Beverly Woods, Transportation Planning Director
- New England Electric Railway Historical Society (Seashore Trolley Museum) - Jim Schantz, Chairman
- City of Lowell – John Cox, City Manager
- City of Lowell – Colin McNeice, Director Of Economic Development
- City of Lowell – Linda King, Department of Planning and Development
- LNHP – Patrick McCrary, Superintendent
- LNHP – Peter Aucella, Assistant Superintendent
- LNHP – Christina Briggs, Planning and Grants Manager

In addition, special acknowledgments are offered to individuals who contributed significantly to the development of this Trolley Study:

- Adrienne Anderson, NPS Denver Service Center
- Bob Holzheimer, NPS Northeast Region
- Craig Miller, Winchester Engineering Associates
- Diana E. Prideaux-Brune, University of Massachusetts, Lowell
- Jim Corless, Chief of Education and Visitor Services, LNHP
- Chuck Parrott, Historic Architect, LNHP
- David Kronberg, Greater Lowell Community Foundation
- Roger Somers, Jeffrey Sisson and Daniel Cohen, Seashore Trolley Museum

The following Volpe Center staff assisted in the development of this plan: Bob Hallett, Eran Segev, Eric Plosky, Gary Ritter, Ross Gill, Richard Porcaro, Barry Mickela, Paul Vallahura, Jeff Bryan, Mary Lawler, and Mike Jacobs. The following on-site EG&G Technical Services staff also provided technical support under the direction of Bob Brodesky: Terrence F. Smith, Scott Peterson, Randy Clarke, Frank Ford, Emmett Harris, John Boiney, and Anusha Seetharaman.

Executive Summary

This Plan was developed to help the Lowell National Historical Park (LNHP), the City of Lowell (the City), and other partners in this project assess opportunities for expanding the Park's historic trolley line by implementing a light rail system reminiscent of late 19th/early 20th Century trolley lines. The National Park Service has operated historic trolley service for visitors since 1984, and providing transit service as well as service to LNHP visitors has been considered since the late 1970s.

The impetus for this study is a Memorandum of Understanding (MOU) between the National Park Service, the City of Lowell, the Lowell Regional Transportation Authority (LRTA), the Northern Middlesex Council of Governments (NMCOG), and the New England Electric Railway Historical Society (Seashore Trolley Museum). The Park Service selected the US Department of Transportation's Volpe National Transportation Systems Center to develop this Plan.

National Park Service Mission

The National Park Service preserves the natural and cultural resources and values of the National Park system for the enjoyment, education, and inspiration of this and future generations. The Park Service's Transportation Mission is to preserve and protect resources while providing safe and enjoyable access within the National Parks by using sustainable, appropriate, integrated transportation solutions.

This Plan uses as a starting point the existing trolley system, the Park Service and the LNHP commitment to Alternative Transportation Systems (ATS), and the on-going efforts to revitalize the City of Lowell. The National Park Service has established the ATS Program to meet high levels of visitor demand, enhance mobility within National Parks, and reduce environmental impacts. The ATS program is also designed to work with Gateway communities, such as Lowell, to improve overall transportation services in and around Park sites.

Planning for the development of the Lowell National Historical Park was the result of significant partnerships between the National Park Service, the City of Lowell, the Commonwealth of Massachusetts, and organizations and businesses in the greater Lowell area. The City of Lowell has experienced redevelopment and reinvestment as a result of the establishment of the Lowell National Historical Park and this proposed trolley expansion project is designed to build on those accomplishments. The participation by the Seashore Trolley Museum, and its plan to establish the National Streetcar Museum at Lowell as part of this project, will establish a new visitor destination in Lowell and add a new partner to the City's redevelopment efforts.

The City's efforts to revitalize Lowell have been substantial. It has recently completed major planning studies for the Northern Canal Economic Development Area (NCEDA), Downtown Lowell, the Jackson-Appleton-Middlesex (JAM) district, and the Acre Neighborhood, and has brought major new investments into the community. Investments include the Tsongas Arena, LeLacheur Park, expansion of the UMASS-Lowell campus, and redevelopment of mills for commercial, office, and residential uses.

Over the past 25 years, historic trolleys have demonstrated their capacity to fulfill – and sometimes exceed – the goals set for them, and these projects have encouraged economic development and served as valuable additions to communities throughout the United States. There are presently 17 historic trolley systems in operation in the United States with several new systems under construction, and about 20 others being planned.

Trolley Concept

The proposed trolley system will use the existing Park Service line as a backbone for the system. New service will extend from this line to establish loops to serve major sites in central Lowell including Park Service sites, Downtown Lowell, NCEDA, the JAM district, the Acre neighborhood, the Tsongas Arena, LeLacheur Park, and UMASS-Lowell. Service will be provided to areas that are currently popular with visitors as well as areas, such as the Lawrence Mills site, that are being redeveloped into mixed-use communities that will include residences, retail, and employment.

The benefits of the proposed service include addressing the transportation objectives of the Park Service's General Management Plan for the LNHP, providing service to areas identified for redevelopment and investment by the City of Lowell, addressing traffic and parking issues that are growing constraints on continued economic growth, and establishing new attractions for visitors to Lowell while enhancing Lowell's links to other sites in Eastern Massachusetts. In keeping with the nature of the LNHP the new service has been influenced by the history of trolley service in Lowell. The proposed lines, where possible, follow trolley routes that existed in the early 1900s and the trolley cars will be replicas of trolleys that ran in Lowell.

Concept Development

The trolley concept was designed with the goal of generating the most identifiable benefits for the Park and the City of Lowell. "Footprint" possibilities were considered against physical and urban design constraints, and for compatibility with the existing transportation network and services. For this analysis, Objectives and Route Selection criteria were developed to guide the

selection of routes. Objectives related to mobility for visitors and residents, reducing traffic congestion, intra-regional connectivity, economic development, and maintaining and interpretive and educational context. Selection criteria focused on node connections, compatibility with the roadway network, service to residents and economic development, maximizing the use of existing infrastructure, service interconnectivity and efficiency.

Trolley service is being designed to enhance and preserve the visitor service operated by the Park Service, while providing greater mobility and accessibility to sites in and around central Lowell. Four major routes were identified, and options for these routes evaluated, using the Objectives and Route Selection Criteria. This process also identified potential future routes. This plan goes beyond simply identifying potential routes by identifying how these routes coordinate with existing transit service, and identifying stop locations that would best serve riders.

Proposed Routes and Construction Phases

This proposed concept extends the Lowell National Historical Park's existing historic trolley line to improve access to the Park and to provide access to the following important activity centers in or near the central Lowell:

- Gallagher Intermodal Transportation Center
- Paul E. Tsongas Arena
- Lowell Memorial Auditorium
- Edward A. LeLacheur Baseball Park
- Lawrence Mills
- Middlesex Community College
- University of Massachusetts at Lowell.

The concept also incorporates:

- The proposed Operations and Maintenance facility/National Streetcar Museum at Lowell
- Two neighborhoods, the Acre neighborhood along Fletcher Street, and the Jackson, Appleton, and Middlesex (JAM) neighborhood, south of LNHP, that have been designated for redevelopment and revitalization
- The Artists Loft District on Middle Street
- Museums throughout Lowell
- Restaurants and Retail shops.

The concept calls for three development phases through 2010.

- Phase A will connect the existing line at Swamp Locks to the Gallagher Intermodal Transportation Center, double-track part of the existing right-of-way, extend the current past the Tsongas Arena to LeLacheur Park, and initiate design for replacing the bridge over the Northern Canal (Pawtucket Street).
- Phase B will complete the Arena/Ballpark/Acre Loop by extending the transit system from the track at the ballpark constructed under Phase A by building track along Perkins Street, across the Northern Canal, along Pawtucket Street to Fletcher Street, down Fletcher Street to the connection to the Gallagher Center.
- Phase C will create the Museum/JAM/Downtown Loop by extending the trolley line at the National Streetcar Museum at Lowell site built in Phase A to Middlesex Street, Central Street, Prescott Street, and Bridge Street connecting to the existing trolley line at the Boott Mills. The loop would then return to the Gallagher Center on the Boott Mills track to the double tracked right of way on Dutton Street. Completion of this loop will also allow for service on a third loop, the Central Lowell Loop that would continue west at the intersection of the Dutton Street and Boott Mills tracks to the Arena/Ballpark/Acre Loop.

In developing these routes extensions beyond Phase C, it has been suggested to include a riverfront line, adding track on Market Street, providing service to UMASS-Lowell's academic campus across the Merrimack River from the residential campus and to UMASS-Lowell's South Campus, and providing service to the CrossPoint development (the former Wang Labs headquarters) on Chelmsford Street.

Urban Context

Approximately 28,000 people will live within a quarter mile of the trolley route at full build-out. Several thousand people work within the area that would be served and visitors to the Park and other attractions in Lowell further boost the number of potential riders. The trolley route is expected to have a positive economic impact on Lowell while complimenting on-going revitalization and economic development efforts including the planning for Downtown Lowell, the JAM district, and the Acre neighborhood.

Travel Demand Forecast

Four categories of rider have been identified in this Plan. The first category is Park Service visitors, the people who use the existing trolley service. Lowell residents make up the second major category of riders. The third major

category is people coming to Lowell for special events such as baseball and hockey games, the annual folk festival, and concerts. The final category includes riders drawn to live or work in Lowell by on-going development efforts.

The system is designed to provide frequent service during morning and evening rush hours to serve commuters with slightly less frequent service during the mid-day and evenings. Additional service is planned for special events and the system has been designed to allow for trolleys to queue following an event to reduce waiting times for riders. The planned trolleys will have room for up to 90 passengers, up to 45 seated and 45 standing. The number of cars, four, and the headways and travel time should provide service at adequate frequencies to conveniently serve commuters and visitors.

Costs

Preliminary development costs were developed for this study, but it is important to remember that these costs will likely change once more detailed design and engineering analysis is completed. A range of capital costs and options, depending on the option selected to connect to the Gallagher Center, is presented in the report. At this time, this range of capital costs is from $23.4 million to $52.7 million. Operation and maintenance costs are based on national averages for light rail systems. The range of yearly operations and maintenance costs are between $750,000 and $2 million, depending on frequency of service and phase of construction. No more definite costs are possible given several factors, including the need to identify the administrative structure for the operation and maintenance of this system.

Outside funding will be necessary to build and operate the system. Preliminary fare box recovery analysis has identified a need for operating subsidies. Several capital funding sources are identified in the report including the FTA New Starts Program and the Park Service ATS program. Other possible capital and operating funding sources include the Commonwealth of Massachusetts, the City of Lowell, the Federal Highway Administration, and private sources such as selling naming rights and advertising and joint development efforts coupled with transit oriented development projects. A possible method to both build and possible operate the system is the use of Design-Build, also called Turnkey, or Design-Build-Operate-Maintain, also called Super Turnkey, to build and possibly operate the system. It is likely that a combination of funding sources will be needed to both build and operate the proposed system. Opportunities to match FTA New Starts funds using NPS, LNHP, and other sources available to the community as local match funds will require receipt of a "Letter of No Prejudice" from FTA.

Institutional Issues

This Plan provides a starting point in the expansion of the Lowell Historic Trolley system. This project has come this far with the active participation of a number of stakeholders including the National Park Service, the City of Lowell, the LRTA, UMASS-Lowell, NMCOG, and the Seashore Trolley Museum. Moving beyond this conceptual design will require involvement by a number of other partners including Federal, State, and Regional agencies, Lowell residents, businesses, and property owners and community and business organizations.

The partners in this process are working with FTA to secure a "Letter of No Prejudice, a step that is necessary for NPS and LNHP funds already committed to this project to be counted toward local match with FTA New Starts funding. Federal funding for planning and implementing transportation projects also depends upon the projects being derived from a continuing, comprehensive, and cooperative (3C) planning process. State and regional agencies will also have significant involvement in the development of this system. Moving from conceptual design to project construction will require the completion of an Environmental Impact Study (EIS) and, if Federal transportation funds are to be used, an Alternatives Assessment. Other regulatory issues may also need to be addressed at the Federal and State level including meeting Americans with Disability Act (ADA) requirements. All of these efforts will require developing new partnerships to move from this conceptual design to an operating system.

TABLE OF CONTENTS

1 Introduction 1

2 National Park Service Mission 5

TRANSPORTATION MISSION AND ALTERNATIVE TRANSPORTATION SOLUTIONS 5
EVOLUTION OF THE ALTERNATIVE TRANSPORTATION SYSTEMS PROGRAM 5
ATS and Gateway Communities 7
LOWELL NATIONAL HISTORICAL PARK MISSION 8
PARTNERSHIPS 9
Memorandum of Understanding 10
National Streetcar Museum at Lowell 10
Relationship with other Planning Efforts 12
Cooperative Planning Charette 13
OTHER "NEW" HISTORIC TROLLEY SYSTEMS 13
Historic Trolley Success Stories 16

3 The Lowell Trolley Concept 19

EXISTING TROLLEY LINE 19
LNHP Trolley Rail and Wheel Evaluations 20
EXPECTED BENEFITS OF A LOWELL TROLLEY SYSTEM 22
PROPOSED ROUTES AND CONSTRUCTION PHASES 23
PROPOSED ROUTES AND HISTORIC TROLLEY SERVICE IN LOWELL 28

4 Concept Development 31

CONCEPT DEVELOPMENT OBJECTIVES 31
ROUTE EVALUATION/SELECTION CRITERIA 32
COORDINATING WITH NATIONAL PARK SERVICE INTERPRETIVE TOURS 33
ROUTE ANALYSIS 35
Loop Services 35
Gallagher Connector 36
Museum Link (Swamp Locks Bridge) 37
Ballpark/Arena/Acre Loop 37
Museum/JAM/Downtown Loop 41
ROUTE OPTIONS 43
Downtown Route Options 43
Gallagher Connection Options 45
Future Route Options 52
INTEGRATION WITH THE LRTA SYSTEM 55
TROLLEY STOPS LOCATIONS 56

5 Urban Context 61

BENEFITS TO LOWELL 61
Traffic Congestion Mitigation 62
Improving Access to the LNHP and Downtown 62

Improving Intra-Regional Transportation Connections *63*
Extending the Interpretive Experience offered to Visitors by the LNHP *63*
SERVICE AREA DEMOGRAPHICS 63
ECONOMIC IMPACTS 64
LAND USE 65
PLANNING AND REDEVELOPMENT 67
Acre Urban Revitalization and Development Project Plan *68*
JAM Urban Revitalization and Development Project Plan *69*
Downtown Master Plan *71*
GROWTH AND ECONOMIC REVITALIZATION 72

6 Travel Demand Forecasts 75

WHO WILL RIDE THE TROLLEY? 75
TROLLEY SERVICE CHARACTERISTICS 77
TROLLEY CAPACITY – REQUIRED PRICE AND HEADWAY COMBINATIONS 78

7 Costs 81

CAPITAL COSTS – TRACK AND WIRES 81
Phase A Construction *82*
Phase B Construction *83*
Phase C Construction *83*
Downtown Traffic Mitigation *83*
CAPITAL COSTS – TROLLEY CARS 84
OPERATING AND MAINTENANCE COSTS 86
OPERATION & MAINTENANCE COSTS, REVENUES, AND COST RECOVERY 87
FUNDING 88
Funding Commitments to Date *89*
Capital Funding Plan *89*
Operation and Maintenance Funding *92*
Design/Build/Operate/Maintain *93*

8 Institutional Issues 95

LIST OF FIGURES

Figure		Page
1	EXISTING BACKLOG OF ATS PROJECTS BY TYPE	6
2	HISTORIC TROLLEY SYSTEMS NATIONWIDE	14
3	EXISTING LOWELL TROLLEY LINE	21
4	LOWELL TROLLEY LINE PHASE A	25
5	LOWELL TROLLEY LINE PHASE B	26
6	LOWELL TROLLEY LINE PHASE C	27
7	LOWELL HISTORIC TROLLEY SYSTEM	28
8	GALLAGHER CONNECTION OPTION 1A	46
9	GALLAGHER CONNECTION OPTION 1B	48
10	GALLAGHER CONNECTION OPTION 2	50
11	GALLAGHER CONNECTION OPTION 3	51
12	POTENTIAL FUTURE ROUTES	54
13	LOWELL BUS ROUTES	55
14	LOWELL TROLLEY LINE PROPOSED STOPS	59
15	LOWELL ZONING	66
16	ACRE REDEVELOPMENT	69
17	JACKSON APPLETON MIDDLESEX URBAN REVITALIZATION AND DEVELOPMENT PLAN	70
18	CITY OF LOWELL ECONOMIC OPPORTUNITY AREAS	73

LIST OF TABLES

Table		Page
1	SNAPSHOTS OF HISTORIC TROLLEY SYSTEMS IN THE U.S.	15
2	EXPECTED BENEFITS OF A DOWNTOWN TROLLEY SYSTEM	22
3	LRTA BUS ROUTE CONNECTIONS TO PROPOSED TROLLEY SYSTEM	56
4	PROPOSED TROLLEY STOPS	57
5	CURRENT AND FUTURE DEMOGRAPHICS BY PHASE	64
6	ECONOMIC BENEFITS	65
7	ANNUAL TROLLEY RIDERSHIP, PHASE C	75
8	TROLLEY EXTENSION SERVICE CHARACTERISTICS	77
9	SYSTEM CAPACITY	78
10	DOWNTOWN TRAFFIC MITIGATION MEASURES	84
11	ESTIMATEED CAPITAL COSTS	85
12	SUMMARY OF ANNUAL OPERATING AND MAINTENANCE COSTS	87
13	O&M COSTS, REVENUES, AND REVENUE RECOVERY BY FARE, PHASE C	88

LIST OF ACRONYMS AND ABBREVIATIONS

3C	Continuing, Comprehensive, and Cooperative (3C) planning process
ADA	Americans with Disabilities Act
ARENA	Paul E. Tsongas Arena
ATS	Alternative Transportation Systems
BALLPARK	Edward A. LeLacheur Park
CAA	Clean Air Act
CATS	Charlotte Area Transit System
CBD	Central Business District
CMAQ	Congestion Mitigation and Air Quality
EA	Environmental Assessments
EIS	Environmental Impact Statement
EOTC	Massachusetts Executive Office of Transportation and Construction
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GMP	General Management Plan
HART	Hillsborough Area Regional Transit System (Tampa, FL)
HOV	High Occupancy Vehicle
HUD	United States Department of Housing and Development
JAM	Jackson-Appleton-Middlesex Redevelopment District
MBTA	Massachusetts Bay Transportation Authority
NCEDA	North Canal Economic Development Area
NMCOG	Northern Middlesex Council of Governments
LNHP	Lowell National Historical Park
LRTA	Lowell Regional Transit Authority
LRTR	Long Range Transportation Plan
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
NPS	National Park Service
O&M	Operations and Maintenance
RTA	Regional Transit Authority
TAG	Transportation Assistance Group
TCM	Transportation Management/Congestion Relief Strategies
TEA-21	Transportation Equity Act of the 21st Century
TIP	Transportation Improvement Plan
TOD	Transit-Oriented Development
USDOT	United States Department of Transportation
UMASS	University of Massachusetts
VMT	Vehicle Miles Traveled

1 Introduction

The Lowell National Historical Park (LNHP) and the City of Lowell (City) are considering expansion of the LNHP's historic trolley line. The United States Department of Transportation's Volpe National Transportation Systems Center (Volpe Center) has been examining the feasibility of implementing a light rail system reminiscent of late 19th/early 20th Century trolley lines. The recommendations in this report are to be considered conceptual in nature, with a goal of forming consensus with stakeholders and the community. This report commences the process for consideration into the Federal Transit Administration (FTA) New Starts program. Subsequent work will focus on environmental assessments, including an alternatives analysis study to evaluate various modal and alignment options for addressing the mobility needs in the corridor, and preliminary engineering of a preferred operating system. The preliminary concepts discussed throughout this report have been developed consistent with the mission of the National Park Service, and supports the City's transportation, economic, and redevelopment objectives.

The National Park Service has been operating historic trolley service for the LNHP visitors since 1984. Providing transit service as well as service to LNHP visitors has been considered since the late 1970s. This Plan follows a series of studies, done with the participation of the LNHP and other partners, completed over the past twenty years. The impetus for this study is a Memorandum of Understanding (MOU) between the National Park Service, the City of Lowell, the Lowell Regional Transportation Authority (LRTA), the Northern Middlesex Council of Governments (NMCOG), and the New England Electric Railway Historical Society (Seashore Trolley Museum).

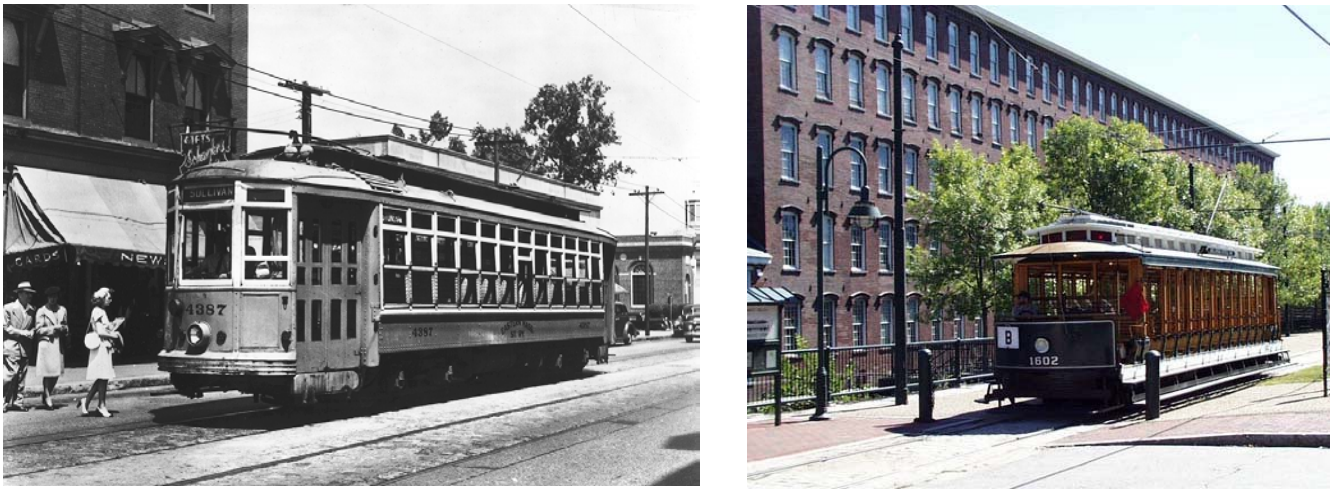
The design concept is simple – a single-track historic trolley system serving central Lowell. The proposed concept calls for a phased build-out of a light rail system that would run replica trolleys resembling early 20th Century cars, much like those operated by the Eastern Massachusetts Street Railway. There is also the possibility of operating, on a supplemental basis, authentic rehabilitated early 20th Century trolleys, currently preserved at the Seashore Trolley Museum in

Kennebunkport, ME. At the present time, no entity has been identified to operate and maintain the proposed system. However, there are numerous options available including not-for-profit organizations, contracted for-profit service providers, a Design-Build-Operate-Maintain consortia, and the Lowell Regional Transportation Authority (LRTA). Identification of who will operate and maintain the system will be addressed in future studies.

The proposed system is designed to improve mobility in downtown Lowell where streets are narrow and auto congestion is common. It will connect sites operated by the LNHP, and provide access to the City's major activity centers, each of which has been influential in the City's economic turnaround: the Gallagher Intermodal Transportation Center (Gallagher Center), the Paul E. Tsongas Arena (Arena), Edward A. LeLacheur Baseball Park (Ballpark), Middlesex Community College, and the University of Massachusetts-Lowell (UMASS-Lowell) campus. An integral component is the construction of a combination Operations and Maintenance facility/National Streetcar Museum at Lowell. The museum will house vehicles and artifacts from the Seashore Trolley Museum collection, and possibly transit artifacts from other streetcar museums nationwide.

The concept builds upon the historic and interpretive experience of 19th century mill town life that has been re-created by the National Park Service in Lowell:

- **Lowell represents the most significant planned industrial city in the United States and symbolizes in physical form, the Industrial Revolution.**
- **The Park tells the story of the Industrial Revolution, in general, and the textile industry in particular.**



Trolleys in Eastern Massachusetts, Then and Now

The concept leverages the preservation activities of the National Park Service that have led to Lowell becoming a tourist attraction. It is also consistent, from an urban design perspective, with ongoing redevelopment activities in downtown Lowell that include converting 19th Century mills into residential and commercial space. The City also expects that complete build-out of the trolley system will revitalize interest in neighborhoods within walking distance of the proposed routes.

The inclusion of the Gallagher Center – the city's nexus for auto, rail, and bus service – will improve intra-regional connectivity, and enhance Lowell as a place to visit, live, work, attend school, or operate a business. This connection increases the probability that the public – whether they are living in or visiting Boston – will consider visiting Lowell, and provides greater access for commuters originating in Lowell's downtown neighborhoods. It also offers the opportunity for LNHP visitors to access and enjoy the LNHP and Lowell's other attractions without the need for the personal automobile, and provide a direct transit link between Park Service sites in eastern Massachusetts.

Mock-up of Gallagher Intermodal Transportation Center, with completion of new Bus Transit Center, Phase II parking garage, and day care center

2 National Park Service Mission

The National Park Service preserves, unimpaired, the natural and cultural resources and values of the National Park system for the enjoyment, education, and inspiration of this and future generations. The service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout this country and the world.

The National Park Service is subject to a number of legal requirements for planning, all intended to support the best possible decision-making for the agency and the public it serves. Good planning helps provide everyone who has a stake in the decisions with an opportunity to be involved in the planning process and to understand the decisions as they are being made. The planning process ensures that decision-makers have adequate information about benefits, environmental impacts, and costs.

Transportation Mission and Alternative Transportation Solutions

The implementation of the proposed trolley system is consistent with the National Park Service's mission of preserving and protecting the country's natural, historical, and recreational resources for future generations. It recognizes the strategic importance of providing access, ensuring a safe and enjoyable Park Service experience, and working closely with 'gateway communities' to coordinate transportation services.

The National Park Service has been committed to providing, as well as sustaining, a range of transportation services, recognizing that the provision of these services creates opportunities for the public to visit National Park sites and experience natural and historical wonders.

NPS Transportation Mission: Preserve and protect resources while providing safe and enjoyable access within the National Parks by using sustainable, appropriate, integrated transportation solutions.

Evolution of the Alternative Transportation Systems Program

Almost 280 million people visited US national parks in 2001. Many parks experience traffic congestion, particularly during the summer months and on

holiday weekends. This detracts from visitor's enjoyment of the parks and damages natural resources. To alleviate these conditions, some parks offer visitors alternatives to driving their own vehicles, such as shuttle buses, trams or in the case of Lowell, trolleys. Congress encouraged the use of such alternatives through enactment of the Transportation Equity Act of the 21st Century (TEA-21) in 1998. The legislation provided federal land management agencies, including the Park Service, with increased responsibilities for managing transportation activities. Funding for meeting these responsibilities has been provided through the US Department of Transportation, which annually funds the Park Service to initiate or expand alternative transportation systems where appropriate. To administer these funds, the National Park Service established the Alternative Transportation Program in 1998. Program objectives include relieving traffic and parking congestion; reducing air, noise, and visual pollution; enhancing visitor experience; preserving natural and cultural resources; and improving safety conditions.

Section 3039 of TEA-21 required "a comprehensive study of alternatives transportation needs in national parks and related lands." The *Federal Lands Alternative Transportation Systems (ATS) Study – Congressional Report,*[1] was completed in August 2001. The report included a summary of alternative transportation system needs and estimated costs between 2001 and 2020. The project team reviewed 169 park units and found that 118 of them had ATS needs. The study identified a backlog of needed improvements to 57 existing Alternative Transportation Systems. In addition, the study showed that new or expanded Alternative Transportation Systems are needed at 105 park units. Figure 1 shows the breakdown of the existing backlog of ATS projects by project type.

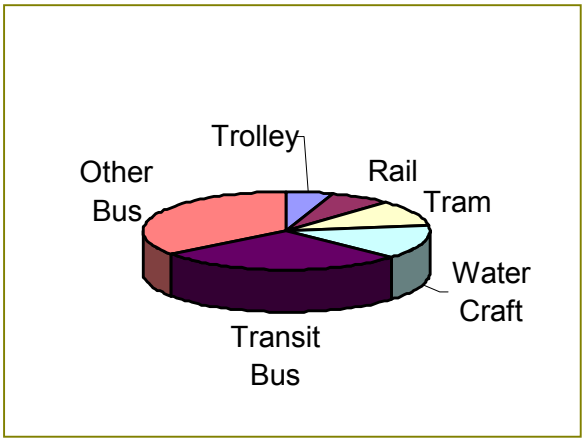


Figure 1. Existing Backlog of ATS Projects by Type

[1] Authorized by Section 3039 of TEA-21 (Transportation Equity Act for the 21st Century). Completed in August, 2001, and delivered to the Congress in January 2002.

Expansion of the LNHP trolley system was identified as a candidate project for consideration of funding. A NPS Transportation Assistance Group (TAG) team made a visit to LNHP on January 9, 2001. The intent was to review the merits of this trolley study. After a number of recommendations, the TAG recommended funding in mid-2001 that resulted in this study.

ATS and Gateway Communities

The Park Service's transportation network includes roads, parkways, and Alternative Transportations Systems (ATS). Congress requires the Park Service to plan and implement ATS in cooperation with state and local agencies. A major focus has been coordinating with communities, called Gateway Communities, closest to Park Service sites. Lowell is the Gateway Community for the LNHP.

The historic trolley concept that is being proposed for Lowell is an example of an ATS. These systems, which frequently include high occupancy vehicles, allow the Park Service to meet high levels of visitor demand, enhance mobility within the Parks, and reduce environmental impacts. They can also contribute to the historic fabric of a park, enhance the visitor experience, and promote economic development. The "Red Bus" on the "Going to the Sun Highway" at Glacier National Park is an example of a system that provides historic context, adds to the overall visitor experience, and attracts visitors.

Glacier National Park Red Bus

Through innovative and cooperative partnerships with Gateway Communities, the National Park Service has been able to leverage federal monies for demonstration projects at Acadia, Grand Canyon, and Zion National Parks and the Golden Gate National Recreation Area by more than five to one.

- Acadia National Park along with local towns and businesses and the Maine Department of Transportation (using Congestion Mitigation and Air Quality funds) initiated a free shuttle serving the Park and local communities, called the Island Explorer. The service is credited with reducing 1.3 million of vehicle miles traveled and measurable amounts of air pollutants.

- Zion National Park and the local gateway community jointly sponsored a shuttle bus system that has reduced pollution, helped the local economy, and provided visitors with enjoyable experiences.

Zion National Park Shuttle Bus

Lowell National Historical Park Mission

Moving forward with an historic trolley system is consistent with the LNHP mission of preserving and interpreting the story of the Industrial Revolution and the changing role of technology in a 19th and 20th Century setting. The historic and cultural sites, structures, and districts in Lowell represent the most significant planned industrial city in the United States. The cultural heritage of many of the ethnic groups that immigrated to the United States, and worked in Lowell's mills during the 19th and early 20th Centuries, is still preserved in the city's neighborhoods.

The creation of the LNHP has provided a vehicle for economic progress in a community that had witnessed a steady decline in its manufacturing base, beginning in the 1950s. It has generated renewed business investments, downtown revitalization, and improvements in the City's quality of life with the development of sporting and cultural venues.

The Lowell National Historical Park provides a vehicle for economic progress in the community, encouraging creative and cooperative preservation and interpretive programs.

Providing trolley service as part of the LNHP experience was an objective early in the development of the LNHP. The existing system, which is designed primarily to move LNHP visitors between sites as part of LNHP Ranger led tours, opened in 1984. Providing public transit circulation alternatives has been an objective of the LNHP since its inception. This report builds on the efforts of the LNHP and

partners in Lowell to expand on the existing LNHP trolley system and return trolley transit service to this community.

Partnerships

Planning for the development of the Lowell National Historical Park was the result of significant partnerships between the National Park Service, the City of Lowell, the Commonwealth of Massachusetts, and organizations and businesses in the Greater Lowell area. The LNHP represents an innovative park concept in the National Park System, where the historic and cultural resources remain largely in private ownership. The concept adopted at LNHP provides for a historical/cultural park in an urban environment, with a unique partnership between Federal, State, and local governments, and the private sector. These partnerships have been fundamental to achieving the LNHP's mission, and have allowed the LNHP to minimize its ownership of property while still being involved in the treatment and use of the significant historic and cultural properties that comprise its 19th century urban setting.

Partnerships have been critical to the development and operation of the LNHP's integrated visitor transportation system of canal boats, trolley, and walkways. In the past two decades, LNHP has completed numerous transportation projects totaling nearly $40 million in LNHP, Federal Highway Administration, Commonwealth of Massachusetts, and local funds. The LNHP has been very successful in obtaining funds for a variety of projects including the development of the Tremont Yard Trolley Terminus, canal walkway improvements, Boston & Maine Railroad Terminal Headhouse rehabilitation, and canalway/riverwalk wayside signage. The key to Lowell's success is the partnering, networking, and political skills of the LNHP personnel. They have effectively worked with government partners and the Metropolitan Planning Organization (NMCOG). They are familiar with the State and local transportation process, and have key partners advocating projects involving multiple sources of funds. This proposed expansion of the historic trolley system builds on these partnerships and establishes new partnerships.

Memorandum of Understanding

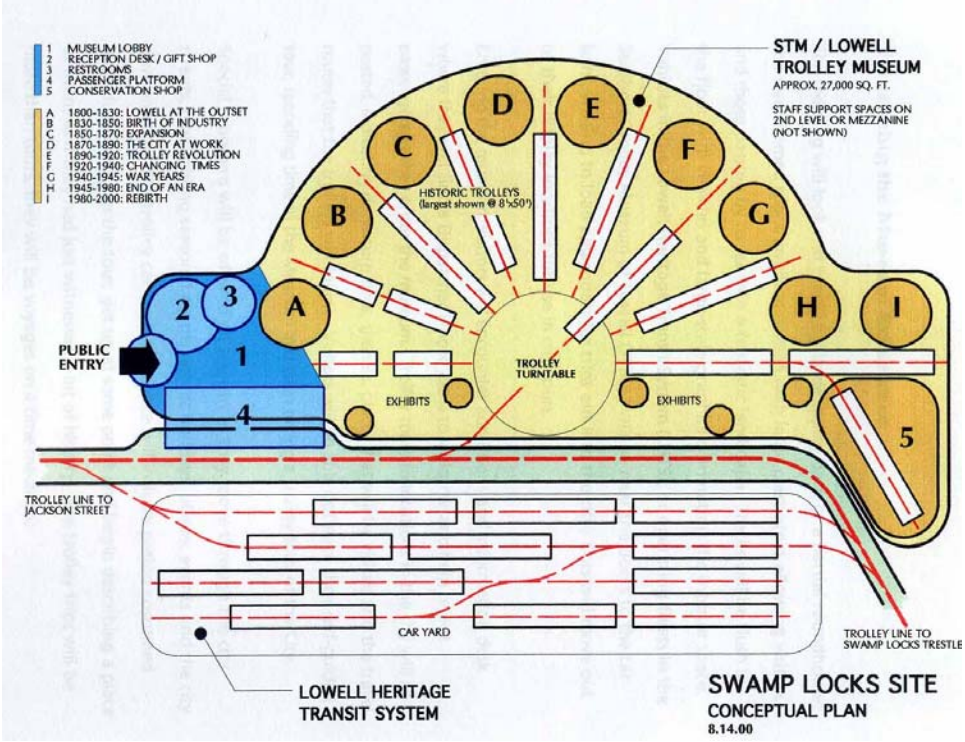
In June 1999, the NPS signed a Memorandum of Understanding (MOU) with the City of Lowell, the Lowell Regional Transportation Authority (LRTA), the Northern Middlesex Council of Governments (NMCOG), and the New England Electric Railway Historical Society (Seashore Trolley Museum). The objective of the MOU was to '*undertake a joint effort to evaluate the feasibility of potential additions to the National Park Visitor Transportation System, the creation of a downtown electric trolley system, and trolley museum in the City of Lowell, Massachusetts*.' The team members were also to evaluate and define the objectives and outcomes of this study. The Seashore Trolley Museum agreed to supply cars from its collection on a rotating basis for display in LNHP. Periodic use of the cars on the trolley system is expected as the project matures. Also, this group is working on initiating the National Streetcar Museum at Lowell as a branch of the Seashore Trolley Museum.

National Streetcar Museum at Lowell

The Seashore Trolley Museum is spearheading the creation of a National Streetcar Museum at Lowell to complement the trolley system. The Museum is envisioned to describe the history of public transit in Lowell, the region, and America. The Museum will be in a building, but will also extend into the City of Lowell through wayside exhibits, interpretive tours and field learning experiences. Seashore Trolley and the LNHP are currently working with the National Building Museum in Washington DC to establish a partnership that will bring a large portion of an exhibit entitled *On Track – Transit in the American City* to Lowell[2].

The City of Lowell has granted permission to the LNHP to display this exhibit in the state-owned Mack building (located on the trolley line in the Lowell Central Business District) from July 2003 until October 2004. Also, the Seashore Trolley Museum and the LNHP are pursuing an affiliation with the Smithsonian Institution. This affiliation will enhance the Museum's stature and visibility, while improving opportunities for fund raising for design, construction and operation of the Museum. Working with the Smithsonian Institution holds the promise of new levels of interpretation, collection management, and programmatic excellence. Other partnership opportunities with philanthropic entities, federal and state agencies, schools and universities, and local concerns are planned, but are currently in the nascent stage.

[2] *On Track: Transit and the American City* maps the unique relationship between transportation, especially public transportation, and the American city through three metaphorical places: Expanding City, Suburban City and Regional City.



National Streetcar Museum at Lowell Conceptual Floor Plan

NPS Denver Service Center Proposed Exterior Design

The National Streetcar Museum at Lowell is about people, cities and public transportation, using Lowell as the stage to present the history of public transportation in America

Relationship with other Planning Efforts

The City of Lowell has undertaken significant efforts to plan for the redevelopment of central Lowell. The establishment of the LNHP in the late 1970s established a starting point for the development and adaptive re-use of historic mill buildings, as well as the preservation of other historic sites within central Lowell. The area to be served by the proposed trolley system includes all of central Lowell, which is made-up of four specific districts: Downtown Lowell, the North Canal Economic Development Area, the Acre Neighborhood, and the Jackson-Appleton-Middlesex (JAM) redevelopment area.

Significant development, including the Arena, the Ballpark, and new developments at UMASS-Lowell's North campus, as part of the Northern Canal Economic Development Area (NCEDA), demonstrate that new developments can be compatible with maintaining Lowell's historic character. This proposed expansion of the historic trolley system is designed to enhance these sites and further development in this area by improving transportation connections between this area and the rest of the Lowell Central Business District (CBD). The planned redevelopment of the Lawrence Mills site to a transit oriented mixed-use development in this area will benefit from the expansion of trolley service.

While the success in the NCEDA is a clear indication that Lowell has the potential for new investment opportunities, the City is not resting on those successes. The City has completed Revitalization and Redevelopment Plans for the Acre Neighborhood and the Jackson Appleton Middlesex (JAM) area, and has completed a draft Master Plan for Downtown Lowell. Development of the proposed expansion of the trolley system focused on enhancing and complementing these planning efforts.

The City has identified each of these areas for commercial and residential development and adaptive re-use of existing buildings. Each neighborhood, however, has unique characteristics. For example, the Acre neighborhood is primarily residential and planning efforts focus on maintaining the residential community while providing needed services for neighborhood residents, such as a grocery store and pharmacy.

The JAM redevelopment area is dominated by blighted mill structures, and other industrial buildings. The focus of planning efforts in this area is adaptive re-use

of these buildings into a combination of office, residential, commercial, and industrial uses.

The Downtown Master Plan focuses on maintaining downtown Lowell as a commercial and employment center, continuing to attract residents to downtown, and preserving the character and history of downtown Lowell. Major issues identified in the draft Downtown Master Plan include traffic congestion and the decreasing availability of parking, as successful development efforts lead to increased parking demand.

Cooperative Planning Charette

On August 28, 2002, an all-day urban design charette was held at the LNHP. It was the first formal public meeting to discuss the elements of this project. It included an overview of the project, a presentation of Bus/Trolley Shelter designs and a roundhouse concept, an overview of trolley urban design considerations, and formal presentations and breakout sessions relating to Land Use, Transportation Systems, Architectural Character, and the Visitor Experience. Attendees included representatives from the LNHP, Seashore Trolley Museum, NPS Denver Service Center, NPS Northeast Regional Office, City of Lowell Department of Planning and Development, Northern Middlesex Council of Governments, Lowell Regional Transit Authority, Middlesex Community College, Lowell Historic Board, Center City Committee/Community Teamwork, Boott Cotton Mills, Inc. (developer), and the Downtown Lowell Business Association. Recommendations from this charette were instrumental in the development of this report.

Other "New" Historic Trolley Systems

Over the past 25 years, historic trolleys have demonstrated their capacity to fulfill – and sometimes exceed – the goals set for them. There are presently 17 historic trolley systems in operation in the United States, and their successes have inspired new historic-trolley designs (Figure 2). This enthusiasm shows no sign of abating as several new systems are currently under construction, and about 20 others are being planned.

As it considers options for trolley expansion, Lowell can learn from the experiences of other cities

that have implemented historic trolley systems. As shown in Figure 2, these other systems are quite varied. However, it is possible upon examination to identify some of the best practices that have come to light. Summary information on all of the other historic trolley systems currently operating in the United States is given in Table 1.

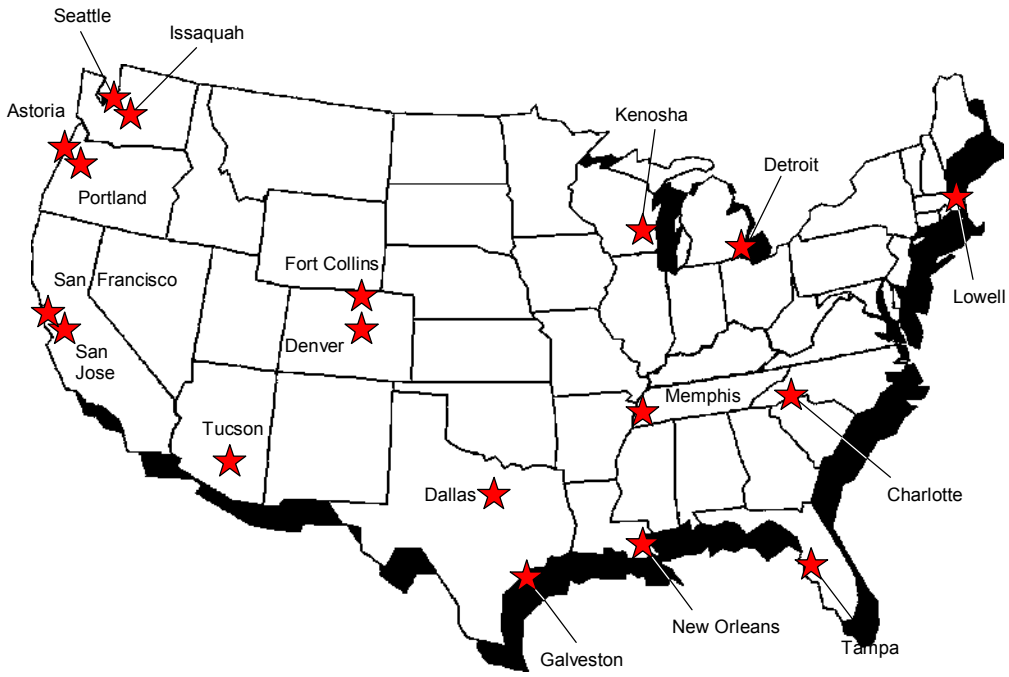


Figure 2. Historic Trolley Systems Nationwide

"Vintage streetcars have proven to be a popular and viable local transit option in a number of communities."

- Congress for the New Urbanism

Table 1. Snapshots of Other Historic Trolley Systems in the U.S.

Tampa, Florida ~ The newest line which was opened in October 2002. It connects the waterfront Cruise Ship terminals and commercial activities with the City's main entertainment district. Creatively financed.
Seattle, Washington ~ Established in 1982 as part of waterfront-restoration effort. Serves parks, shops, restaurants, and new residential development.
Issaquah, Washington ~ This short line, single-car operation was built mostly as a tourist attraction, but it serves the historic downtown.
Astoria, Oregon ~ Small-scale one-car operation concentrates on historic experience and interpretive services, including narration of local history and anecdotes.
Portland, Oregon ~ Vintage line opened in 1991 as adjunct to new light-rail system; runs from downtown to major shopping area and also serves historic district.
San Francisco ~ Introduced in the 1980s, proved so popular that service now runs full-time as a transit line downtown. A second line opened in 2000 along the waterfront.
San Jose, California ~ The historic trolley service here runs mostly on the tracks of a modern light-rail system, although a short shuttle line in a park is a purely historic service. Serves retail, hotels, museums, and convention center.
Tucson, Arizona ~ Founded as part of the 1985 University of Arizona centennial celebration. The line serves the university but stops short of downtown due to original funding constraints; volunteers operate the single car.
Denver, Colorado ~ The Platte Valley Trolley runs along the edge of Denver; it does not serve downtown. It is essentially an excursion service used for seasonal operations.
Fort Collins, Colorado ~ Single line and single car began operations in 1984; volunteer labor was and is essential. Runs from city park to edge of downtown.
Dallas, Texas ~ Project began at behest of local business owners to revive restaurant/entertainment area, after discovering abandoned trolley tracks in that area.
Galveston, Texas ~ Line links beach to Victorian downtown area; loop between historic downtown and beachfront hotel/entertainment area.
New Orleans, Louisiana ~ The only historic trolley service to actually have been in service since inception (1831). Serves commercial, residential, and medical/educational venues, and French Quarter district. Popularity led to second and third lines being constructed.
Memphis, Tennessee ~ Built as part of rehabilitation of under-performing pedestrian mall constructed in 1970s; extended to redeveloping area and new intermodal system. Serves sports center, provides scenic river ride, and serves new residences.
Kenosha, Wisconsin ~ Conceived to link downtown, a commuter-rail station and new development. Serves municipal buildings, library, retail, museum, rail station, and park.
Detroit, Michigan ~ First urban vintage trolley in U.S. (1976); part of Bicentennial downtown-revitalization project.
Charlotte, North Carolina ~ Recent system designed as an economic growth engine to spur business development along route. Only first phase yet in operation.

Historic Trolley Success Stories

The historic trolley in Memphis has been credited with reviving the Main Street Mall in central Memphis, which had been a failing commercial district. Commercial and residential development has followed the introduction of the historic trolley line, and the original line has been extended to additional redevelopment areas. The residential population has expanded from less than 1,000 to more than 5,000, and a number of entertainment related developments have located on the trolley route.[3] Along the Riverfront line, there are a great number of new homes in evidence, as well as loft conversions underway in several historic industrial buildings. The Memphis Center City Commission values the current building boom at over $2 billion dollars.


Memphis, TN Historic Trolley

The City of Charlotte and the Charlotte Area Transit System (CATS) are investing $19.7 million to create a two-mile transit corridor in addition to the current system. Anticipation of the new service has already spurred additional development along the corridor. According to a 2000 Economic Development Report from the City of Charlotte "...the trolley serves as a catalyst for business development and has spurred a 16% increase in tax values along this corridor."

Charlotte, NC Car 85 Historic Trolley

Galveston, TX is a tourist-oriented island port on the Gulf of Mexico of about 60,000 that uses its historic trolley to link the Downtown "Strand" historic district with other attractions on the island. The trolley was conceived as the result of a

[3] Paul M. Weyrich and William S. Lind, Bring Back the Streetcars! A Conservative Vision of Tomorrow's Urban Transportation, A Study Prepared by the Free Congress Research and Education Foundation, June 2002, http://www.heritagetrolley.org/artcileBringBackStreetcars9.htm.

lengthy redevelopment process. Studies addressing revitalization of the Strand had started in the early 1970s, and a trolley was first proposed in 1979. The line also had to overcome tremendous public opposition, but has since proven successful enough to merit an expansion of its downtown loop in 1995. Most of the line's 55,000 annual riders are tourists, with the heaviest riding during the peak May to September season. In 1995, operation of the line was turned over to Island Transit, the local bus system with coordinated hours of operation and fare structure.


Galveston, TX Historic Trolley

The San Francisco's Municipal Railway owns more than fifty vintage streetcars operated on the F-line. Ridership on the F-line now averages about 20,000 daily, a more than three fold increase from the 5,800 riders carried by the bus line that previously served the Market Street section of the route.


San Francisco, CA Historic Trolley

In 1994, the San Jose, CA Kelley Park Trolley became part of the California Trolley & Railroad Corporation, a non-profit organization which combined the trolley with a local railway preservation group to form a comprehensive regional railway museum. Lessons learned from this partnership can be applied to the National Streetcar Museum at Lowell concept.


San Jose Kelley Park Historic Trolley

3 The Lowell Trolley Concept

The LNHP, the City, and the other partners in the development of an expanded transit trolley system in Lowell asked the Volpe Center to review options for this expansion. The starting point for this analysis is the existing trolley line, both to examine its usefulness as a starting point for developing an expanded system, and to ensure that the services currently provided by the LNHP will continue. The LNHP has identified transportation objectives in its General Management Plan (GMP) that were used in identifying benefits to the LNHP of the proposed expansion project. These two factors, the existing system and the GMP, were the starting points for the development of this trolley concept. Another factor, given the historic preservation and education objectives of the LNHP in Lowell, was putting this service into a historic context.

Existing Trolley Line

GOMACO Lowell HistoricTrolley

As part of the development of the LNHP, trolley service was reestablished in Lowell's downtown to transport LNHP visitors to LNHP interpretive sites in the City. The GOMACO Corporation of Ida Grove, Iowa, built the LNHP's small fleet of trolleys. Two open-car trolleys were designed as replicas of trolleys built by the J. G. Brill Company for the Eastern Massachusetts Street Railway Company, successor to the Bay State Railway Company. The third trolley is a closed car authentic reproduction of a 4100 series car built by the St. Louis and Laconia Car Company for the Bay State Railway Company. Because the old trolley tracks were torn up from Lowell's streets during World War II, the LNHP's trolleys run on tracks of the former Boston and Maine Railroad. An overhead 600-volt line of direct current powers the cars. Each of the LNHP's two open-air cars seats 75 people and the enclosed trolley seats 48.

The LNHP operates the existing trolley service daily from early March through Thanksgiving. The turn-of-the-century design of the trolley cars preserves the look and feel of historic Lowell. The current system is primarily used for LNHP

Ranger led interpretive tours. It is not a major means of transportation for area residents or workers, and does not directly serve area businesses or attractions other than the LNHP.

Figure 3 shows the existing trolley system. Current service runs along approximately 1.2 miles of track laid out roughly in a "T" shape. The track begins on the north side of the Swamp Locks canal junction, the start and endpoint of LNHP canal boat tours. From Swamp Locks, the track runs along the north bank of the Merrimack Canal and passes by the LNHP Visitor Center, the site of another trolley stop. Towards the end of the Merrimack Canal, the trolley has a "T" junction.

Current Trolley Line at the Boott Mills

The left branch of the "T" runs parallel to French Street and reaches the LNHP's Suffolk Mill exhibit at the junction of the Northern and Western canals; the right branch crosses the Merrimack Canal, and runs along the Eastern Canal to the Boott Cotton Mills. Past the Boott Cotton Mills, the route follows the Eastern Canal and ends at Middlesex Community College, across from the Lower Locks and the Doubletree Hotel. Regular trolley service ends at the Boott Cotton Mills, with service to Lower Locks provided on an occasional basis for special groups and events.

LNHP Trolley Rail and Wheel Evaluations

Early in this planning process, the stakeholders considered running authentic 1920s historic trolleys, currently stored at the Seashore Trolley Museum. By showcasing these period trolleys, in addition to the replicas currently being operated, it was thought that this could serve as a marketing tool to show what could be possible, and to generate excitement for the project. A number of discussions were initiated between the LNHP, Seashore Trolley and the Volpe

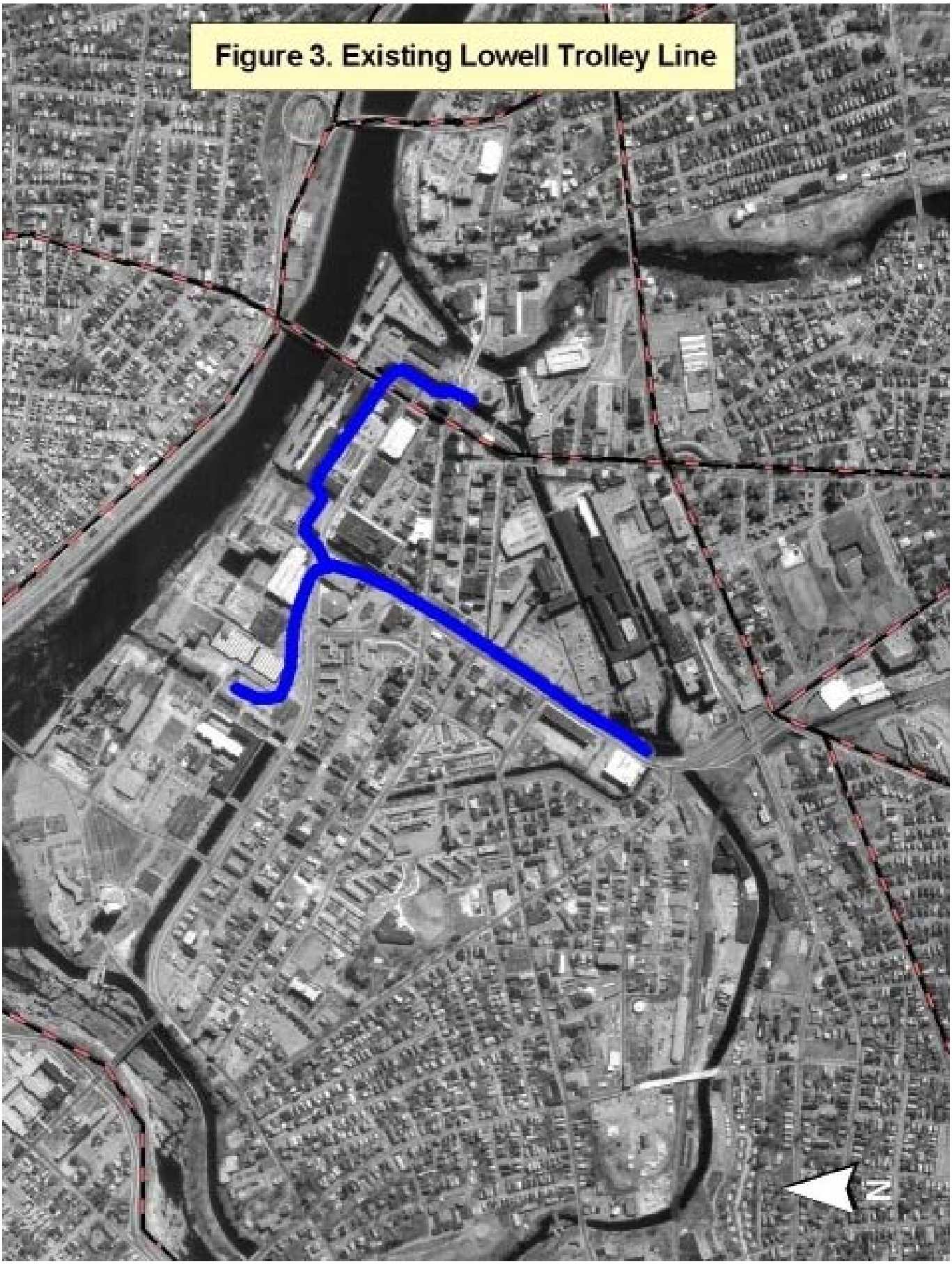


Figure 3. Existing Lowell Trolley Line
N

Center on the issues and opportunities for running these trolleys on a limited basis. A key issue was that the current tracks and replica cars are engineered for freight width tracks, while the authentic trolleys are engineered for trolley width tracks, which are somewhat narrower. Because the current switches (called frogs) are engineered for freight widths, the authentic trolleys would derail if they entered them. Appendix A provides the scenarios that would need to be explored to allow authentic trolleys to operate on the system presently. Currently, no funding has been identified to modify these switches.

Expected Benefits of A Lowell Trolley System

The National Park Service is committed to enhancing the historical and cultural resources of the LNHP and contributing to the City of Lowell's economic well-being. Transportation objectives included in the LNHP's General Management Plan (GMP) have provided a guide for projecting the benefits and conducting the planning for an expanded trolley system. Table 2 illustrates expected benefits of the trolley system relating to the GMP.

Table 2. Expected Benefits of A Downtown Trolley System

General Management Plan Transportation Objectives	Potential Benefits of A Downtown Trolley System
Minimize the impact of vehicular traffic on local streets	Provides an alternative to automobile travel in and around Central Lowell for tourist, work, shopping, and other trips.
Incorporate public transit as the major means of visitor circulation within the LNHP	Expands the existing trolley service so that it connects more of the LNHP's historic sites, and improves visitor circulation.
Encourage LNHP visitors to travel to Lowell by means other than the private automobile	Provides intra-regional travelers with service to and from downtown and the Gallagher Center, and to connect with other eastern Massachusetts NPS parks. Provides improved local access to LNHP sites and other downtown locations by connecting with LRTA bus service/stops.
Develop, in conjunction with the City of Lowell and other interested parties, an effective and efficient public transportation system and traffic network that addresses the need of LNHP visitors and City residents	Serves a range of users: LNHP and special events visitors, and City residents for shopping and work purpose trips.
Contribute to the economy and revitalization of Lowell through LNHP activities	Attracts more visitors whose spending contributes to the local economy and spurs reinvestment by local businesses and civic organizations. Studies show that the construction of fixed rail lines stimulate an increase in the value of real estate along the routes and close to the stops.

Proposed Routes and Construction Phases

This proposed concept extends the LNHP's existing historic trolley line to improve access to the LNHP and to provide access to the following important activity centers in or near central Lowell:

- Gallagher Intermodal Transportation Center,
- Paul E. Tsongas Arena,
- Lowell Memorial Auditorium,
- Edward A. LeLacheur Baseball Park,
- Lawrence Mills,
- Middlesex Community College, and
- University of Massachusetts at Lowell.

The concept also incorporates:

- The proposed Operations and Maintenance facility/National Streetcar Museum at Lowell,
- Two neighborhoods, the Acre neighborhood along Fletcher Street, and the Jackson, Appleton, and Middlesex (JAM) neighborhood, south of LNHP, that have been designated for redevelopment and revitalization,
- The Artists Loft District on Middle Street,
- Museums throughout Lowell, and
- Restaurants and Retail shops.

The concept calls for three development phases over a 10-year development horizon:

- Phase A (Figure 4): Connect the existing line at Swamp Locks to the Gallagher Center, build a new Swamp Locks Bridge to access the planned Operations and Maintenance facility/National Streetcar Museum at Lowell, double-track the existing Dutton Street right-of-way from the Swamp Locks to the Locomotive and Rail Car Exhibit, extend the current line .5 mile past the Arena to the Ballpark, and initiate design for replacing the bridge over the Northern Canal (Pawtucket Street).
- Phase B (Figure 5): Complete the Arena/Ballpark/Acre Loop – 1.5 miles. Complete a loop starting from the track at the Ballpark constructed under Phase A. This line will run from the Ballpark, along Perkins Street, across the Northern Canal, along Pawtucket Street to Fletcher Street, down Fletcher

Street to the Thorndike/Dutton Street intersection constructed under Phase A as part of the connection to the Gallagher Center. When completed this Arena/Ballpark/Acre Loop will connect the Gallagher Center, the LNHP, the Arena, the Ballpark, Lawrence Mills, UMASS-Lowell North Campus, the Heritage Nursing Care Center and the HealthSouth medical facility on Pawtuxet Street, and the Acre neighborhood.

- Phase C (Figure 6): Museum/JAM/Downtown Loop – .8 mile. Create a loop by extending the Line built in phase A from the Gallagher Center to the Operations and Maintenance facility/National Street Car Museum at Lowell to Middlesex Street, serving the Jackson-Appleton-Middlesex Redevelopment District (JAM), to Central Street through to Prescott Street, across Merrimack Street onto Bridge Street, to serve Downtown Lowell, then to the existing tracks across from the Massachusetts Mills to the Boott Mill complex. The loop will be completed by connecting to the existing track at the Boott Mill to Dutton Street and returning to the Gallagher Center. This loop will improve access to LNHP sites, the National Streetcar Museum at Lowell, the JAM redevelopment district, Lowell's commercial downtown, the planned parking garage at the eastern end of Middlesex and Jackson Streets, Middlesex Community College, Lowell Memorial Auditorium, the Massachusetts Mills, and the Boott Mills.

At the completion of Phase C, the Central Lowell Loop will be established using the two loops created in Phases B and C. Trips would begin at the Gallagher Center, travel on the Museum/JAM/Downtown Loop to Dutton Street, then connect to the Arena/Ballpark/Acre Loop before returning to the Gallagher Center.

In developing these routes, extensions beyond Phase C have been suggested. These include:

- A riverfront line that would connect the Ballpark/Arena Line along the riverfront to the Massachusetts Mills.
- Market Street line serving downtown.
- Providing service to UMASS-Lowell's academic campus across the Merrimack River from the residential campus, and to UMASS-Lowell's South Campus.
- Service to the CrossPoint development (the former Wang Labs headquarters) on Chelmsford Street.

These routes should be considered beyond the scope of this report.

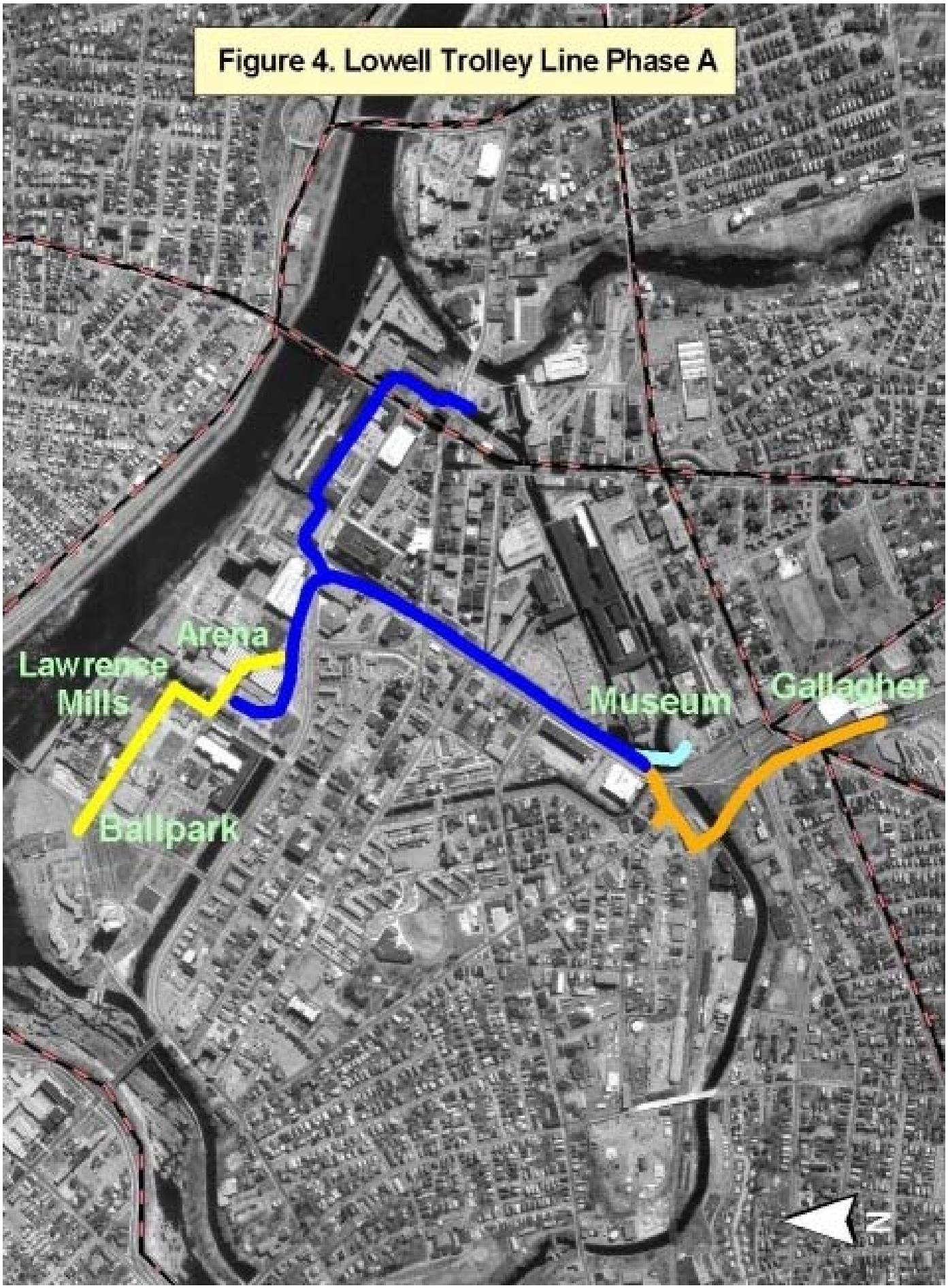


Figure 4. Lowell Trolley Line Phase A
Arena
Lawrence
Mills
Museum
Gallagher
Ballpark
N

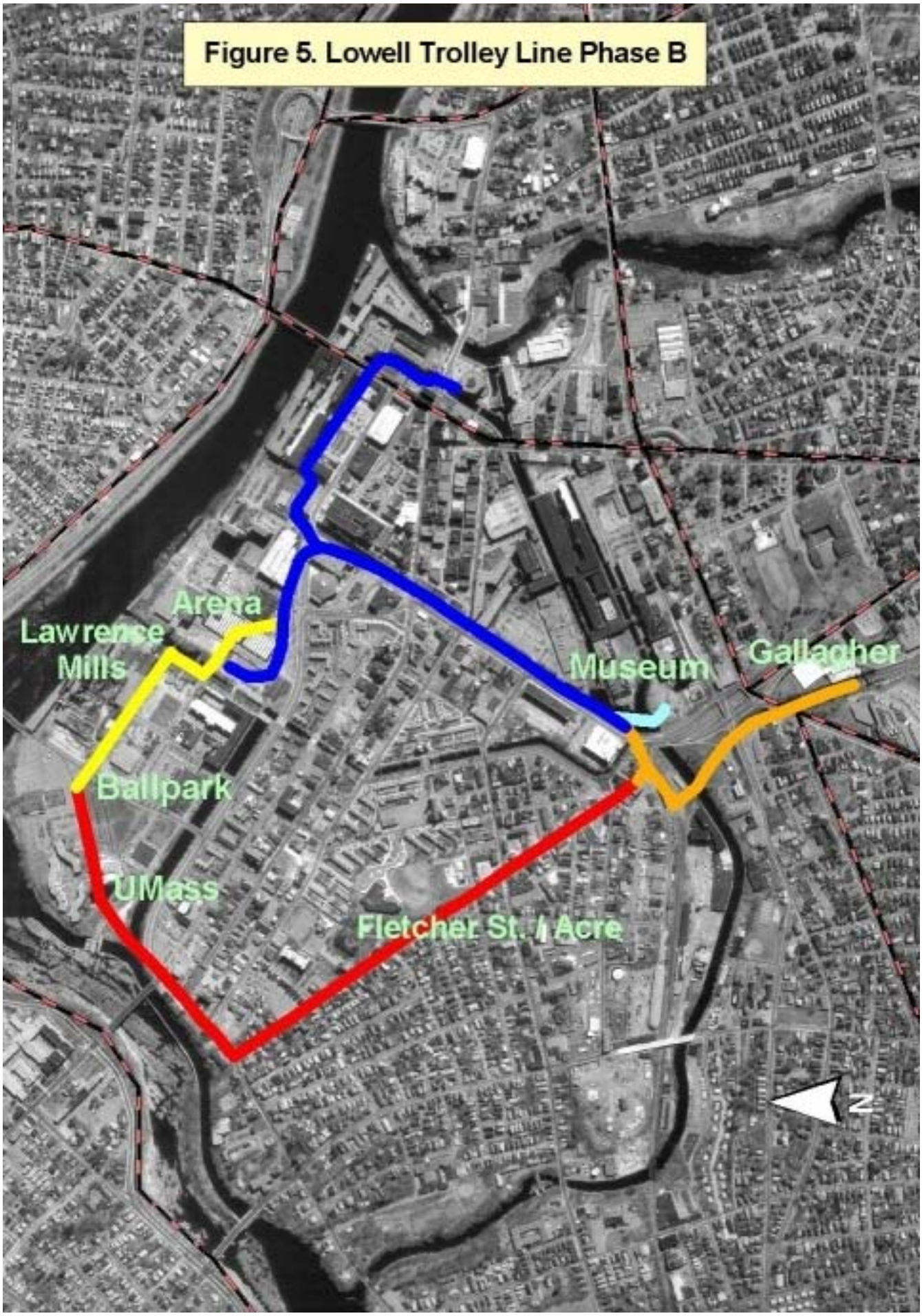


Figure 5. Lowell Trolley Line Phase B
Arena
Lawrence Mills
Museum
Gallagher
Ballpark
UMass
Fletcher St. / Acre
N

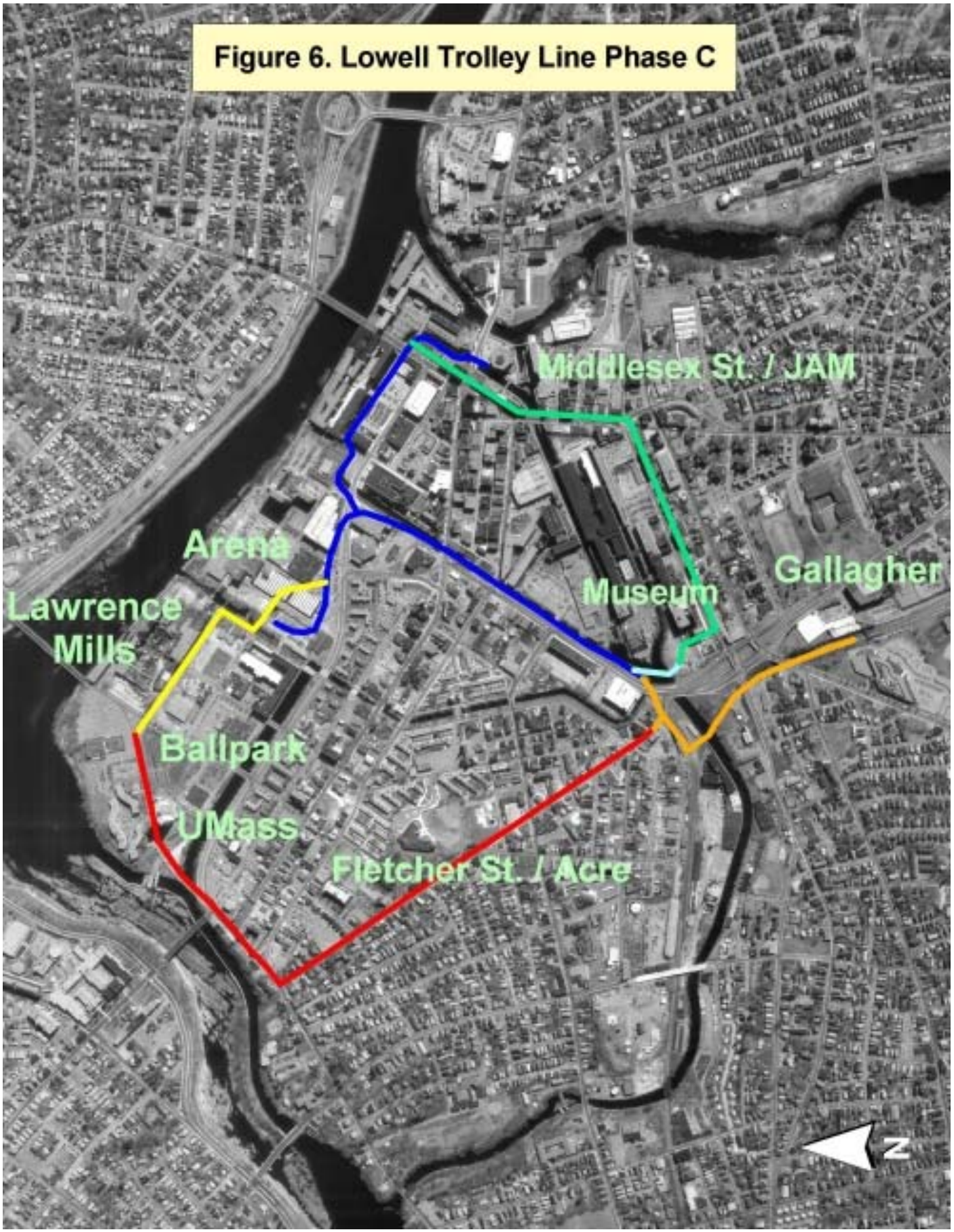


Figure 6. Lowell Trolley Line Phase C
Middlesex St. / JAM
Arena
Lawrence Mills
Museum
Gallagher
Ballpark
UMass
Fletcher St. / Acre
N

Proposed Routes and Historic Trolley Service in Lowell

The National Park Service inaugurated trolley service in the LNHP in 1984, almost 50 years after the end of regular trolley service in Lowell. Horse drawn trolley service was introduced to Lowell in 1864. Electric service began in 1889 and trolleys operated until 1935 when the last trolley routes were closed.

The service provided by the LNHP operates on a former Boston and Maine Railroad right-of-way, alongside what was once a trolley line. It has succeeded in giving visitors an understanding of Lowell and its role in the industrial development of the United States. Figure 7 shows trolley routes in Lowell in 1910 with the proposed system overlaid on those routes.

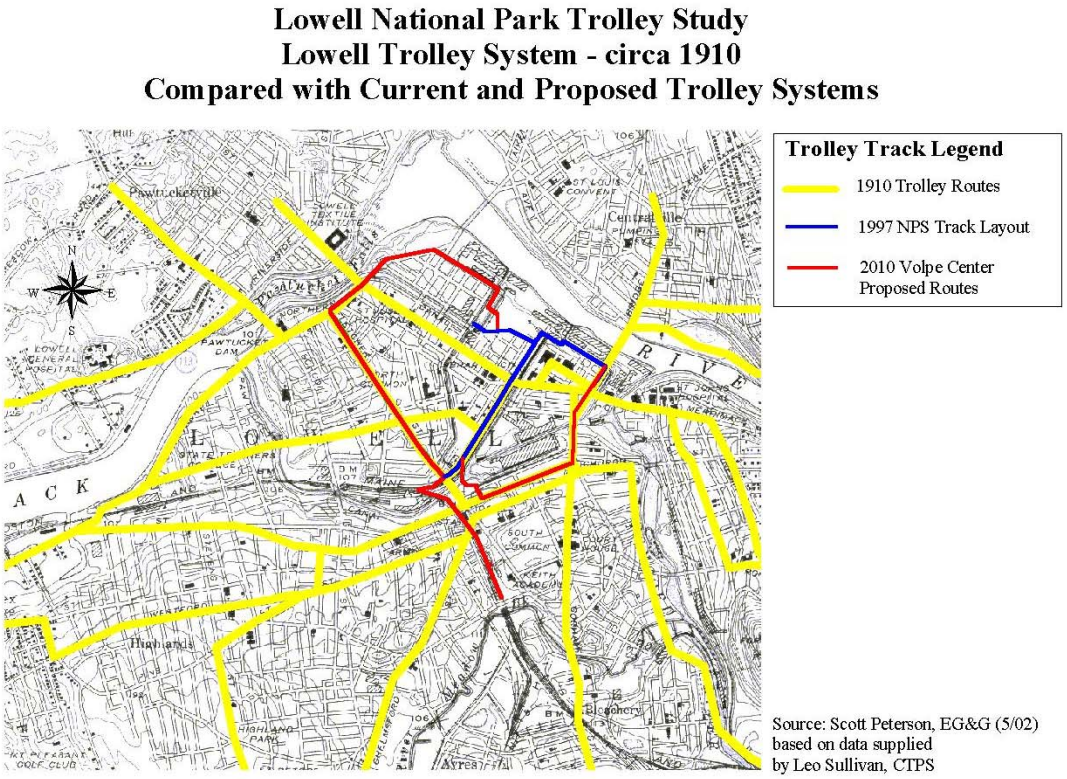


Figure 7. Lowell Historic Trolley System

The proposed trolley service will build on the LNHP success and add to the LNHP visitors experience and understanding of Lowell's role in the industrial development of the United States, while providing a service to Lowell residents and visitors. The proposed service will operate on six streets - Fletcher, Pawtucket, Middlesex, Central, Prescott, and Bridge - that previously had trolley routes, as well as alongside Dutton Street, which had trolley service in the street.

The proposed service will provide trolley connections for the working-class Acre neighborhood with the industrial mills and the downtown employment center. The introduction of electric trolley service in the 1880s allowed people to live further than walking distance from their work place in Lowell and in other industrial cities. The proposed service will provide a re-creation of this experience for LNHP visitors, while providing regular transit service to residents of this neighborhood for work, shopping, and recreation. In this way, the revised transit system will be a direct link to the past while providing mobility for visitors and residents.

A key difference between the proposed service and the historic service is that, prior to the widespread ownership of automobiles, trolley service was the major link people had between "suburban" neighborhoods and work and shopping. Trolley lines ran into newly developed areas, thus attracting residents and development to areas beyond the boundaries of the industrial city center.

The proposed service is limited and focused on the downtown restaurant, retail, and residential areas, the artist district, museums, the LNHP, and nearby key activity centers. The proposed route will provide access to sites within and adjacent to the LNHP that are currently difficult for LNHP visitors to reach. The proposed service meets the LNHP's interest in providing access and mobility within the LNHP and to areas near the LNHP. The proposed routes, where possible, replicate historic trolley lines in the city, and are designed to spur development in urban renewal areas.

4 Concept Development

The trolley concept was designed with the goal of generating the most identifiable benefits for the LNHP and the City of Lowell. "Footprint" possibilities were considered against physical and urban design constraints, and for compatibility with the existing transportation network and services.

This analysis began with identifying concept development objectives and route evaluation/selection criteria. Concept Development Objectives address the National Park Service mission and the National Park Service's commitment to work with state and local agencies in Gateway communities. Objectives and criteria focus on maintaining the LNHP as a link to the past, while providing enhanced transportation services to Lowell residents and visitors. The LNHP is one of a number of National Park Service sites in eastern Massachusetts, and a Park Service goal is to provide transit access between Lowell and these other sites, particularly those in and around Boston, without the need for a personal automobile.

Concept Development Objectives

Concept Development Objectives address objectives of the National Park Service and local authorities. The National Park Service is committed to improving access within the LNHP, preserving the LNHP visitor experience, and working with local partners. The City and the LRTA have done extensive planning for the area served by the proposed routes. The Concept Development Objectives of this plan address objectives identified by these partners. The City has identified major redevelopment objectives for several downtown commercial and residential districts, and the LRTA has identified needed operational improvements, including moving its bus hub from the downtown to the Gallagher Center.

Visitor access/mobility:

- Improve access/mobility to the venues within the LHNP,
- Improve access/mobility to key Lowell activity centers,
- Improve access to Middlesex Community college and the University of Massachusetts-Lowell,
- Improve access to sports and entertainment venues,
- Improve access/mobility to other parts of downtown Lowell, and
- Connect the LNHP to National Park Service sites in eastern Massachusetts.

Residential mobility:

- Improve mobility for existing and future residents.

Reduce congestion caused by automobile traffic:

- Divert visitors to the historic trolley system for local trips: work, shopping, and recreation.

Intra-regional connectivity:

- Assist the LRTA in meeting its goal to improve linkages to the Gallagher Center (commuter rail and parking) and its plans to move the bus hub staging area from downtown to the Gallagher Center,
- Improve travel connections/linkages to downtown Boston, and
- Induce visitor trips (increase tourism) to the LHNP.

Economic development/increase tourism:

- Assist in redevelopment of identified redevelopment areas in the CBD,
- Attract more visitors/spending,
- Provide a new visitor attraction, the historic trolley system, and
- Stimulate private investment along the trolley route.

Interpretive/educational context:

- Enhance the mission of the National Park Service: to preserve and protect, but also provide an interpretive and educational LNHP experience,
- Maintain existing interpretive services and enhance those services, and
- Access LNHP sites not currently interpreted.

Route Evaluation/Selection Criteria

Route Evaluation/Selection Criteria address identified needs of the LNHP and local partners. The LNHP is committed to improving access to sites within the LNHP, and both the LNHP and the City want to improve transit access to other parts of the region by way of commuter rail. The City wants to minimize changes to the existing roadway network while improving transportation systems to reduce congestion and spur economic development. UMASS-Lowell has identified the need to improve access to the City for resident and commuter students.

Node connections:

- Connect venues within the LNHP,
- Connect Lowell activity centers,
- Connect with the Gallagher Center, and
- Connect with the proposed trolley museum.

Roadway Network:

- Facilitate shared usage/right-of-way: autos and trolleys,
- Minimize interference with street traffic/rotaries,
- Minimize bridge crossings,

- Compatible with street directional flow,
- Minimize modifications to lane geometries,
- Minimize the loss of parking spaces, and
- Facilitate one-way directional flow for trolley system.

Proximity to Economic Development Areas:

- Within walking distance of economic development areas: The Acre; the JAM redevelopment area; the North Canal Economic Development Area and vacant mills, and
- Serve existing businesses while promoting development.

Service to Area Residents:

- Serve residents who may not drive such as seniors and youth, and
- Connect residents to shopping and services.

Trackage:

- Maximize the use of existing right-of-way,
- Leverage the existing trolley line/trackage,
- Minimize the construction of new track, and
- Ensure proper turning radii.

Transit Interconnectivity:

- Connect with planned bus hub,
- Connect/complement local bus service/routes/bus stops, and
- Serve as possible replacement of UMASS-Lowell campus bus service.

Service Considerations:

- Create circulator loops to satisfy travel needs of potential users,
- Limit total trip time - within a tolerable threshold,
- Create opportunities for expansion and other services (loops within the loop), and
- Allow for creating a rational fee structure.

Coordinating with National Park Service Interpretive Tours

The present trolley system was developed as part of an integrated system of trolleys and canal barges designed to let visitors experience the LNHP as a whole without the need to drive a car to visit exhibits within the LNHP. The trolley takes visitors to the Locomotive and Rail Car exhibit at the Mack Plaza, the Boott Cotton Mills, Suffolk Mills, and provides access to the Canal boat landing at the Swamp Locks. The Mill and Canal Tours, which are at the heart of LNHP's interpretive program, provides a comprehensive overview of Lowell and the LNHP.

The existing National Park Service historic trolley line provides the backbone for the proposed route expansions.

Using the existing trolley system as the spine of the expanded transit trolley system may, as has been suggested by LNHP staff, result in conflicts that will affect both the LNHP visitor experience and safe and efficient transit operation. Trolleys currently making interpretive trips operate at 5 MPH on the single track in both directions. The slow speed allows operators to make visual determination of safe operation, and allow for quick stops eliminating the need for a central control center. LNHP operators also keep in contact with each other by radio.

Transit service will operate at higher speeds, up to 20 miles per hour, and the system is designed for operation in only one direction on two loops that together create one large loop. Speed and the two-direction operation of interpretive trips are the source of potential conflict, but these conflicts can be managed by implementing operational and physical improvements.

The LNHP operates its interpretive tours in late morning and early afternoon and on weekends. Peak commuter hours are typically during weekday morning and early evening hours, when people are going to and coming home from work. Hours when service is in greatest demand for transit thus will not conflict with hours when interpretive tours are being provided. This difference in time of demand for service reduces, but does not eliminate potential conflicts.

The conflict in speeds requires finding ways to allow for safe operation of both types of services. Double tracking the entire right-of-way where conflicts between interpretive and transit trips would occur would solve this problem, but would be expensive and in parts of the route would require purchasing right-of-way and changes in roadways. Double tracking is possible along the existing tracks that run between Dutton Street and the Merrimack Canal from the Swamp Locks to the Locomotive and Rail Car Exhibit at Mack Plaza. This right-of-way was double tracked for freight and sufficient space appears to be available to double track without requiring changes to Dutton Street. This will allow operation in both directions on this part of the system.

Operational practices are recommended to be put in place to coordinate transit trolley schedules and LNHP trips to avoid conflicts arising from differing speeds and interpretive trips running in two directions on some single-track portions of the system. The control system will anticipate potential conflicts and inform operators in enough time to allow for safe and efficient operation of both LNHP tours and transit trolley trips. For example, the control system would hold an interpretive trolley trip returning from the Suffolk Mills on the track extension

prior to the turn to the Arena until a transit trolley turned towards the Arena. The next transit trip from the Gallagher Center would then be held on its track until the interpretive trolley had merged on the track past the Locomotive and Rail Car Exhibit.

The objective of this project is to enhance the existing trolley service operated in Lowell to better serve visitors and residents. A well-designed combination of physical improvements and operation management practices should ensure that transit and interpretive trips coexist to provide safe and efficient transportation services to LNHP visitors taking an interpretive tour and residents and visitors using the transit trolley system.

Route Analysis

This route analysis identified five routes to be added to the existing LNHP historic trolley line. Routes were evaluated using the Concept Objectives and Route Selection Criteria. Several objectives and criteria applied to the selection of all of the proposed routes. These include:

- Maximize linkages with the existing historic trolley system,
- Ensure that expanded system complements the National Park Service's mission and objectives,
- Coordinate routes with City of Lowell plans,
- Coordinate route plans with Lowell Regional Transit Authority plans,
- Utilize existing parking facilities, and help compensate for the loss of parking around the Ballpark site,
- Minimize changes in the roadway system to accommodate trolley routes,
- Minimize bridge crossings,
- Follow existing traffic directions and patterns for the on-road parts of the system
- Ensure that routes would accommodate a safe turning radius for equipment.

Loop Services

The Lowell Trolley Project will be built in three phases. Each phase will result in the expansion of service within Lowell and when all three stages are completed three service loops will be established. Looped service, serving an origination and destination in one direction, is necessary because much of the area will be served by a single track, which will not allow for two-directional service. The proposed loops take advantage of the plan to double track Dutton Street, which

will allow for two–way service on this part of the system. Three loops will be completed at the end of this project, they are:

- Arena/Ball Park/Acre Loop
- Museum/JAM/Downtown Loop
- Central Lowell Loop

All three loops will begin and end at the Gallagher Center. The Arena/Ball Park/Acre Loop and the Museum/JAM/Downtown Loop will operate on Dutton Street, but in different directions taking advantage of the double tracking of Dutton Street. The Central Lowell Loop will serve the Lowell CBD. The first two Loops are designed to serve transit users whose trips originate or terminate at the Gallagher Center, and who are traveling to specific areas of interest in Lowell.

The Central Lowell Loop is designed to provide link sites within the Lowell CBD from different origination and destination points. Downtown employment, commercial, retail, restaurant and bar establishment will be directly linked to the Ballpark, Arena, Acre neighborhood, and the planned Lawrence Mills Transit Oriented Development. Also, a proposed stop on Bridge Street at the intersection of the current Boott Mills line will be in front of the entrance to the underutilized 327,000 s.f. Massachusetts Mills.

Gallagher Connector

The Gallagher Intermodal Transportation Center is the commuter rail station serving Lowell, and is being established as Lowell's inter-modal transportation hub. All service loops will begin and end at the Gallagher Center, providing links to a new parking facility being built at this site, and to other transit services including MBTA commuter rail, LRTA bus, and private bus service. The LRTA and private bus companies either have, or are in the process of, establishing this site as a service hub. Connecting the historic trolley system to the Gallagher Center will provide increased access and mobility for LNHP visitors and the public. This line will meet several other objectives including:

- Improve access to LNHP sites,
- Provide the starting point for historic trolley system service to other activity centers in and around downtown Lowell, and
- Link, via commuter rail, National Park Service sites in Eastern Massachusetts.

The Gallagher Connector will provide increased mobility and access for LNHP visitors and commuters arriving in Lowell, and will establish a major link in the

planned route expansion. With the establishment of the Gallagher Connector, LNHP visitors arriving in Lowell by commuter rail, automobile, or private bus will have immediate access to downtown attractions by way of the historic trolley line. Completion of the rest of the planned trolley routes will give Lowell residents and visitors to the LNHP access to a variety of venues in central Lowell.

The Gallagher Center is designed to serve as Lowell's Intermodal Transportation hub

This link establishes a basis for coordination between the Park Service, the Massachusetts Bay Transportation Authority (the commuter rail provider) and the Lowell Regional Transit Authority that will allow for a rational fee structure and innovative fee payment systems, such as smart cards. LNHP visitors would be able to buy a single ticket for transportation and access to Park Service sites in both Boston and Lowell. Establishing a method for this type of payment would allow for commuters and other transit riders to use one payment medium to travel on the commuter rail and MBTA bus and subways, the trolley, and Lowell bus routes.

Museum Link (Swamp Locks Bridge)

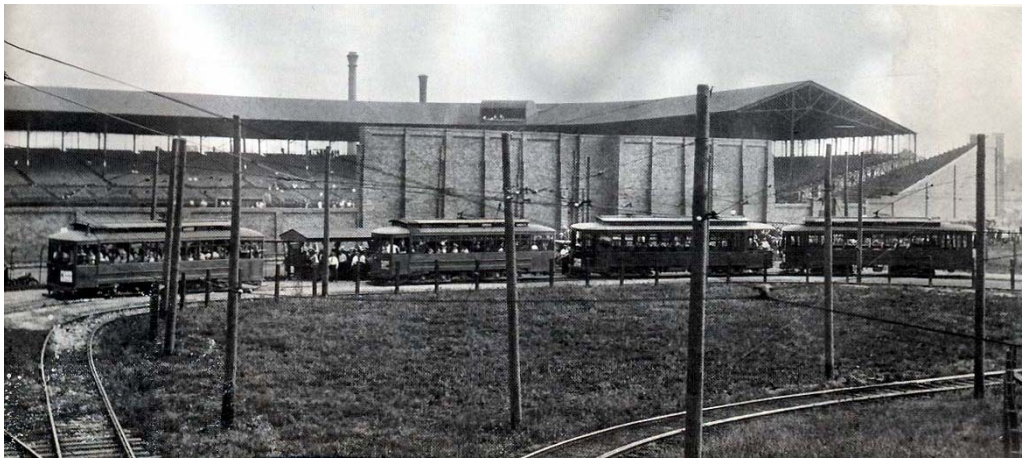
With the development of the planned Operation and Maintenance facility/National Streetcar Museum at Lowell, the Museum Link will provide a new educational experience for National Park Service visitors and provide a storage and maintenance facility for the trolleys. The museum and maintenance facility will be designed to celebrate the surrounding architecture, and serve as a gateway into the historic context of both the surrounding area and its use as a working museum. The museum and maintenance facility will enhance the mission of the LNHP by providing new exhibits focused on historic urban trolley systems, and should attract new visitors to the LNHP. This link is also necessary for the establishment of the routes south of the existing line.

The National Street Car Museum at Lowell will enhance the mission of the Park Service by providing new exhibits focused on historic urban trolley systems.

Ballpark/Arena/Acre Loop

The Ballpark/Arena/Loop will make the historic Lawrence Mills site accessible to transit-oriented development possibilities while providing trolley service to two of Lowell's newest sites, the Arena, and the Ballpark, and one of its oldest neighborhoods, the Acre. This route will also serve the UMASS-Lowell Residential North Campus. By making the Arena, Ballpark, and UMASS-Lowell

North Campus accessible by trolley, this route improves connections within Lowell and the LNHP.



Trolleys outside of Parkway Field, Louisville, KY circa 1930

The Arena/Ballpark section of this loop will be completed in construction Phase A of this project, and will link these two venues to the existing service on Dutton Street. The Acre section, from the Ballpark returning to the Gallagher Center by way of Perkins, Pawtucket, and Fletcher Streets, will be completed in construction Phase B. The route will run on existing roadways and other right-of-ways.

The Ballpark/Arena/Acre line should be attractive to visitors to these sites given the opportunity to reach Lowell by commuter rail and the arena or stadium by a quick trolley ride, thus avoiding traffic around these facilities and will encourage use of other downtown parking facilities.

Lawrence Mills site on Perkins St., looking towards LeLacheur Park

Service to the Arena is designed to either follow the roadway in front of the Arena, or cross through the middle of the rotary at the John F. Cox Circle, a common practice for early 20th century transit service. Trolley service to the Ballpark will address the expected loss of parking (resulting from university and city development plans) near the Ballpark, by providing a link with other downtown parking facilities and will provide the opportunity to include a trolley trip as part of the ballpark experience.

Example of trolley running through middle of rotary (Neponset Circle, Boston MA)

This loop will promote transit-oriented development at Lawrence Mills, planned for mixed-use through adaptive re-use of existing mill buildings, and development of the site adjacent to the Arena currently used as a vehicle maintenance facility by the US Postal Service. It is expected that the Postal Service will leave this facility at the end of its current lease. With completion of the Lawrence Mills development, the route will serve two residential areas,

Lawrence Mills and student housing at the UMASS-Lowell North Campus. It will also pass by the Heritage Nursing Care Center and the HealthSouth medical facility on Pawtucket Street.

Service to the Acre neighborhood will improve accessibility to LNHP sites, other Lowell venues, and the Gallagher Center with connections to Boston. The route will provide residents access to a neighborhood supermarket, a new pharmacy, and new senior center within the Acre and, with completion of the other proposed routes, to employment, shopping, and services throughout central Lowell.

"In 1822 Irish laborers walked from Boston to the rural village of East Chelmsford to build the canals, factories, and boardinghouses that gave rise to the industrial city of Lowell."

- National Park Service History of the Acre

This route will run through the center of the Acre, a community identified for residential and small-scale commercial redevelopment by the City. This service should help spur appropriate neighborhood development, while providing enhanced mobility to the neighborhood's working class, low–income, and immigrant population.

Fletcher Street looking east toward the Acre Neighborhood

The trolley route through this neighborhood will allow the LNHP to provide interpretive programs about the Acre and Lowell's immigrant history. The Acre was first settled by immigrants in 1822, and has been an immigrant neighborhood for the past 180 years. Lowell's immigration history can be

explored through this route, which recreates a trolley route that operated in the late 19th and early 20th centuries.

The proposed route has been selected to maximize the positive impacts that expanded trolley service can provide for residents and businesses, while promoting economic development that is appropriate for this community. The Acre Urban Revitalization and Development Project calls for improvement of Fletcher Street and other neighborhood roadways, which provides the opportunity to develop the trolley service as part of the roadway improvement project.

This route will serve a community with a large transit dependent population who will benefit from this additional service. In addition to connecting to transit service through the Gallagher Center, the route will connect with two LRTA bus routes, the #10 at Broadway and Fletcher and the #11 at Broadway and Pawtucket.

Museum/JAM/Downtown Loop

The Museum/JAM/Downtown Loop will continue from the Operations and Maintenance facility/National Street Car Museum at Lowell to Middlesex Street (serving the JAM), to Central Street through to Prescott Street, across Merrimack Street onto Bridge Street (serving Downtown Lowell), then to the existing tracks across from the Massachusetts Mills to the Boott Mill complex. The loop will be completed by connecting to the existing track at the Boott Mill to Dutton Street and returning to the Gallagher Center. This extension will be completed in Construction Phase C, and will complete both this Loop and the larger Central Lowell Loop. The Middlesex Street to Boott Mills route will connect the LNHP, Lowell's historic downtown, the Jackson-Appleton-Middlesex (JAM) redevelopment area, and the entrance to the Massachusetts Mills site. This route improves access and mobility for residents and visitors, and should reduce traffic congestion by diverting some residents and visitors to the historic trolley system.

The expanded system should attract additional visitors to Lowell, increasing and supporting economic activity in the City and the planned redevelopment of downtown Lowell and the JAM area.

The trolley route on Middlesex Street will operate through the center of the JAM redevelopment area, a neighborhood of mill buildings and other commercial and industrial buildings. An on-going redevelopment effort will maintain the neighborhood's physical characteristics while the uses of these buildings change, providing an opportunity for LNHP visitors to understand how old industrial

buildings can be saved and successfully re-used. It will also connect with the proposed new parking garage at the eastern end of Middlesex and Jackson Streets. The Middlesex Street service also recreates a trolley route that ran at the turn of the century.

Service on Central, Prescott, and Bridge Streets will serve the western edge of downtown Lowell and sites west of downtown, including the underutilized 327,000 s.f. Massachusetts Mills complex, Middlesex Community College, and Lowell Memorial Auditorium. By providing return service to the Gallagher Center on Dutton Street, a commuter working in downtown Lowell could exit the trolley at Central and Prescott or Prescott and Merrimack during the morning commute and board to return on Dutton Street, avoiding additional travel time necessitated by the loop service.

This loop will share the road with the existing #9 bus route on Middlesex Street, and will connect with the #3 and #4 bus routes at Central and Middlesex Streets. The line will operate parallel to the #8 bus that runs one block south of Middlesex Street on Appleton Street. These connections provide access to employers, shopping, and other services, and attract additional development to the downtown and the JAM redevelopment area, while providing mobility to downtown and JAM residents who do not have access to an automobile.

Middlesex Street looking towards Central Street and the Boston & Maine Freight House

Route Options

The focus of this report is the presentation of a trolley concept that meets the LNHP's and the City of Lowell's objectives. This concept is intended to be general in nature – a reasonable facsimile of what is feasible. Further definition of the routes requires in-depth corridor analyses and the completion of an environmental impact assessment.

At this conceptual level, urban design and physical constraints unique to Lowell were considered in defining what is possible. This is particularly so in two instances – serving Lowell's downtown commercial district, and connecting with the Gallagher Center. A range of route options for each of these is presented below.

This section also identifies additional expansion opportunities for extending the proposed trolley concept beyond service recommended in this report. These routes would be reviewed once the proposed concept has been implemented, ridership demand has been realized, additional redevelopment occurs, and as the residential population increases in the downtown area.

Downtown Route Options

The Lowell CBD is bordered by three canals: the Merrimack Canal on the west, the Pawtucket Canal on the south and east, and the Eastern Canal on the north. The major commercial streets are Merrimack and Market. Providing trolley service to this area will provide access to a number of sites in Lowell that are of interest to residents and visitors, and trolley service will link downtown restaurants and bars to the Arena and Ballpark, a goal of the City. The proposed Museum/JAM/Downtown Loop is designed to serve downtown businesses, workers, residents, and visitors, and link the JAM redevelopment area, the Arena and Ballpark, and the Acre neighborhood.

Four other routes have been suggested for this service:

- Market Street
- Merrimack Street
- Middle Street
- Middlesex Community College connection

<u>Market Street</u>

The Market Street route would enter from the existing track on Dutton Street and exit onto Central Street. The major advantage to this route is that it will provide access to the southern end of the downtown retail district and direct

access to the LNHP Visitor Center located on Market Street. Market Street has residential and commercial uses, and is convenient to a number of restaurants and bars. A large city-owned parking garage at Market and Central links this route to parking.

Disadvantages to using this route are the need to operate in traffic on a somewhat busy street, and the loss of 27 street parking spaces. According to the Downtown Lowell Master Plan, this area included a small surplus of parking spaces in the Market St. garage, which should reduce the negative impact of the loss of these spaces.[4]

Merrimack Street

Operating trolley service on Merrimack Street would be historically accurate, as trolleys served this street at the turn of the century. The City is not in favor of operating service on Merrimack Street due to the existing congestion and concern that the loss of parking on-street to make way for a trolley line may negatively impact businesses. An objective of this plan is to connect trolley service to parking, and the closest parking garages to Merrimack Street are two blocks north, at John and Paige Streets, and two blocks south, at Market and Central Streets.

Middle Street

Middle Street, between Merrimack and Market, has been suggested as a compromise between these two streets. Middle Street is a cobblestone street lined with first floor commercial spaces, and buildings converted to artist lofts and studio space. The street is very narrow and the one-way streets leading to Middle Street are not designed for an easy loop. Using Middle Street would require either changing direction of one or more streets, which would likely increase traffic on Middle Street, or operating against traffic on streets used to enter or leave Middle Street. The changes required to make this a useful option are considerable, and other options show much more promise.

Middlesex Community College connection

The existing historic trolley line serves the Boott Mills and Middlesex Community College on tracks running east of the main tracks the run along Dutton Street. The tracks from the current Boott Mills stop to Middlesex Community College are only used occasionally for special purposes. The analysis of Downtown route options considered linking this line at the Community College to a loop serving downtown. Physical constraints, such as narrow streets and the Pawtucket

[4] Downtown Lowell Master Plan 2001, Draft, page 61.

Canal, and consideration of other transportation issues in an already congested area were identified that limited this option. However, this analysis did identify the proposed loop from Middlesex Street to the Boott Mills. This service will provide accessibility to Middlesex Community College and Lowell Memorial Auditorium. Accessibility to these sites were the major consideration in analyzing the possibility of providing a direct connection to the Community College using existing tracks and the proposed loop addresses that need.

Gallagher Connection Options

Providing access for trolley service to the Gallagher Center has been studied and discussed since the late 1970s. A number of options have been looked at over time and three were considered for this study[5]. The major barrier to connecting the downtown to the Gallagher Center is the Appleton Street Bridge over Thorndike Street (called the Lord Overpass), a connection to the Lowell Connector that disperses traffic onto major streets in central Lowell. The American Association of Safety Highway Transportation Officials (AASHTO) has given the Lord Overpass a rating of 36. According to AASHTO, a bridge rating under 50 is considered to be substandard and structurally deficient. While the Lord Overpass is not listed by NMCOG in the Transportation Improvement Plan, Massachusetts Highway officials are aware that rehabilitation or replacement will need to occur in the near future.

The Volpe Center considered options that provided access by using existing track to go around the Lord Overpass, building an aerial structure to go over the Overpass, accessing the Gallagher Center by way of Middlesex Street, and accessing the Gallagher Center on Thorndike Street. Integrating a trolley connection into any redesign or rebuilding of this overpass would, of course, simplify this connection.

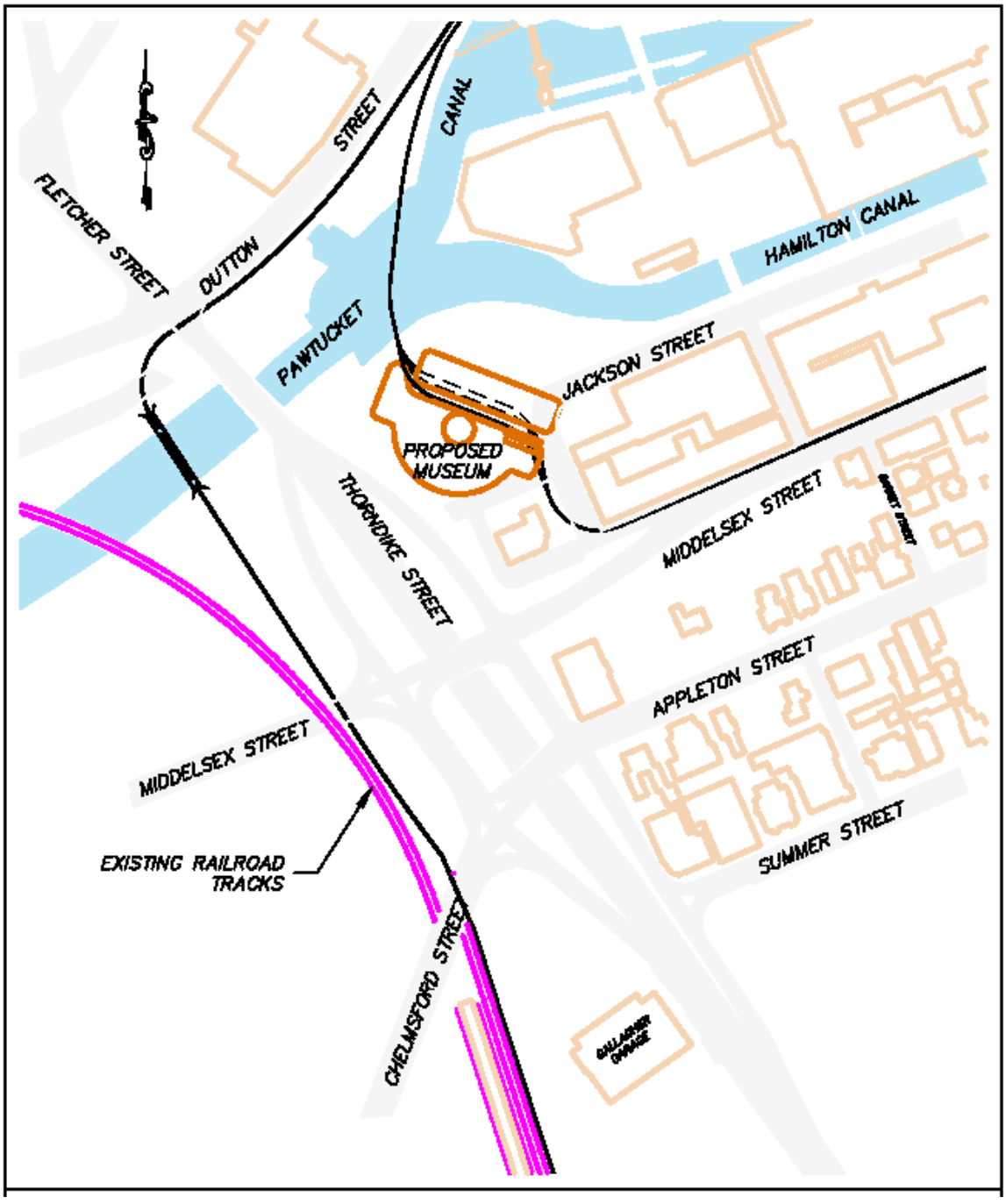
Double tracking Dutton Street, which has been previously identified as a solution to conflicts between LNHP interpretive tours and transit operations, also provides opportunities to access the Gallagher Center. Adding an additional track would require removing the existing track and constructing two additional lines in the same right-of-way. The cost estimate for double tracking the line along Dutton St. is approximately $1.2 million.

<u>Alternative 1A: Crossing the Fletcher-Dutton Street Intersection at Grade</u>

This option depicted in Figure 8 connects the trolley system to the Gallagher Center by using the double track from the Visitor Center through the Swamp Locks site to connect to tracks that cross the intersection of Fletcher, Thorndike,

[5] In addition, NMCOG is currently revising the Regional Transportation Plan which is anticipated for completion in September 2004.

Figure 8. Alternative 1a
Crossing Fletcher-Dutton-Thorndike Street
Intersection at Grade



and Dutton Streets at grade. The tracks would turn sharply left, cross over the Pawtucket Canal on a new bridge, continue parallel to the existing freight track under Middlesex and Chelmsford Streets, and terminate at the Gallagher Center. There is an existing siding at the proposed terminus that does not appear to be in use that would serve as the beginning and endpoint for trolleys to the Gallagher Center. Trolleys would operate in both directions along this single track.

The advantages of this option are that it would only require two new bridges, would have minimal visual impact on Dutton Street, would maximum construction at grade, and would simplify the connection to the Fletcher Street loop. The major disadvantages of this option are that it will interfere with traffic at the Fletcher-Thorndike-Dutton Street intersection, will require substantial reconstruction of the Fletcher-Thorndike-Dutton Street intersection and associated traffic signals, and may require filling of wetlands near Middlesex and Chelmsford Streets. This would create additional environmental permitting concerns. The estimated cost of this option is $6.5 million.

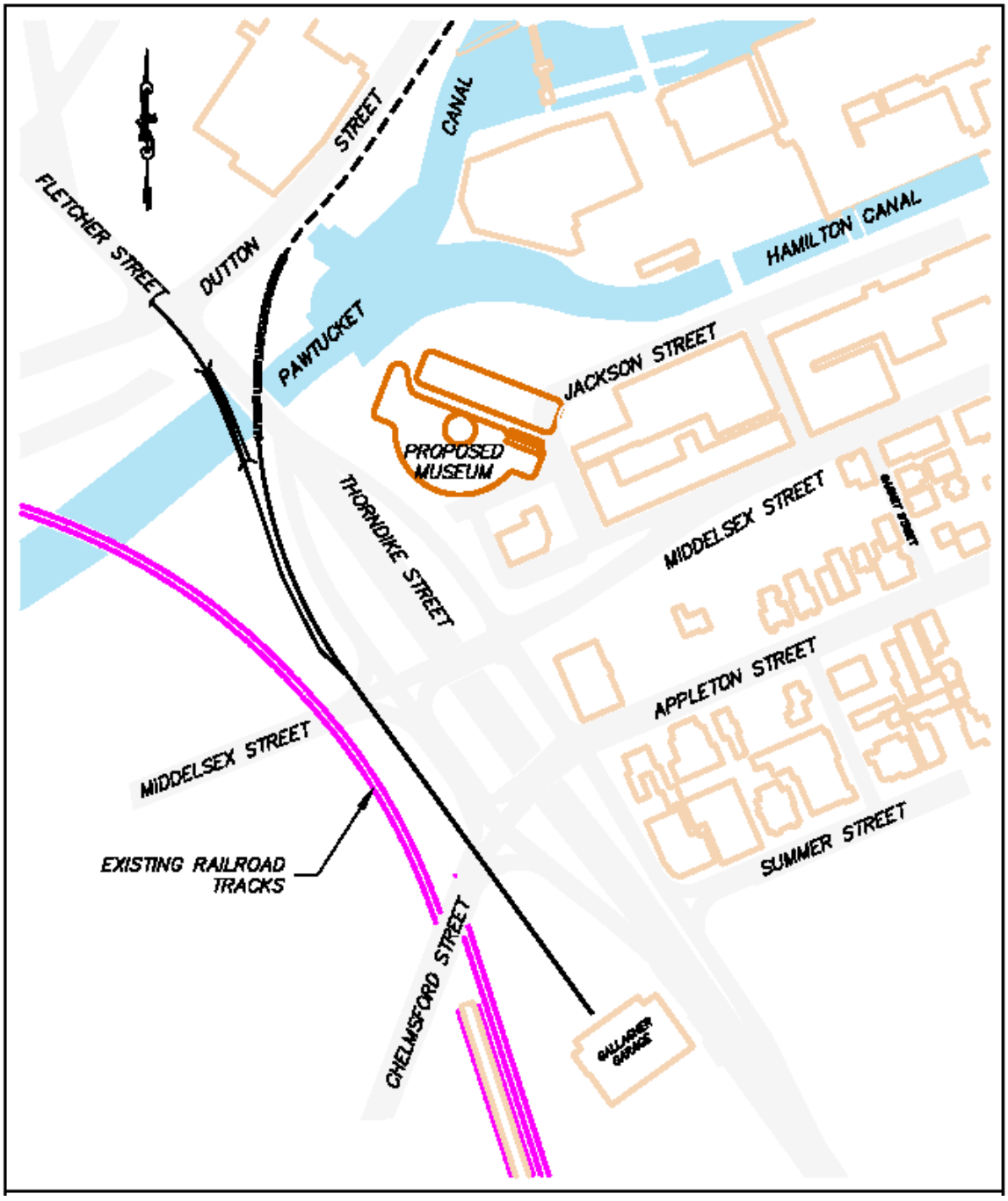
Alternative 1B: Fletcher-Dutton Street Overpass

This option depicted in Figure 9 uses the same right-of-way as the previous option up to the Fletcher-Thorndike-Dutton Street intersection. Rather than traveling at grade, this option will require constructing a ramp on the Dutton Street right-of-way beginning approximately 600 feet from this intersection. Trolleys would then travel on an overpass approximately 18' above the Fletcher-Thorndike-Dutton Street intersection. Once elevated, the track would remain elevated, cross Middlesex and Chelmsford Streets at grade, and terminate north of the existing garage. A portion of the existing garage could be remodeled as a boarding area, or a new boarding area could be constructed.

A variation of this alternative is that once the track is over the Fletcher-Thorndike-Dutton Street intersection, the track could descend under Middlesex Street and continue to the Gallagher Center as described in the previous option. The feasibility of this would require a more detailed design to ensure that there is enough distance to descend under Middlesex Street.

The advantages of this option are that it eliminates interference with traffic in the Fletcher-Thorndike-Dutton Street intersection and maximizes separation of trolley activities and commuter rail activities. The disadvantages include increased costs to elevate the track, build additional track, elevate the crossing over the Pawtucket Canal and build an additional retaining wall. This also complicates the design of the Fletcher Street connection. It is likely that some of the Fletcher Street loop construction would have to be done during construction

Figure 9. Alternative 1B
Elevated Crossing of
Fletcher-Dutton-Thorndike Streets



of the Gallagher Center connection. The estimated cost of this option is $14.3 million.

Alternative 2: Middlesex Street Connection

This option depicted in Figure 10 is to connect to the Gallagher Center from east of the Gallagher Center by way of Middlesex Street. The advantages of this option are that the Gallagher Center connection would pass by the proposed Trolley Operation and Maintenance facility/National Street Car Museum at Lowell, providing easy access from commuter rail and parking to this planned new visitor attraction. This option has several major disadvantages including excessive roadway crossings, conflicts with the proposed Market and Middlesex Streets loop, and the need for a separate connection for the Fletcher Street loop. This alternative appears unfeasible without land takings, removal of buildings or major reconstruction of existing roadways. No cost estimate was prepared for this alternative.

Alternative 3: Thorndike Street Connection

This option depicted in Figure 11 would connect to the Gallagher Center by way of Thorndike Street. The Trolley would cross the Pawtucket Canal as they do under the other three options. Once over the canal, the track would turn right, pass over Thorndike Street, descend under the Lord Overpass, rise again to pass over Thorndike Street and, turn into the Gallagher Center area elevated. Track would run down the center of Thorndike Street. The suggestion that track be placed in the embankment along the side of Thorndike Street was not pursued because of concern that this would interfere with traffic on the Lord Overpass ramps. Once in the Gallagher Center area, several options are available. The track can stay elevated and a portion of the existing parking garage can be used as a boarding area for the trolley, or the track can descend and terminate at the southwest area of the Gallagher Center property. The estimated cost of this option is $29.3 million.

The advantages of this option are that it avoids the Fletcher-Thorndike-Dutton Street intersection, provides a direct connection between the Gallagher Center and the Operations and Maintenance facility/National Streetcar Museum at Lowell, maximizes separation of trolley activities and commuter rail activities, and avoids interference with Lord Overpass ramps. Major disadvantages include the need for a substantial amount of elevated track construction and the need for a separate connection for the Fletcher Street loop to reach the Gallagher Center.

Figure 10. Alternative 2
Gallagher Connection via Middlesex Street

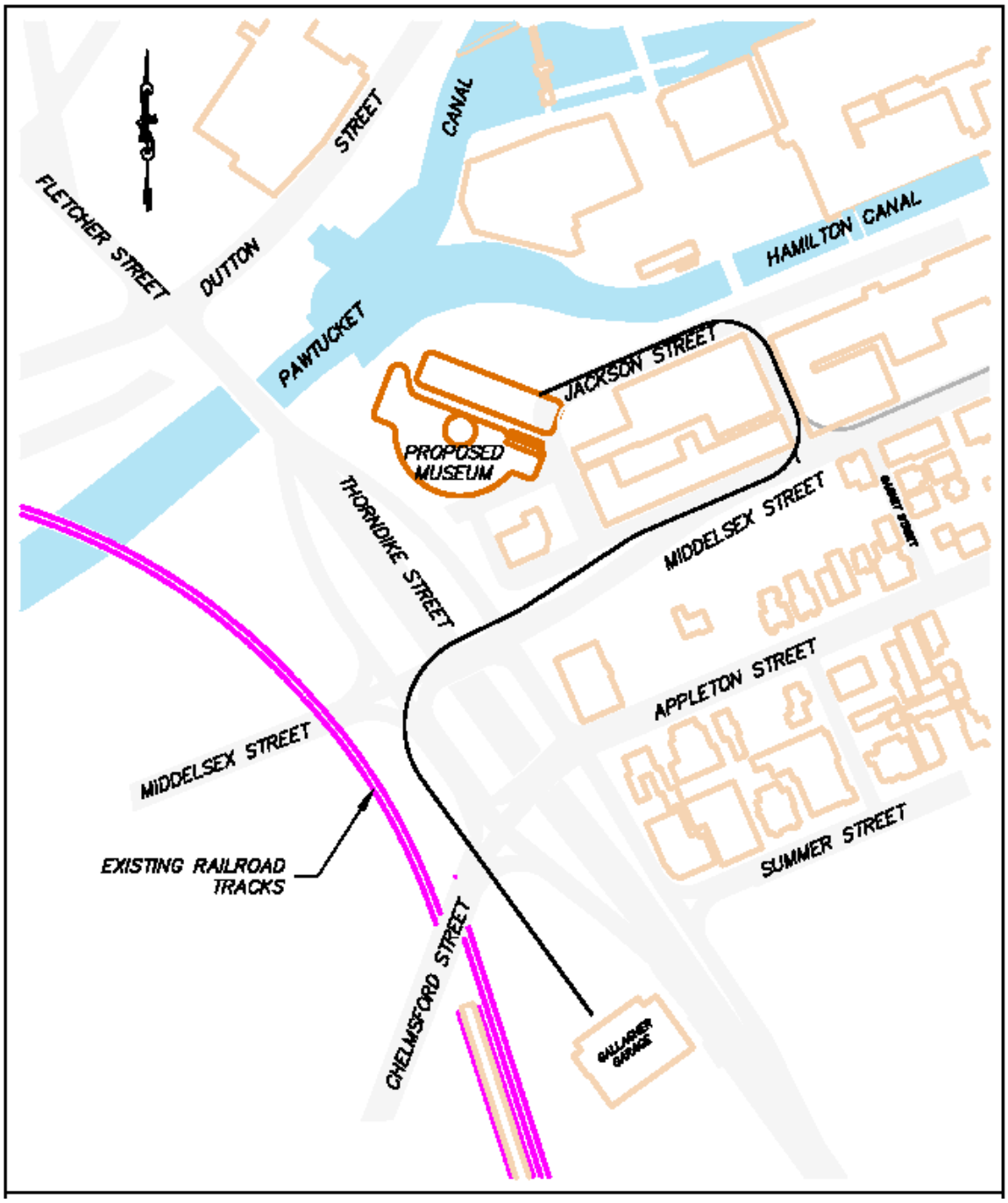
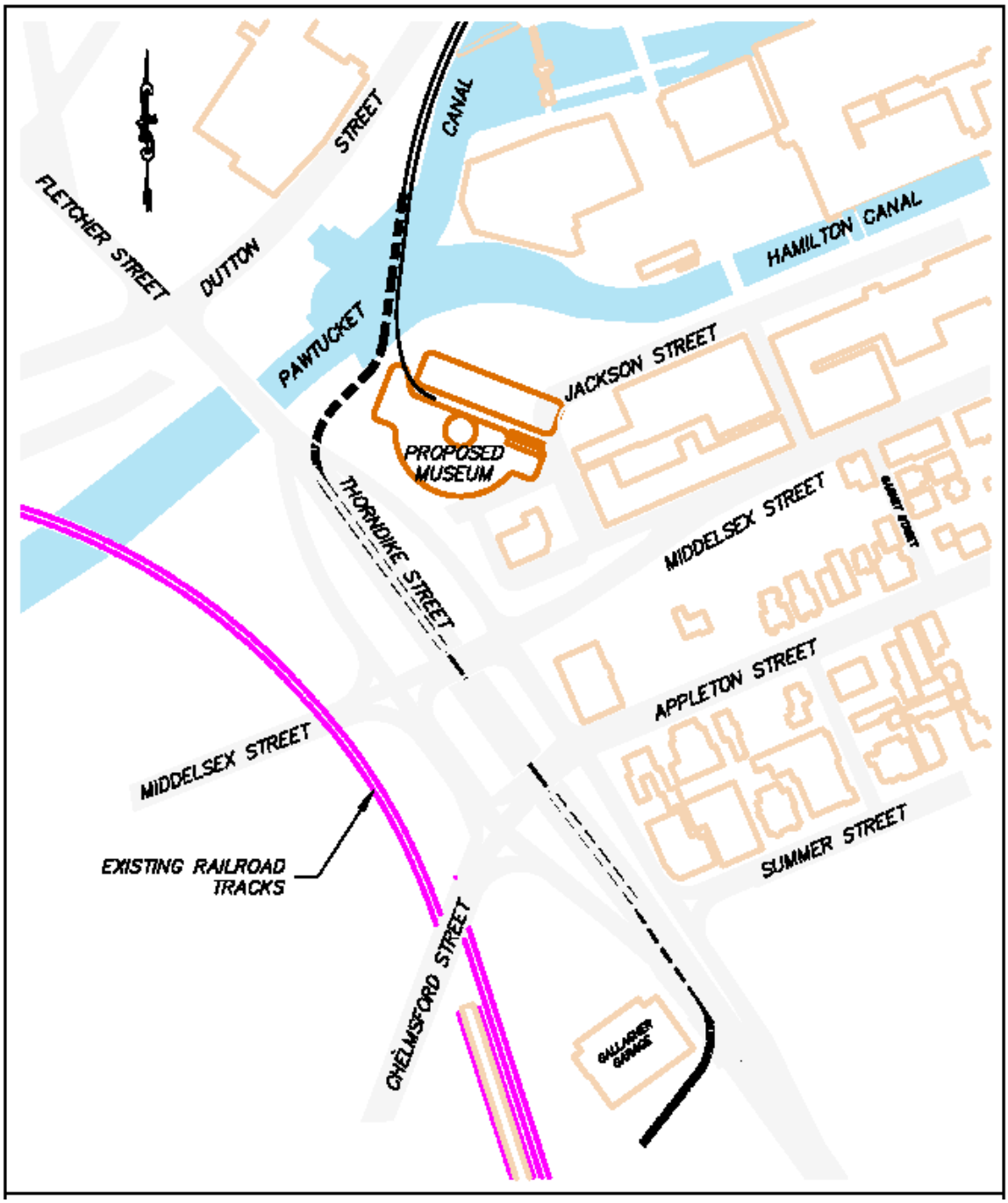


Figure 11. Alternative 3
Gallagher Connection via Thorndike Street



Future Route Options

The routes identified in this plan are not the only opportunities for increased historic trolley service in Lowell. This analysis also identified additional routes, shown on Figure 12, that could be developed in the future following completion of the routes proposed in this plan.

Riverfront Line

The LNHP has expressed an interest in a route connecting the expanded trolley system to the underutilized 327,000 s.f. Massachusetts Mills, a difficult to reach historic mill site along the Merrimack River. This area is currently connected to the rest of the LNHP sites by a river walk. The LNHP would like to use trolley service to increase accessibility to these sites. The critical issue is identifying a route that will best meet the LNHP's interests and can be developed at a reasonable cost with minimal delays. Lack of access to this area is the major problem in identifying a route.

Simulation of Trolley on the Riverfront Line at the Massachusetts Mills, courtesy of Craig Miller – Winchester Engineering Associates

Market Street Line

Providing service from Dutton Street to Central Street was seriously considered in this analysis but the suggested Museum/JAM/Acre Loop is proposed as a better solution in the initial stages of this project. A line on Market Street would provide accessibility to the southern edge of Downtown Lowell and direct accessibility to the Park Service's Visitors Center and may be worth considering in a future phase of this project.

UMASS-Lowell Service

Two routes have also been proposed to help link UMASS-Lowell's campuses. A trolley bridge across the Merrimack River would link the academic North Campus with the residential North Campus by way of the Arena/Ballpark loop. Note that design activities for rehabilitating the University Avenue Bridge (aka Textile Bridge) over the Merrimack River have commenced. **Consideration should be given by the City of Lowell and the Massachusetts Highway Department to include trolley planning in this project.** A second route would connect UMASS-Lowell's South Campus to the Fletcher Street route via Pawtucket Street, resulting in UMASS-Lowell's South campus and the North Campus being connected by trolley service. UMASS-Lowell is interested in these connections as a way to reduce or eliminate an existing shuttle-bus system.

CrossPoint/Chelmsford Street Line

This route would provide service, either on Chelmsford Street or on an existing unused rail line, to the CrossPoint (the former Wang headquarters) development. The CrossPoint towers complex consists of three towers totaling approximately 1.4 million square feet of office space. The adjacent area includes restaurants, a national cinema chain, parking, and easy access to Interstate 495. This service would link to the rest of the system at the Gallagher Center and would provide transit service to a major employment center outside of central Lowell.

CrossPoint Towers at Lowell

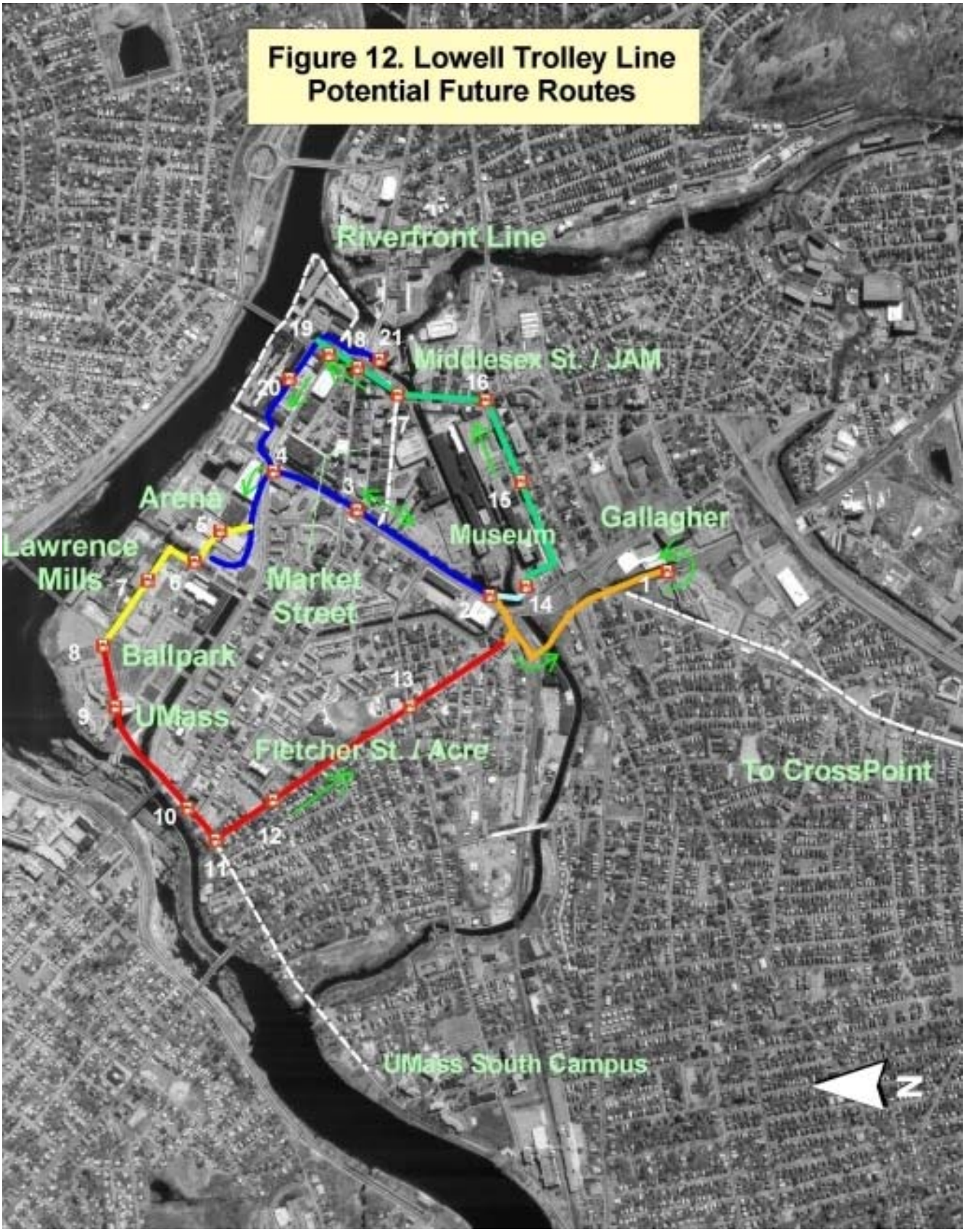


Figure 12. Lowell Trolley Line
Potential Future Routes
Riverfront Line
Middlesex St. / JAM
Arena
Lawrence
Mills
Market
Street
Museum
Gallagher
Ballpark
UMass
Fletcher St. / Acre
To CrossPoint
UMass South Campus
N

Integration with the LRTA System

The Lowell Regional Transportation Authority (LRTA) provides local bus and paratransit service in and around Lowell. The proposed trolley system is envisioned to complement existing LRTA service, shown on Figure 13, to provide greater mobility options. The proposed trolley system will have a total of 21 stops, including the main stops at the LNHP Visitor Center, the Gallagher Center, UMASS-Lowell, the Ballpark, and the Arena.

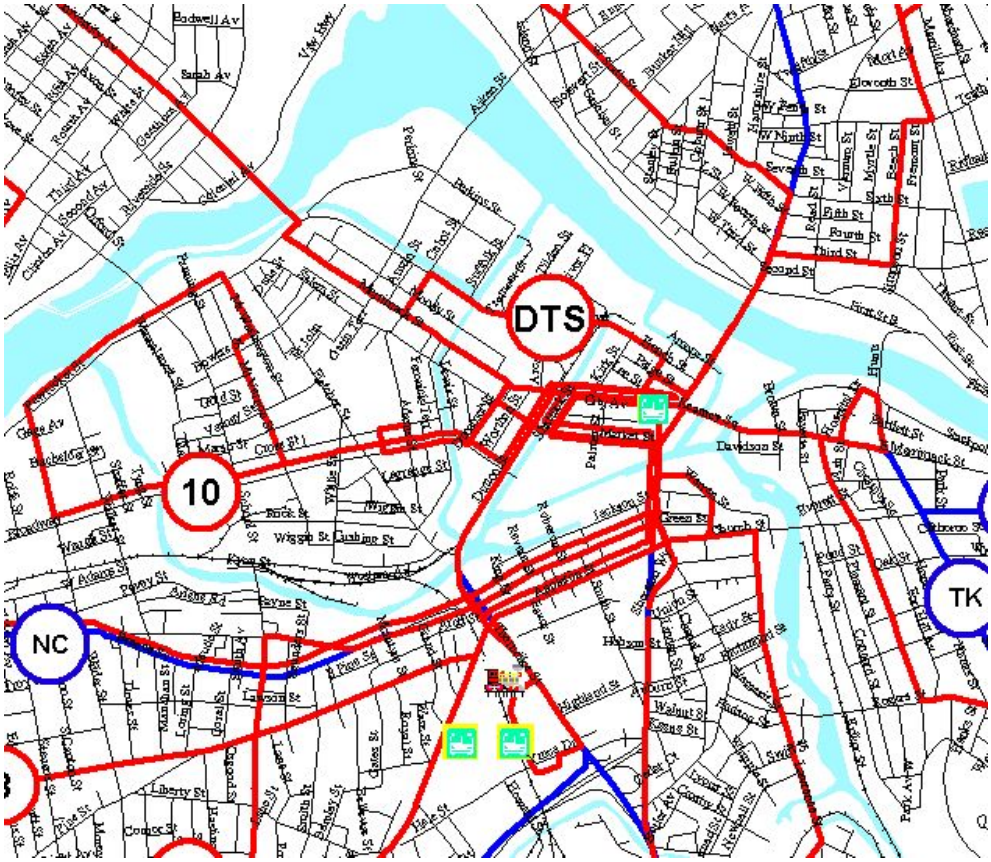


Figure 13. Lowell Bus Routes

Several bus routes would be linked to the proposed trolley routes either through direct connections at bus and trolley stops or by a short walk to or from a trolley or bus stop. It is likely that once the trolley line is built efforts will be made to coordinate trolley and bus routes to maximize convenience for transit riders and maximize efficiency of the local public transit system.

Table 3 identifies where the current bus system links to the proposed trolley system:

Table 3. LRTA Bus Route Connections to Proposed Trolley System

Route	Connection to Trolley Route
1	Museum/JAM/Downtown Loop at Market and Prescott
3	Museum/JAM/Downtown Loop at Central and Middlesex
4	Museum/JAM/Downtown Loop at Central and Middlesex
6	Dutton Street line on Dutton Street
8	One block from Museum/JAM/Downtown Loop on Appleton
9	Museum/JAM/Downtown Loop on Middlesex
10	Arena/Ballpark/Acre Loop at Fletcher and Broadway
11	Arena/Ballpark/Acre Loop at Pawtucket and University

It should be noted that at the time of this report, NMCOG and the LRTA are working together to design new routes based on the LRTA decision to move the main bus hub from Merrimack Street to the Gallagher Center.

Trolley Stops Locations

The Concept Objectives and Route Selection Criteria were also applied to determining proposed locations of trolley stops. These include:

- Maximize linkages with the existing heritage trolley system,
- Ensure that the expanded system complements the National Park Service's mission and objectives,
- Coordinate routes with City of Lowell economic development plans, and
- Coordinate route plans with Lowell Regional Transit Authority plans

Phase A includes eight (8) stops, including the current stops at the Swamp Locks, Locomotive and Rail Car Exhibit and Working People Exhibit. It is anticipated that Phase B will include five (5) stops, and Phase C will include eight (8) stops. The total number of trolley stops at full build-out through Phase C is anticipated to be twenty (21) trolley stops. Two of these stops, at the Boott Cotton Mills and Middlesex Community College, currently serve LNHP interpretive trips and will continue serving only that purpose. These stops will not be integrated at this time into the transit trolley service. Table 4 describes the proposed trolley stops by phase, and the stops are shown on the full system build-out map in Figure 14:

Table 4. Proposed Trolley Stops

Phase A		
Stop	**Location**	**What Will be Served?**
1	Gallagher Intermodal Transportation Center	Trolley transfer point for the LRTA new intercity and planned regional bus hub and MBTA commuter rail service to Boston. New day care facility planned for the Gallagher center, and the Center parking garages.
2	Dutton Street at the Swamp Locks	LNHP canal boat tour at Swamp Locks. Connections to LRTA #10 bus (1 block). American Textile History Museum. National Streetcar Museum at Lowell.
3	Dutton and Merrimack Streets	Locomotive and Rail Car exhibit, Mack Building, Revolving Museum, New England Quilt Museum and the LNHP Visitor's Center and adjacent Market Mills. Short walk to City Hall and the Civic Center, Whistler House Museum of Art, Artist Lofts, some elderly, subsidized and market rate housing, and downtown Lowell. The LNHP operates a large visitor parking lot adjacent to the Visitor's Center.
4	Dutton Street at Father Morrissette Boulevard	Lowell High School, Working People Exhibit, Lucy Larcom Park, Ayotte Parking Garage, and Boarding House Park.
5	Tsongas Arena	Tsongas Arena, Post Office.
6	Suffolk and Hall Streets	Wannalancit Mills.
7	Perkins Street and Cabot	Lawrence Mills redevelopment complex.
8	Perkins and LeLacheur Park	LeLacheur Park/UMass Lowell Residential complex/Student Center.
Phase B		
Stop	**Location**	**What Will be Served?**
9	Pawtucket Street at UMASS-Lowell	UMASS-Lowell resident halls and Student Center connect to UMASS-Lowell Bus Shuttles.
10	Pawtucket and Salem Streets	Residential neighborhood, Saints Memorial Medical Center, other health care facilities.
11	Pawtucket and Fletcher Streets	Residential neighborhood, Heritage Nursing Care Center, HealthSouth facility.
12	Fletcher and Bowers Streets	Residential neighborhood, elementary school, North Commons.
13	Fletcher and Broadway Streets	Grocery store, post office, pharmacy, and a newly constructed senior center.
Phase C		
Stop	**Location**	**What Will be Served?**
14	The Operation and Maintenance Facility/National Street Car Museum at Lowell	Swamp Locks Bridge, the Operation and Maintenance Facility/National Street Car Museum at Lowell, future Middlesex Street Garage.
15	Middlesex and South Streets	JAM and one block from South Commons. Future Middlesex Street Garage.

16	Central, Gorham and Middlesex Streets	Historic Boston and Maine Railroad Freight House, retail, restaurant, commercial, and residential properties.
17	Central and Market Streets	Retail shops, restaurants, residential properties, and artist's lofts. Downtown business district, many historic buildings and as a busy stop for the loop within the large loop concept. Roy parking garage (1,000 car).
18	Prescott and Merrimack	Downtown Lowell, Middlesex Community College, Lowell Memorial Auditorium.
19	Bridge near French	Downtown Lowell, John Street Parking Garage, entrance to Massachusetts Mills complex.
20	Boott Cotton Mills	Boott Cotton Mills Trolley Stop, John Street Parking Garage.
21	Middlesex Community College	Lower Locks Parking Garage, Davidson Street Parking Lot, Middlesex Community College, Lowell Auditorium, Lower Locks, Doubletree Hotel – LNHP trips and special events only.

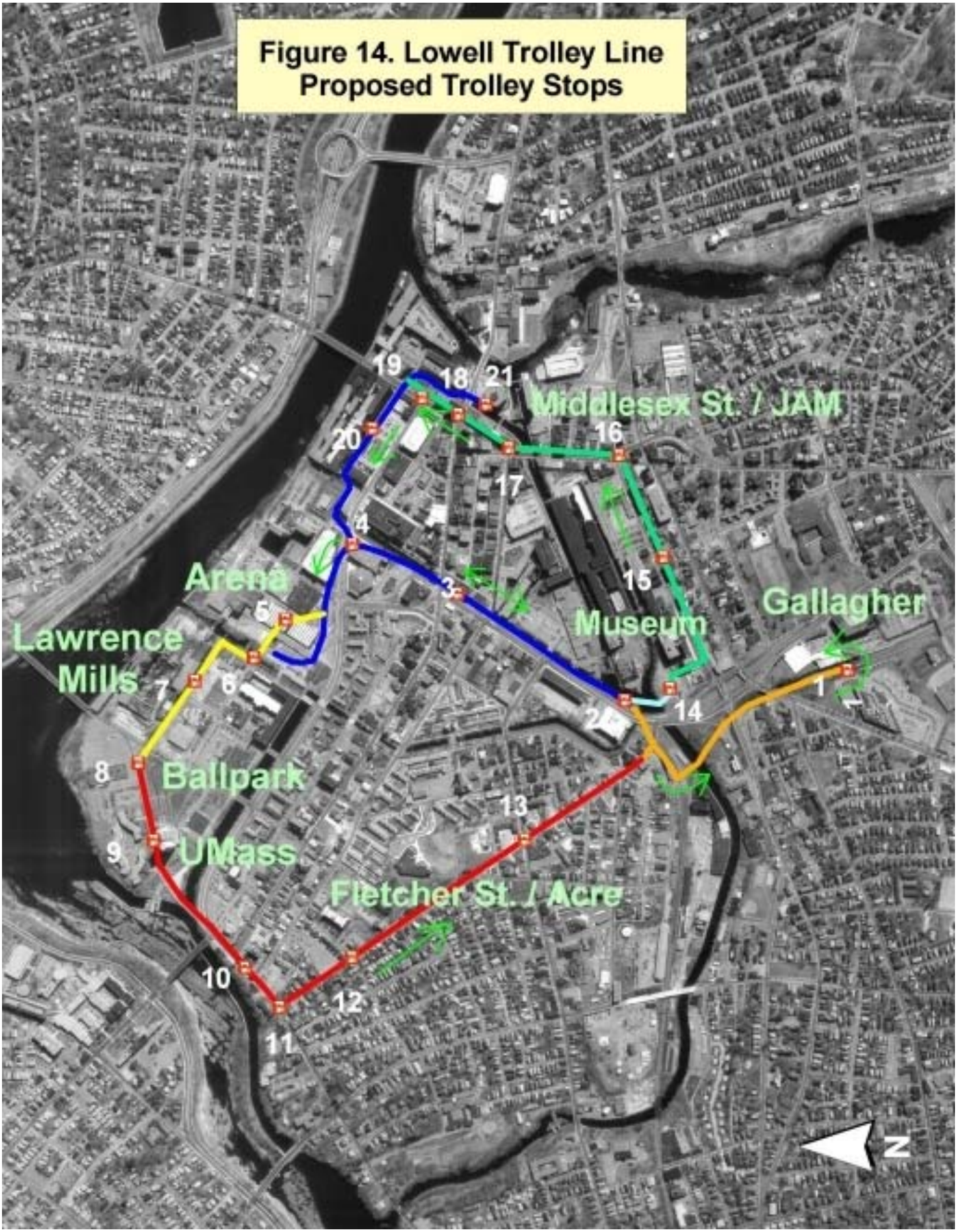


Figure 14. Lowell Trolley Line
Proposed Trolley Stops
Middlesex St. / JAM
Arena
Lawrence
Mills
Museum
Gallagher
Ballpark
UMass
Fletcher St. / Acre
19
18
21
20
16
17
4
3
15
5
7
6
1
14
2
8
13
9
10
12
11
N

5 Urban Context

The proposed expanded trolley routes will serve the central part of Lowell. The service area for the proposed trolley system incorporates the 141-acre Park district and a 583-acre preservation district that includes Lowell's business district. The inclusion of the Acre neighborhood as part of the trolley system's service area extends the LNHP mission of providing an educational and interpretive experience. The neighborhood has been historically the entry point and home to immigrants, many of whom found employment in the City's mills.

The Park is the City – The City is the Park.
It is a living, working, learning environment.

Sites in this area include:

- Lowell National Historical Park
- UMASS-Lowell
- Paul E. Tsongas Arena
- Edward A. LeLacheur Park
- Lawrence Mills.

The areas to be served include:

- Downtown historic industrial and commercial center of the City
- The Acre residential neighborhood
- The planned mix-use neighborhoods at the Lawrence Mills transit oriented development
- The planned commercial and industrial JAM redevelopment area.
- Gallagher Intermodal Transportation Center

Benefits to Lowell

The proposed service will address some major problems facing Lowell including the need to mitigate traffic congestion, improve access between the LNHP and other parts of central Lowell, and improve intra-regional connections. The planned routes will also provide the opportunity for the LNHP to extend interpretive efforts to other parts of central Lowell.

Traffic Congestion Mitigation

The success of the LNHP and the economic revitalization of Lowell have created accessibility and mobility challenges in Lowell. Increased traffic congestion and demand for parking may limit opportunities for continued tourism and economic development.

Congestion is directly related to the idiosyncratic street pattern designed around the 19th Century mills. The trolley line will reintroduce a means of travel that was important to the City's growth, and will provide a mobility option that complements the physical character of the City. Locations including LNHP sites, museums, the Arena, the Ballpark, employment, housing, and shopping will be served by the trolley system, allowing residents and visitors to move within the CBD without the need for an automobile.

Improving Access to the LNHP and Downtown

Congestion compounded by the lack of parking threatens the LNHP's long-term success and Lowell's economic revitalization. The trolley system has the potential of resolving these compounding effects. Its construction could lead to moving traffic from the Lowell CBD to parking on the periphery, while providing access to sites and mobility between areas of interest to visitors, residents, and workers.

Supply and Demand For Parking in Central Lowell is Near Equilibrium. Further Economic Development Requires Addressing the Parking Supply Issue

To date the City has addressed the parking issue by building a number of parking facilities in Lowell CBD and around the periphery. Economic growth in the downtown area has resulted in the demand and supply for parking being

near equilibrium. New solutions to address potential parking shortages are needed to allow for Lowell to continue its economic renewal.

Improving Intra-Regional Transportation Connections

The connection to the Gallagher Center will enhance the attractiveness of selecting transit as a commuter option for Lowell residents and visitors. This is further enhanced with the expansion of the Center's parking garage which, when coupled with trolley service, creates an opportunity to channel travelers originating outside of Lowell and traveling by commuter rail, bus or private automobile into the parking garage and onto the trolley system. This could be a very attractive option when special events are scheduled at the LNHP, the Arena, or the Ballpark.

Extending the Interpretive Experience offered to Visitors by the LNHP

By improving mobility for visitors around the LNHP, the LNHP will be able to interpret additional aspects of life in Lowell during and after the Industrial Revolution. The trolley service will make it possible for the LNHP to develop and expand both LNHP led and self-guided tours that direct visitors to a sequence of LNHP interpretive sites located throughout the city.

One of the proposed routes will provide access to the Acre – a neighborhood that has been home to many of the immigrant groups that played an important role in the industrial history of Lowell. The LNHP has developed interpretive materials related to the Acre neighborhood and trolley service to this community will provide opportunities to enhance the LNHP interpretive efforts.

Service Area Demographics

The population living within a quarter mile of the existing historic trolley line is about 8,000. As the trolley line is expanded, the population served will grow as the line reaches a greater geographic area. In Phase A, the population within a quarter mile of the expanded trolley line will increase by almost 55% and when Phase B is complete, the population served will almost double to more than 25,000. By Phase C, the population served by the expanded trolley line is expected to be approximately 28,000. Planned development efforts focusing on increasing the residential population of central Lowell should further increase the population that would be served by the proposed system.

The following Table 5 shows the Volpe Centers projected population, LNHP visitation and special events attendance projected for the different phases of development of the Trolley system. This analysis assumes full build-out of the historic trolley system described in this report, and based on that assumption,

annual LNHP visitation is projected to increase by more than 30% to approximately 910,000 persons (See Appendix C for detail).

Table 5. Current and Future Demographics by Phase

	Base	Phase A	Phase B	Phase C
Service Area Population	8,600	13,300	25,300	28,700
Increase		55%	90%	13%
LNHP Visitors	605,000	623,000	661,000	908,000
Increase		3%	6%	37%
Special Event Visitors	545,000	653,000	591,000	630,000
Increase		1.5%	7%	6.5%
Tsongas Arena	320,000	328,000	357,000	387,000
UMASS-Lowell Hockey	45,000	45,000	54,000	63,000
LeLacheur Baseball Park	180,000	180,000	180,000	180,000

Economic Impacts

The Volpe Center's examination of the economic benefits of extending the trolley system focused on estimating the effects on sales, personal income, and job creation. The availability of the trolley system is expected to improve mobility. It is expected that improved mobility will then stimulate increases in LNHP visitors, special event visitors, and residents living in downtown Lowell.

A range of these benefits is presented below in 2002 dollars for the period 2002 through 2022. Because benefits that occur sooner are valued more than those that occur later, it is necessary to discount future benefits to assess overall project value in the present. A higher estimate of benefits is based on a discount rate of 4.58 percent, which is consistent with the historical average rate for long-

term U.S. government bonds. The more conservative estimates provide a sensitivity measure and are based on an interest rate of 6.58 percent. Table 6 shows the economic benefits over the 20-year horizon.

Table 6. Economic Benefits

Economic Measures	2002-2022 Estimates (4.58% discount rate)	2002-2022 Estimates (6.58% discount rate)
Sales	$313,300,000	$277,800,000
Personal Income	$110,960,000	$98,390,000
Value Added	$174,060,000	$154,330,000
Jobs	8,800	8,800

The economic activity measures show the projected impact of the trolley system from several aspects. Business sales are forecasted to increase by more than $313 million over a twenty-year period. Personal income is expected to increase by nearly $111 million, and the value added to final goods and services produced within the region is expected to grow by over $174 million. In addition, the full build out of the system is expected to result in the creation of nearly 9,000 jobs, as businesses expand to take advantage of increased visitor and residential spending. (Additional details of projected economic impacts are contained in Appendix B).

Residential property values will also be affected by expanded trolley service, though the magnitude of the impact is difficult to quantify. The degree of improved accessibility, the desirability of locations surrounding stations, and general conditions in the local real estate market are all factors. Despite these difficulties, past studies have been conducted which suggest that, within a ½- to one-mile radius, residential property values increase $75 - $90 for every 100 feet closer the property is to a station[6].

Land Use

The proposed routes will cover different types of land uses. Figure 15 shows current zoning for the area to be served by the proposed trolley system. The area east of the existing historic trolley route includes the commercial and industrial heart of historic Lowell including downtown and the JAM redevelopment area. Land-uses are characterized by commercial, industrial, and institutional, and this area is the center of LNHP and other museum facilities. The area includes mill buildings that have been, or are being considered,

[6] Brinckerhoff, Parsons. *The Effects of Rail Transit on Property Values: A Summary of Studies*. Research carried out for Project 21439S, Task 7; NEORail II, Cleveland, Ohio. February 27, 2001.

for adaptive re-use for housing, office and research and development. Street patterns conform to the canals built in 19th century to power the mills. Zoning in this area is commercial and industrial. A large part of the area is part of an artist overlay district that permits artist work/live space.

The area west of the existing historic trolley route includes the Arena, the Ballpark, Lawrence Mills and UMASS-Lowell's residential campus. Most of this area is identified as the North Canal Economic Development Area in City planning studies, and this is one of the most successful reinvestment efforts by the City. This area is zoned for industrial and commercial use, with the Lawrence Mills site zoned as a Mixed-Use Planned Unit Development.

As the route proceeds to Fletcher Street, land uses are primarily residential and small commercial in the Acre neighborhood. Housing types in the Acre range from single-family homes to large multifamily housing developments. Commercial activity is primarily neighborhood retail and some institutional uses; including schools, churches, and health care facilities. The Acre neighborhood is zoned for multifamily housing, local business, and mixed-use retail and housing.

Planning and Redevelopment

All of the areas to be served by this project have been the subject of significant planning studies and significant investments have been made or are planned. The most significant activities include the investments by the National Park Service to establish the LNHP, and sites associated with the LNHP including the existing historic trolley line, development in the North Canal Economic Development Area including the Arena and the Ballpark, and expansion of the UMASS-Lowell North Campus. Lawrence Mills is in the process of being developed as a mixed-use transit oriented development. Other mill buildings have or are being renovated for residential and commercial use. The 327,000 s.f. Massachusetts Mills site at Bridge St. and the Merrimack River is currently underutilized, in large part because of a lack of parking and access. A trolley stop at the entrance, along with the increased mobility to other areas of Lowell and the Gallagher Center that this stop would bring, allows for the possibility that this site can be revitalized.

The City of Lowell completed Urban Revitalization and Development Plans for the Acre in 1999, and for the JAM redevelopment area in 2001. A draft Downtown Lowell Master Plan was completed in 2001.

Dutton Street, Swamp Locks, Lord Overpass, Gallagher Center and Future O&M/Museum Site

Acre Urban Revitalization and Development Project Plan

In 1999 the City approved the Acre Urban Revitalization and Development Project Plan. The Acre Plan proposes the following:

- Acquire 18.28 designated acres (16.2%) of the area for demolition and rehabilitation,
- Adopt new zoning to increase residential and commercial uses and to resolve incompatible land use issues,
- Undertake infrastructure improvements,
- Adopt economic incentive programs,
- Implement a comprehensive housing revitalization program, and
- Adopt design review guidelines and procedures

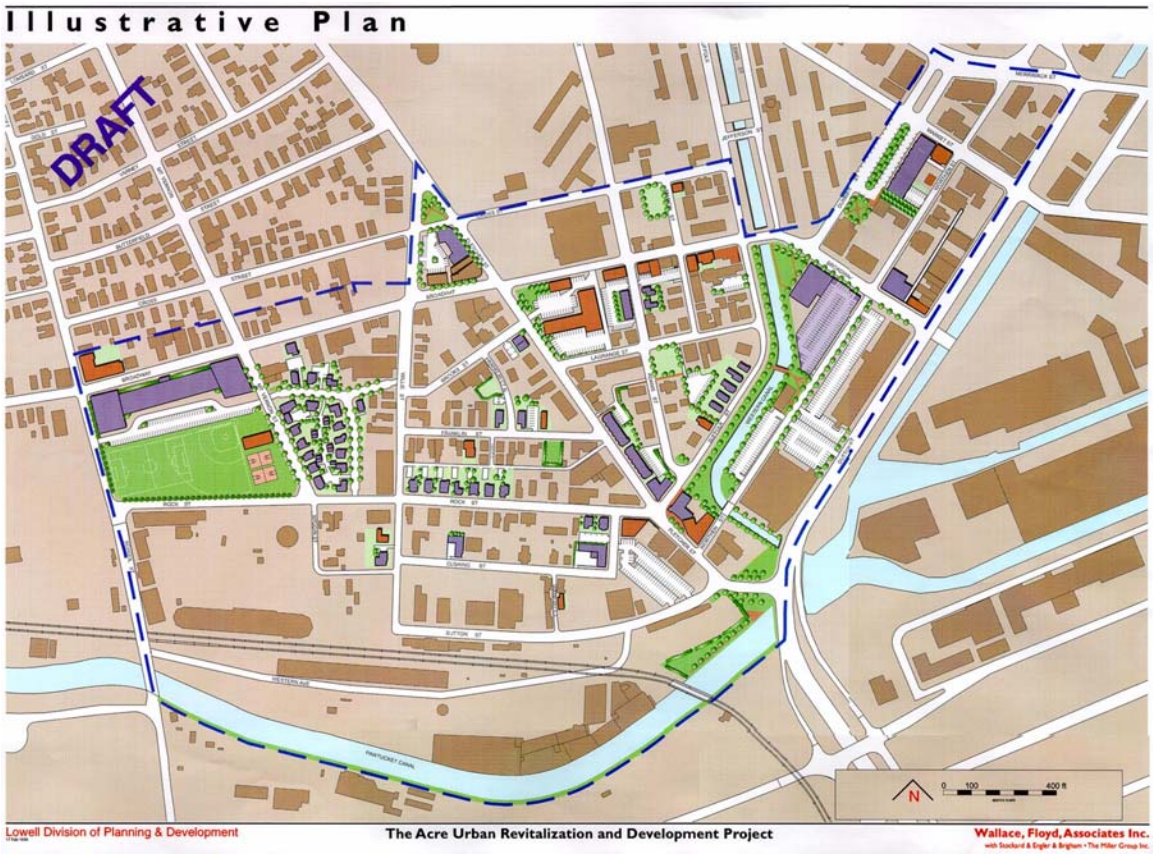


Figure 16. Acre Redevelopment

The proposed trolley line on Fletcher Street will re-emphasize the City's public policy strategies that supported the development of a supermarket, pharmacy, and senior center in this neighborhood. Infrastructure improvements recommended in the Acre Plan, such as the complete reconstruction of all streets in the project area, provide a basis for coordinating development of the trolley route with other City priorities. The planned trolley route should either be built as part of this recommended roadway reconstruction effort or, if funding is not available in a timely matter for trolley construction, the planned reconstruction should be designed to accommodate future trolley development.

JAM Urban Revitalization and Development Project Plan

The JAM redevelopment area has been the subject of several planning efforts over the past 30 years. The current plan was developed because previous planning efforts have not led to significant public investment in the JAM redevelopment area neighborhood. The Plan proposes the following:

- Acquire 18.21 designated acres of the area for demolition and rehabilitation,
- Adopt new zoning to increase residential and commercial uses and to resolve incompatible land use issues,

- Undertake infrastructure improvements, and
- Adopt economic incentive programs

A lot that has been suggested as the site for the proposed Operations and Maintenance facility/National Street Car Museum at Lowell is part of the JAM redevelopment area. This 67,000 square foot vacant lot is identified in the Plan for redevelopment as an institutional use.

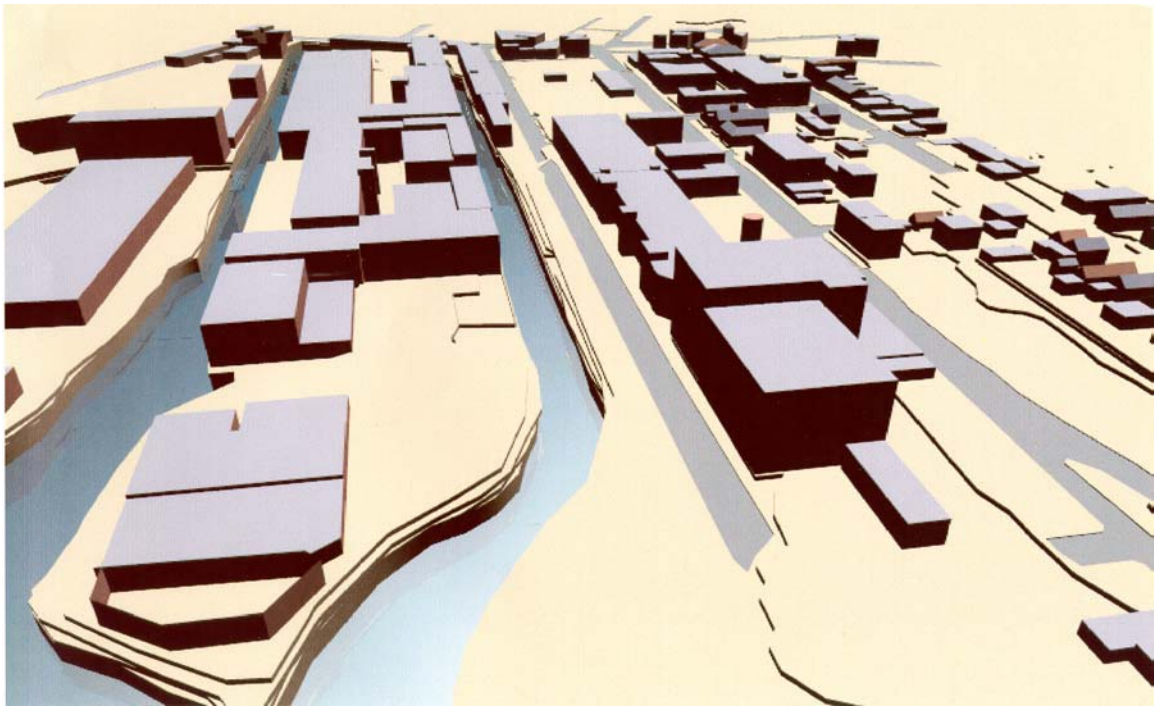


Figure 17. Jackson Appleton Middlesex Urban Revitalization & Development Plan

The JAM Urban Revitalization and Development Plan calls for infrastructure improvements including establishing new streets, reconstructing streets, developing pedestrian paths serving major destinations, constructing separate sanitary and storm drains, and creating new open space. The Plan call for two City-sponsored development projects to provide major "bookends" to jump-start reinvestment in the area. The first project is a new parking garage at the eastern end of Middlesex and Jackson Streets, with commercial and public uses at the ground floor level. The other project is a commercial development at the western end of Middlesex and Jackson streets. It is also anticipated that Middlesex Street will be converted to two-way traffic. The planned trolley route should either be built as part of this recommended roadway reconstruction effort or, assuming funding is not available in a timely matter for trolley construction, the planned reconstruction should be designed to accommodate future trolley development.

Downtown Master Plan

The Draft Downtown Master Plan notes that Lowell "appears to be on the verge of becoming a dynamic, exciting place." The need for the Plan is identified as ensuring that revitalization takes Lowell to "the next level." The goals and strategies included in the plan are designed to build on past success. The Plan establishes several goals for the future of Downtown Lowell. These goals are:

- Utilize the unique cultural heritage, historic tradition, and natural resources of Downtown Lowell to generate new economic opportunities and growth in the Downtown,
- Make Downtown Lowell safe and convenient for pedestrians,
- Create new housing opportunities in Downtown Lowell, especially for artists,
- Create an active, clean, and safe urban riverfront that creates opportunities for recreation and becomes the spine of the Downtown community,
- Enhance the positive image of, and investment in, the Downtown, and
- Develop cooperation and coordination amongst Downtown groups – particularly in the areas of marketing and maintenance.

The Downtown Master Plan identifies strategies to meet these goals, including strategies for housing, office development, retail enhancement, public improvements, and parking improvements. Both the public improvement and parking improvement strategies identify the need to provide access and mobility for downtown workers, residents, and visitors.

Growth and Economic Revitalization

The City of Lowell has actively sought economic development assistance from state and federal sources. The designation of Lowell by the National Park Service as the nation's first urban National Historic Park was the beginning of an economic development strategy that focuses on building on Lowell's history and its architecture. Economic revitalization efforts build on the successful partnership with the LNHP.

The plans for the areas to be served by the proposed trolley system identify growth in both the residential and work populations, as redevelopment plans move forward. Efforts to build on Lowell as a destination for tourists and visitors also suggest growth both during and after work hours. The residential population of the downtown area has grown from 859 in 1970 to 3,881 in 2000.

The US Department of Housing and Urban Development designated a large part of Lowell, including the area served by the proposed trolley route, as a Renewal Community. This designation provides federal tax incentives for investment in the designated area.

The Commonwealth of Massachusetts has committed $10 million over the next 18 years for urban renewal investments in the Acre. Funds will be used for acquisition, relocation, environmental remediation, public improvements, and administrative costs related to the Acre Redevelopment Plan.

The City has designated three areas, the Acre, North Canal Economic Redevelopment Area (CBD North), and the JAM redevelopment area (CBD South) as Economic Opportunity Areas. The City provides tax and investment benefits for investment in these designated areas.

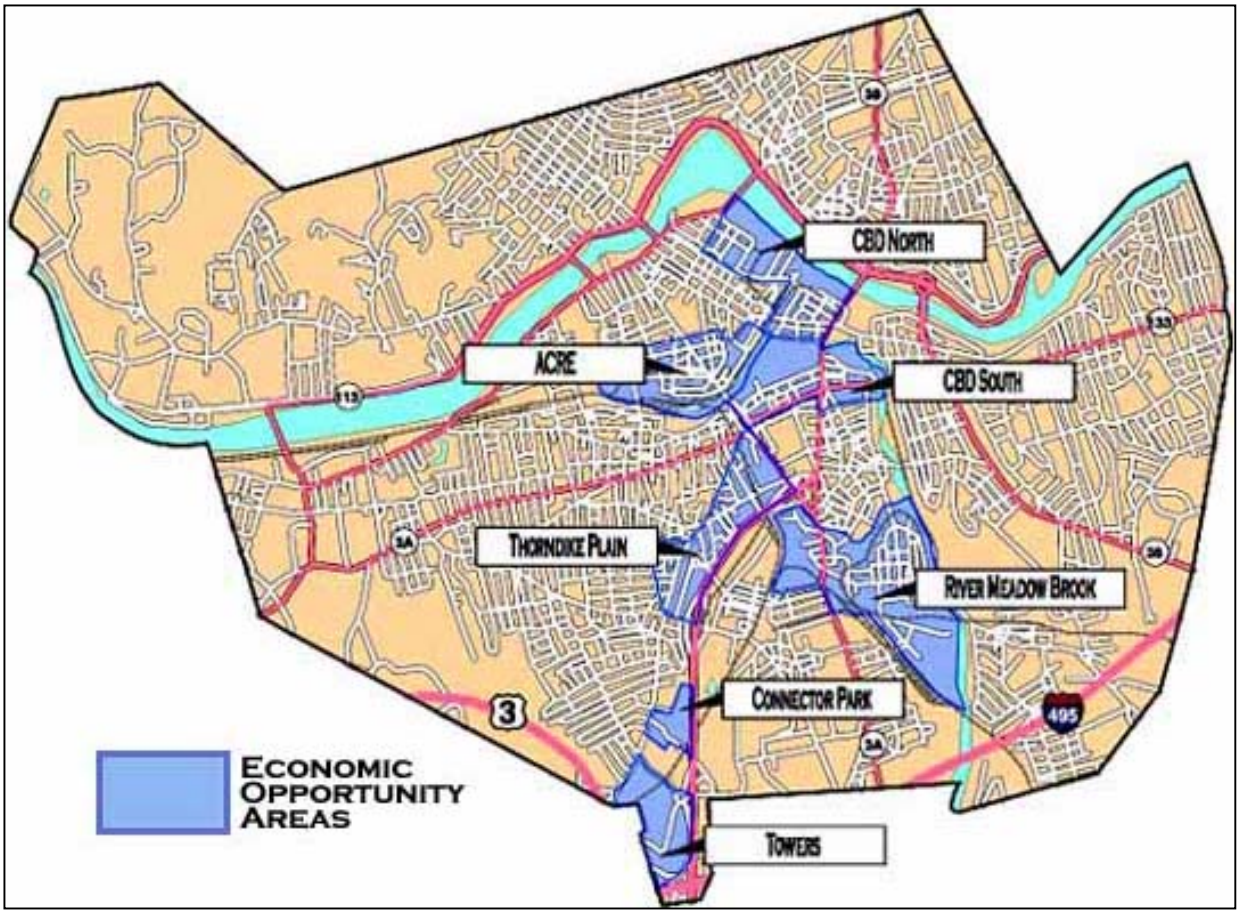


Figure 18. City of Lowell Economic Opportunity Areas

6 Travel Demand Forecasts

Trolley use is a function of the supply of the service provided and the demand generated by the people and places that it serves. The supply component consists of the trolley service, number of stops, its frequency, run time, and how much it costs to use it. The demand is based on the characteristics of the people and places the trolley serves. The forecasts were based on four sources of demand - LNHP visitation, local residents, special events, and new development.

The travel demand analysis clearly indicates the importance of the LNHP and the City working cooperatively to plan and implement the trolley system. In many respects, the demand generated by LNHP visitors is a prerequisite to ensuring that Lowell residents have "unlimited" access to the trolley service.

Who Will Ride the Trolley?

A spreadsheet demand model was developed to forecast future levels of trolley use for alternative scenarios, focusing on several groups of users – LNHP visitors, local residents, attendees of special events, and those traveling to or from future downtown developments described in the 2001 Downtown Lowell Master Plan.[7] For each construction phase, forecasts were made for the three headway alternatives (10, 15, and 20 minutes), at five fare levels - $0, $0.50, $1.00, $1.50, and $2.00.[8] (Complete detail on forecasting, Operations and Maintenance information and forecasts are contained in Appendix C).

Table 7 presents the forecast of Phase C annual high/low ridership ranges for the five price scenarios, assuming constant 15-minute

[7] Local residents are defined as those living within ¼ mile of a route, based on preliminary 2000 Census Tract data. Additional markets, such as UMASS-Lowell students living in the area and commuters to existing businesses, are indirectly accounted for by an overlap of some of the ¼ mile corridors.
[8] The model assumes a constant-elasticity convex demand curve as defined by the mid-point elasticity formula. Separate headway and price elasticity ranges were used for each market segment. Additional assumptions were made in order to simulate future conditions without possessing all the necessary information, and to simplify the analysis.

service headways. As Table 7 shows, local residents are the most price-sensitive, followed by both special event-goers and those traveling to future developments. LNHP visitors are the least price-sensitive, maintaining a more stable level of LNHP ridership across the price scenarios than the other groups.

Table 7. Annual Trolley Ridership, Phase C, 15-Minute Headway by Fare and Market

	$0.00 Fare Low Ridership Estimate	**$0.00 Fare High Ridership Estimate**
LNHP Visitors	228,311	280,200
Local Residents	207,900	392,700
Special Events	97,833	147,000
Future Development	150,333	210,467
Year Total	**684,378**	**1,030,367**
	$0.50 Fare Low Ridership Estimate	**$0.50 Fare High Ridership Estimate**
LNHP Visitors	186,800	186,800
Local Residents	69,300	69,300
Special Events	63,000	58,700
Future Development	90,200	90,200
Year Total	**409,300**	**405,000**
	$1.00 Fare Low Ridership Estimate	**$1.00 Fare High Ridership Estimate**
LNHP Visitors	163,450	174,748
Local Residents	43,078	49,500
Special Events	48,176	49,669
Future Development	68,976	76,323
Year Total	**323,681**	**350,241**
	$1.50 Fare Low Ridership Estimate	**$1.50 Fare High Ridership Estimate**
LNHP Visitors	150,877	167,898
Local Residents	32,498	40,500
Special Events	41,039	44,939
Future Development	58,758	69,054
Year Total	**283,172**	**322,389**
	$2.00 Fare Low Ridership Estimate	**$2.00 Fare High Ridership Estimate**
LNHP Visitors	143,019	163,474
Local Residents	26,778	35,357
Special Events	36,841	42,028
Future Development	52,747	64,581
Year Total	**259,385**	**305,440**

Partial year ridership, additional headways, and forecasts for phases A and B are shown in Appendix C. In general, the four months from June to September would account for 40 to 50 percent of annual ridership, with May and October adding another 10 to 20 percent, depending on the scenario. Reducing the headway to 10 minutes would increase ridership by about 10 percent, while increasing it to 20 minutes would reduce ridership by about 5 percent. Overall, Phase A would have about half the Phase C ridership, with a few additional percentage points at the higher fares.[9] Phase B ridership is about 65% to 75% of Phase C forecasts.

Trolley Service Characteristics

The existing trolley track will be expanded during three construction phases.[10] As each phase is completed, more people and sites will be served. However, as the size of the system expands, total route miles and running time do not increase proportionally. The total run times reported in Table 8 assume a five mile system, an average speed of 12 miles per hour, and an average of half a minute dwell time at each stop.[11]

Table 8. Trolley Extension Service Characteristics

	Base	Phase A			Phase B			Phase C		
Headway (Minutes)	**15**	**10**	**15**	**20**	**10**	**15**	**20**	**10**	**15**	**20**
Track Mileage	**1.3**	**2.5**	**2.5**	**2.5**	**4**	**4**	**4**	**5**	**5**	**5**
Route Miles	**2.6**	**5**	**5**	**5**	**5**	**5**	**5**	**6.5**	**6.5**	**6.5**
Number of Stops	**5**	**8**	**8**	**8**	**14**	**14**	**14**	**19**	**19**	**19**
Total Run Time	**15.5**	**29**	**29**	**29**	**32**	**32**	**32**	**42.5**	**42.5**	**42.5**
Trolley Cars Required	**2**	**3**	**2**	**2**	**4**	**3**	**2**	**5**	**3**	**3**

Scheduled fare trolley service can operate at various headways between cars, with reductions of headways requiring more trolleys. Note that assumptions of additional trolleys do NOT include the existing LNHP trolley fleet, as it is assumed that they will be used for interpretive tours or as spares. The last row of Table 8 presents the number of additional trolleys to the current LNHP fleet required to meet 10, 15, and 20-minute headways at the completion of each construction

[9] In Phase A, a relatively large proportion of riders are LNHP visitors, who are less price-sensitive.
[10] Additional routes, such as a Riverfront Line and a route to the UMASS-Lowell South Campus, may be added later.
[11] Texas Transportation Institute: Journey Time Prediction Algorithms for Transit, 2002.

phase.[12] LNHP and Seashore Trolley Museum staff may operate non-fare service. Such service would require additional trolleys, and would constitute narrated tours as opposed to transportation services. Non-fare service is not included in this analysis, but could operate concurrently.

Trolley Capacity – Required Price and Headway Combinations

One of the outcomes indicative of the trolley system's overall success is capacity utilization. With low utilization, many trolleys would operate with a low number of riders, while high utilization is characterized by crowded trolley cars. Table 9 presents data for each construction phase and for all the fare and headway options considered. This analysis assumes 45-seat trolley cars. The numbers in Table 9 are based on average forecast ridership levels for each fare and headway combination, assuming high elasticities of demand (See Appendix C for more detail).

Table 9. System Capacity

Fare Charged	$0.00			$0.50			$1.00			$1.50			$2.00		
Headway (minutes)	10	15	20	10	15	20	10	15	20	10	15	20	10	15	20
Phase A															
Summer	67%	93%	117%	33%	46%	58%	28%	39%	48%	25%	35%	44%	23%	32%	41%
Extended Summer	62%	86%	108%	29%	40%	51%	24%	33%	42%	21%	29%	37%	20%	27%	35%
Year	49%	68%	86%	21%	29%	37%	17%	24%	30%	15%	21%	26%	14%	19%	24%
Phase B															
Summer	92%	128%	161%	41%	57%	72%	34%	46%	59%	30%	41%	52%	28%	38%	48%
Extended Summer	89%	123%	155%	37%	51%	64%	30%	41%	52%	26%	36%	45%	24%	33%	42%
Year	76%	105%	132%	29%	40%	50%	22%	31%	39%	20%	27%	34%	18%	25%	31%
Phase C															
Summer	124%	171%	215%	57%	79%	99%	47%	65%	81%	42%	58%	72%	39%	53%	67%
Extended Summer	118%	163%	205%	51%	70%	89%	41%	57%	71%	36%	50%	63%	33%	46%	58%
Year	101%	139%	176%	40%	55%	70%	32%	44%	55%	28%	38%	48%	25%	35%	44%

Table 9 is useful for determining the fare and headway combinations required to meet seasonal and annual demand at each phase. For a scenario with forecast

[12] Headways may need to be shortened to meet demand before and after special events such as hockey games and concerts. The additional cars required for such periods would not operate throughout the day.

capacity utilization over 100%, annual demand will not be met unless the fare is increased, the headway reduced, or both.[13]

[13] Because Table 9 is based on average ridership, the ability to meet peak demand will require either additional service (shorter headways) or higher fares than those necessary for overall capacity utilization below 100%.

7 Costs

The development and operation of the expanded trolley system proposed in this report will require funding for capital costs, and operation and maintenance costs. Given the preliminary nature of this report, both capital and operation and maintenance costs are derived from industry average unit costs, based on the conceptual analysis of the proposed system. More specific costs will be developed in the preliminary engineering stage of development of this project, when the LNHP and the other partners decide to move this project forward.

Capital Costs – Track and Wires

The current LNHP system operates on track owned by the LNHP on alignment from the Lower Locks to Suffolk Mill, and on leased track from Guilford Transportation next to Dutton St.[14] The existing track, which provided freight service to mills around Lowell, was designed to freight train standards rather than trolley standards.

A first step in developing the trolley system is determining what changes in the existing tracks need to be made to adapt the existing right-of-way for transit trolley use. This would simplify maintenance of track, switches, and cars. It would also provide the flexibility to operate a range of historical trolleys, as proposed by the Seashore Trolley Museum, for special events and museum interpretive tours. In any event, track and existing cars need to be upgraded for higher maximum speed. The three replica trolleys currently used in Lowell, and designed to run on the existing track, would need to be adapted to run on the streetcar standard tracks.

Development of the trolley project should be coordinated with other planned city projects. This would reduce the cost of constructing the trolley system and minimize the disruption to neighborhoods and businesses. For example, transit officials in Kenosha, WI coordinated trolley system construction with a roadway-repaving project, and as a result were able to leverage funding.

There is a strong likelihood that Lowell could achieve this level of coordination of capital improvement projects. The Acre and the JAM Redevelopment Plans and the Downtown Master Plan all identify infrastructure improvements. The City is planning a project to separate storm drainage from the sanitary sewers on many of the streets that have been identified for trolley routes. The sewer separation work could be done in conjunction with development of the trolley system, and

[14] The National Park Service is negotiating purchase of track it currently leases from Guilford.

other roadway improvements, to maximize the total impact of infrastructure investments.

As was previously described, the proposed trolley routes would be developed in three phases. The total cost for all three phases is estimated to be between $23.4 million and $52.7 million. These costs include track, wires, trolleys, switches and control equipment, and a basic structure for the proposed Operation and Maintenance facility/National Streetcar Museum at Lowell.

Phase A Construction

Phase A calls for extending the south end of the existing line to the Gallagher Center, across the Swamp Locks to the Operation and Maintenance facility/National Streetcar Museum at Lowell, and the northern end to the Ballpark. The completion of these extensions would require:

- Construction of track and overhead wire including double-tracking the right-of-way along the Merrimack Canal, between the Swamp Locks Bridge and the Locomotive and Railcar Exhibit,
- Reconstruction of the Thorndike/Dutton Street crossing with additional traffic signal protection,
- New railroad bridge over Pawtucket Canal,
- Construction of the Operations and Maintenance Facility/National Streetcar Museum at Lowell,
- Rebuild the bridge at the Swamp Locks, providing access to the Operations and Maintenance Facility/National Streetcar Museum at Lowell, and
- The extension to the ballpark past the Arena and the Lawrence Mills would require the construction of one-half mile of track with overhead wire.

The preliminary estimated cost for Phase A is between $23.4 million and $52.7 million depending on the option selected to connect to the Gallagher Center (Table 11). This figure includes the cost of four new replica trolley cars and the costs for the basic structure for the Operation and Maintenance facility/National Streetcar Museum at Lowell. The figure of $8.1 million for the Operations and Maintenance Facility/National Streetcar Museum at Lowell was arrived as follows: 27,000 square feet for the O&M facility at $150/s.f., and 27,000 square feet for the museum at $150/s.f. This estimate assumes a basic structure and systems for both buildings, but does not include architecturally significant features that can increase the cost. Additional architectural/design work is outside the scope of this project.

Due to space considerations for double tracking along Dutton Street, it appears that it may be necessary to move the Locomotive and Railcar Exhibit from its

current location. At the time of construction, it may be prudent to move this exhibit to the National Streetcar Museum at Lowell area for permanent display.

Phase B Construction

Phase B will complete the loop from the track at the Ballpark constructed under Phase A to the Swamp Locks. This line will run from the Ballpark, along Pawtucket Street, across the Northern Canal, down Fletcher Street to the Thorndike/Dutton Street intersection constructed under Phase A. Major capital improvements would include track and overhead wire and a new bridge over the Northern Canal.

The preliminary estimated cost for Phase B is $3.8 million (Table 11). This estimate includes costs for simple utility relocation. However, a detailed survey of existing conditions and preliminary engineering and design will be required for a more accurate estimate of these infrastructure improvements.

It is likely that during construction, either water and/or gas lines, depending on what side of the street the trolley is located on, will need to be relocated. If the trolley were located over buried utility lines, the system would need to be shut down whenever they needed to be repaired or replaced.[15]

Phase C Construction

Phase C includes the construction of a loop from the JAM through downtown to the Boott Mills. It would start at the Operations and Maintenance Facility/National Streetcar Museum at Lowell, head south on Middlesex Street, turn left onto Central St., then onto Prescott St., cross Merrimack St onto Bridge St., and connect with the existing track at the Boott Mills across from the Massachusetts Mills. As in phase B, almost all of phase C improvements would be constructed on existing roadways, and detailed surveys and preliminary engineering would be needed to identify and resolve major infrastructure conflicts – all of which could lead to higher capital costs.

The preliminary estimated cost for Phase C is $1.25 million (Table 11). This estimate includes costs for simple utility relocation.

Downtown Traffic Mitigation

The proposed Historic Trolley system will operate at grade through downtown Lowell on Central, Prescott, and Bridge Streets, as well as crossing busy

[15] Special track construction would allow access to underground utilities and would be substantially more expensive.

Merrimack St. To maintain smooth operations of the trolley, ensure that traffic can move efficiently and effectively, and protect and inform pedestrians, downtown traffic mitigation measures will need to be implemented. They will primarily consist of technology, signage, and pedestrian improvements. The City of Lowell Department of Planning and Development has provided the following estimates (Table 10) for downtown traffic mitigation measures.

Table 10. Downtown Traffic Mitigation Measures

Downtown Mitigation Measures	Estimated Cost
Traffic Controllers	$ 40,000
Radio Antennas	$ 70,000
Video Cameras	$180,000
Relocate Controllers	$ 3,000
Other Professional Fees	$ 20,000
Signage	$ 7,000
Pedestrian Improvements – Countdown Signal Heads	$ 25,000
Pedestrian Improvements - Crosswalks	$ 5,000
TOTAL COSTS:	**$350,000**

Capital Costs – Trolley Cars

The Gomaco Trolley Company of Ida Grove, Iowa built the three trolley cars currently operated in Lowell. This company appears to be the major source of historic trolley cars in the United States. New cars suitable for use in Lowell would cost between $550,000 and $750,000 each[16]. The major cost factors above the base cost are accessibility and air conditioning. Little Rock, Arkansas is purchasing three double-truck Birney replica cars that have lifts at both ends and air conditioning at a cost of $750,000 each.

Other companies have built replica trolleys. Brookville Equipment in Pennsylvania is rebuilding PCC cars for Philadelphia at a cost of $1.2 million per car. New Orleans is building historic trolley cars in-house at a cost of $1.2 million each, and the Port of Los Angeles is also building cars in-house at a cost of $860,000 each.

Based on this information, it is fair to assume that the cost for trolley cars will be in the $750,000 range, and this is the cost that is being used for this analysis. The Volpe Center's analysis estimates that four vehicles will be needed at full build-out, for a total estimated cost for rolling stock of $3 million.

[16] Based on discussions with John Kallin, Sales Manager at Gomaco Trolley Company, Ida Grove IA

Table 11. Estimated Capital Costs

	Phase A		Phase B	Phase C	Full Build
	Extension	**Additional Cost for New Track**			**Total Project Cost**
Track extension to Lawrence Mills	500,000				500,000
Overhead wire to Lawrence Mills	50,000				50,000
Switch at existing track	30,300				30,300
Museum and Operation and Maintenance Facility	8,100,000				8,100,000
Bridge over Swamp Locks	1,200,000				1,200,000
Remove and replace existing track		1,100,000			1,100,000
Modify overhead wire		55,000			55,000
New frogs*		180,000			180,000
Modify existing trolleys to accommodate streetcar standard track		90,000			90,000
New Track for Fletcher Street Loop			1,200,000		1,200,000
Overhead wire Fletcher Street Loop			120,000		120,000
Bridge over northern canal			650,000		650,000
Reconstruct Roadways and Sidewalks			950,400		950,400
Track along Market, Central & Middlesex Sts				430,000	430,000
Overhead wire along Market, Central & Middlesex Sts				86,000	86,000
Switches				54,300	54,300
Reconstruct Roadways and Sidewalks				280,700	280,700
Subtotal	9,880,300	1,425,000	2,920,400	851,000	15,076,700
10% overhead and profit	988,030	142,500	292,000	85,100	1,507,670
Subtotal	**10,868,330**	**1,567,500**	**3,212,400**	**936,100**	**16,584,370**
Construction Management	381,900	62,700	128,500	37,400	610,500
Engineering Design	763,900	125,400	257,000	74,900	1,221,200
Environmental Review	200,000	0	200,000	200,000	600,000
New Trolleys	3,000,000				3,000,000
O&M Equipment	1,000,000				1,000,000
Downtown Traffic Mitigation (Table 10)					350,000
TOTAL (without Gallagher Connection and Swamp Locks Construction)	**16,214,130**	**1,755,600**	**3,797,900**	**1,248,400**	**23,366,070**
Gallagher & Swamp Lock Connection Options		Cost per Option			**Total Cost**
Fletcher-Dutton Street at Grade		6,451,500			29,817,570
Fletcher-Dutton Street Overpass		14,325,700			37,691,770
Thorndike Street Connection		29,293,500			52,659,570

* Northwest Engineering, Inc., *Lowell National Historic Park Electrified Trolley System Extension for Public Transit Use*, Northern Middlesex Council of Governments, 1996

Operating and Maintenance Costs

It is difficult to determine operating and maintenance costs for "historic" trolley systems. These costs vary from system to system for a number of reasons:

- They are usually a small component of a larger transportation network;
- They are frequently operated and funded through cooperative arrangements between local agencies and private entities that provide materials, labor and expertise at little or no charge.

For the purposes of this conceptual design, operating and maintenance costs were assumed to be $12.05/mile.[17] For comparison purposes, the cost per mile of the Historic Trolley line in Memphis is $7.61 and the cost per mile of the Kenosha line is $10.30. Given the number of unknown factors, including who will operate and maintain the completed system, the national average was used for this analysis. Lowell operating and maintenance cost estimates are summarized below in Table 12.

The entity that will operate and maintain the completed Lowell system has not yet been identified. This will allow for discussion of a number of options in terms of how the system will be managed. Most light rail systems are operated and maintained by transit agencies using in-house staff. Some historic systems are operated and maintained by groups of volunteers, but none of these systems provide regular transit service.

An option is contracting operation and maintenance services. Kenosha, WI has contracted with an outside firm to manage and maintain its trolley system, and is expending $110.00/hour. This contract is renegotiated periodically. Since the Kenosha system does not run during the winter, year round operations would likely result in higher per hour maintenance costs, due to such items as heater maintenance and snow removal.

[17] Source: "2000 Transportation Costs", Florida Department of Transportation, adjusted to 2002 dollars.

Table 12. Summary of Annual Operating and Maintenance Costs for Varying Headways and Periods of Operation

		Headway (minutes)		
		10	**15**	**20**
Phase A				
Period of Operation	**Summer (May-Sept.)**	$494,700	$329,800	$247,300
	Extended Summer (April-October)	$742,000	$494,700	$371,000
	Year Round	$1,484,000	$989,400	$742,000
Phase B				
Period of Operation	**Summer (May-Sept.)**	$494,700	$329,800	$247,300
	Extended Summer (April-October)	$742,000	$494,700	$371,000
	Year Round	$1,484,000	$989,400	$742,000
Phase C				
Period of Operation	**Summer (May-Sept.)**	$643,100	$428,700	$321,500
	Extended Summer (April-October)	$964,600	$643,100	$482,300
	Year Round	$1,929,300	$1,286,200	$964,600

NOTE: O&M costs remain the same for phases A and B because the Vehicle Miles Traveled (VMT) is the same in both phases. Phase B includes more track than phase A, but some of this extra track forms a loop and the VMT remains unchanged.

Operation & Maintenance Costs, Revenues, and Cost Recovery

All transit systems in the United States cover operation and maintenance costs with a combination of fare-box and other revenue. The following cost recovery analysis identifies how much of the estimated operation and maintenance costs will be recovered by fare box revenues. Costs in excess of those recovered from the fare box will need to be made-up through some combination of revenue sources, including advertising, sponsorships, and public subsidy.

Table 13 presents Phase C operation and maintenance costs, revenue, and revenue cost-recovery by fare for summer, extended summer, and year-round operation with 15-minute headways. Costs are based on total vehicle miles traveled, using the national average cost of $12.05 per mile (2002 dollars) for light rail systems. Revenue forecasts are based on average forecast ridership levels for each fare level (Additional O&M cost and fare recovery information is contained in Appendix C).

Table 13. O&M Costs, Revenues, and Revenue Recover by Fare Phase C, 15-Minute Headway, High Elasticities

		Revenue at $.50 Fare	
	O&M Costs	**Revenue**	**% Recovered**
Summer	$428,700	$97,150	23%
Extended Summer	$643,100	$129,850	20%
Year-Round	$1,286,200	$204,650	16%
		Revenue at $1.00 Fare	
	O&M Costs	**Revenue**	**% Recovered**
Summer	$428,700	$158,985	37%
Extended Summer	$643,100	$209,346	33%
Year-Round	$1,286,200	$323,681	25%
		Revenue at $1.50 Fare	
	O&M Costs	**Revenue**	**% Recovered**
Summer	$428,700	$212,597	50%
Extended Summer	$643,100	$277,665	43%
Year-Round	$1,286,200	$424,757	33%
		Revenue at $2.00 Fare	
	O&M Costs	**Revenue**	**% Recovered**
Summer	$428,700	$262,866	61%
Extended Summer	$643,100	$341,508	53%
Year-Round	$1,286,200	$518,769	40%

As shown in Table 13, summer service has a 37 percent revenue recovery with a $1.00 fare. Year-round service with a $1.00 fare is forecast to generate a 25 percent fare recovery; with higher fares yields a higher return but has lower ridership. Phase B cost recovery, not shown in Table 13, is similar to Phase C, while in Phase A recovery percentages are about one fourth lower. Operation and maintenance costs in phases A and B are about three-fourths the Phase C costs.[18]

Funding

The existing trolley system was built using NPS funds, and operating and maintenance funds have come from visitor admission fees and the LNHP's operating budget. This has been appropriate given that the primary function of the system has been to serve LNHP visitors. The expanded trolley system

[18] Due to the layout of the track and resulting route configuration, operation and maintenance costs in phases A and B are forecast to be the same.

however, would serve the general transportation needs of Lowell residents and visitors, and will thus require a broader funding base.

Funding Commitments to Date

National Park Service Alternative Modes Transportation Program has provided the majority of preliminary planning funds for development of the trolley expansion project. The LNHP received $198,000 through the NPS Alternative Modes program in FY02 for this feasibility study, and received $17,800 in supplemental funding by NPS for project planning and design assistance by the NPS Denver Service Center, specifically for design of historic-themed bus and trolley shelters. Congress has appropriated $856,620 through the Federal Land and Water Conservation Fund FY02 budget for acquisition of the trolley system right-of-way along Dutton Street. The LNHP is working with the right-of-way owner to complete this acquisition.

The NPS Washington Office recently informed the LNHP that the Phase II funding request for $572,208 for NEPA compliance, Conceptual Design, and Preliminary Engineering of the Gallagher Terminal alignment is designated as a high priority project. The Park expects to begin this phase of the project in FY03. The Park's NPS Washington office also has expressed support for a $35,000 request for funds to develop an interactive computer program to simulate a life-like model of the proposed trolley system. This simulation model will be an important tool in illustrating the project to stakeholders at the public during the environmental assessment process.

In November, 2002, the City of Lowell committed $20,000 for consultant services to guide the City through the political and administrative process of the Federal Transit Administration's New Starts program.

The above funding represents a total of $1,699,628 in preliminary funding for this initiative.

Capital Funding Plan

FTA New Starts

The primary federal source of capital funds for transit systems is the Federal Transit Administration (FTA) New Starts Program. The New Starts Program funds the development of new transit systems and significant expansion of existing systems. Under TEA-21, FTA authorized 191 New Start projects, and 108 of these projects are authorized for final design and construction. Under the New Starts Program, if the Federal match is $25 million or less, the process for approvals is less onerous versus a project with greater than $25 million Federal

participation. Projects are rated by FTA as "highly recommended," "recommended", or "not recommended." This ranking system is designed to help Congress make informed decisions when providing funds for specific projects. The New Starts Program currently requires a minimum 20% local match; projects with a larger local match generally receive a higher ranking. The local match requirement under the proposed new Federal Transportation Bill is expected to increase, possibly to as much as a 50% local match.

New Federal Transit Administration regulations allow NPS Alternative Modes Transportation funds to be used as a local match under the New Starts Program. Current NPS Alternative Modes funds, such as those received to support this feasibility study, can be applied upon receipt of a 'Letter of No Prejudice' from FTA. This letter protects the eligibility of dollars spent prior to formal approval to the New Starts program. The LNHP is working with FTA to develop this letter for this study, and future LNHP funded trolley work.

Sources of Local Match

Congress is considering authorizing $60 Million in Federal Highway Administration Funds for NPS Alternative Modes Transportation projects in the new Federal Transportation Bill. This represents a significant increase over the $11.5 provided to the NPS in the TEA-21. If this provision is enacted, there is potential for the LNHP to receive significant additional planning and design funds that can, once the Letter of No Prejudice is received from FTA, be applied to the local match.

The national competition for the New Starts program and the FTA ranking system encourages proponents to attract a range of funding sources, thereby reducing reliance on New Starts funds for project implementation. Other capital fund sources include FHWA Congestion Mitigation and Air Quality (CMAQ) and the Surface Transportation Program, as well as bond funding using either state or local bonding authority. Local restricted-use taxes, typically sales taxes, are used in many states to fund transit projects, but this is not possible under Massachusetts law. A number of transit agencies have developed joint development programs where transit projects are developed in partnership with other development efforts. There may be opportunities to create a transit development program in Lowell by tying the trolley expansion project into the University of Massachusetts-Lowell redevelopment program around the Lawrence Mills, and by integrating it into the City's on-going Acre, JAM, and Downtown redevelopment efforts.

Transit Oriented Development (TOD)

Transit Oriented Development (TOD) connects development and redevelopment efforts with transit services throughout the planning and development process. The trolley expansion project will connect locations that either been redeveloped recently, or are targeted for redevelopment. The proposed extension of the trolley system to the Arena and Ballpark, and will connect to the Lawrence Mills site that is currently being planned for transit-oriented redevelopment.

Alternative funding resources for both the trolley system and other redevelopment efforts will be available if the trolley expansion project is considered within the broader context of a TOD effort. Under the structure of a limited partnership, a redevelopment project that includes development at specified nodal redevelopment sites, and construction of the connecting trolley infrastructure, could capture historic tax credits and Renewal Community benefits (i.e. CRD) for the value of the entire effort. The nodal sites would also be eligible for financing through the New Market Tax Credit programs, as well as traditional economic development incentives (i.e. EDIP, TIF).

Planning for this trolley project has already been incorporated into the JAM redevelopment planning effort. The site for the proposed Operations and Maintenance facility/National Streetcar Museum at Lowell is anticipated to be acquired by the City in the near future. The JAM redevelopment plan has identified other sites proximate to the proposed Museum site for redevelopment, including private mixed-use development and a parking garage. The transit line would both serve future businesses and residents in this area, and serve to encourage development that will attract investment to create business and living spaces.

In addition to the parcels identified in the JAM Redevelopment Plan, the City has an opportunity to purchase a 5-acre parcel from Freudenberg Nonwovens that abuts the JAM redevelopment area and the LNHP Visitors Center. This land would dramatically enhance access to the LNHP Visitors Center.

FHWA CMAQ Funding

The Federal Highway Administration Congestion Mitigation and Air Quality Improvement Program (CMAQ) program funds projects in non-attainment areas to help reduce transportation-related emissions. Lowell has been designated a non-attainment area for Ozone under the Clean Air Act Amendments as part of the Boston-Worcester-Lawrence Metropolitan Area. Improved public transit is one of the Transit Management/Congestion Relief Strategies (TCM) in the Clean Air Act (CAA). Eligible projects under the CMAQ program include:

- *Transit facilities* – Eligible capital projects include such facilities as new stations, terminals, transit centers, transit malls, and intermodal transfer facilities. Major new fixed-guideway and bus/High Occupancy Vehicle (HOV) facilities and extensions to existing facilities are also eligible.
- *Transit vehicles and equipment* – New buses, vans, locomotives and rail cars to expand the fleet and augment service are eligible. Major system-wide upgrades, such as advanced signal and communications systems, which improve speed and/or reliability of transit services, are also eligible.
- *Transit operations* – Operating assistance under the CMAQ program can be used for the start up of new major infrastructure projects, such as new rail lines and extensions to the existing system.

TEA-21 Enhancement Funds

TEA-21 Surface Transportation Enhancement funding program could also provide a potential source of project funding for discrete elements of the trolley expansion project, such as development of the Operations and Maintenance facility. This program provides funding for preservation, restoration, and enhancement of components of the Massachusetts multi-modal transportation system that are not traditionally funded by the Federal Highway Administration. Eligible projects include: provision of facilities for pedestrians and bicycles, historic preservation, rehabilitation and operation of historic transportation buildings, structures or facilities, landscaping and other beautification, and establishment of transportation museums.

Operation and Maintenance Funding

Fare box revenue will cover some operation and maintenance costs. Table 13 identifies the gap between fare box revenue and operation and maintenance costs under several scenarios. A number of federal, state, and local funding sources could be made available to cover this funding gap.

LNHP operating funds could be used to cover some of operation and maintenance costs, specifically those costs related to the continued operation of LNHP visitor trips on the expanded system. The LNHP could contract with the transit system management agency to provide its visitor transportation services. Other funding sources will need to be investigated beyond LNHP sources.

The FTA provides limited funds for operation and maintenance. However, this is an unlikely source of funding given FTA's current fund distribution guidelines. Most transit funds in Massachusetts are appropriated by the State and provided to the Regional Transit Authority (RTA). Prior to July 2000, these state funds were provided as a reimbursement for expenses incurred in the previous year, with funding being provided up to 18-months after expenditures had occurred.

In July 2000, the MBTA became the first transit agency in Massachusetts to be forward funded. Under this legislation, the MBTA receives as earmarked funding, one-fifth of sales tax revenue for operation, maintenance, and capital improvements.

Negotiations are ongoing to require Massachusetts fourteen (14) RTA's to forward fund their operations as well. However, given the already limited State funds for Massachusetts RTA's, it is likely that new funds would need to be dedicated to this project rather than taking funds from the LRTA.

As mentioned earlier, CMAQ funds could provide maintenance and operational support for the system for up to the first three years. To meet long-term operational needs, the LNHP and City in cooperation with the Greater Lowell Community Foundation, are investigating the potential for establishing an endowment program similar to that developed by the Hillsborough Area Regional Transit (HART) System in Tampa, Florida. The Tampa endowment program is derived by private sector contributions for naming rights of its newly opened heritage trolley system, and has generated over $4 million in funding toward its $10-million goal. There are also charter tours, and naming rights for benches that contribute funds to the system operations. The fund will provide for the on-going operation of the system without subsidy by HART or the City of Tampa. A non-profit board "Tampa Historic Streetcar Inc." has been created to manage the fund.

Design/Build/Operate/Maintain
Privately Financed Approach

Design-Build (or Turnkey) is an innovative procurement technique in which a public agency contracts with a single private entity to deliver a complete and operational product, such as a fixed guideway system or extension of an existing system. This is in contrast to the traditional method where the agency procures separate contracts for the design of a project and for its construction. With the transfer of a large share of the management responsibility to a private contractor, a turnkey project may reduce the costs and duration of construction, streamline oversight procedures, allocate risk to those participants most able to control it, and improve the organizational environment for communication and system integration. Depending on the make-up of the entity, it may be feasible for the design-builder to initially provide financing to commence the project in return for a discounted future return on investment.

The use of Design-Build for transit in the United States is a recent phenomenon, and has not been used in Massachusetts. The recently completed $1.8 Billion New Jersey Hudson-Bergen Light Rail Transit system is the first mass transit design/build/operate/maintain project in the United States. A consortium of

contractors designed and constructed the system, manufactured the vehicles, and is now operating and maintaining the system and the park-and-ride facilities for a set fee for the first 15 years.

Design-build is currently being used to develop the Route 3 North Project outside of Lowell. The combination of innovative contracting and financing approaches implemented for the Route 3 North Project is expected to generate significant benefits, including measurable economic advantages, cutting the project delivery time line in half, and saving dollars. Specifically, the design-build methodology is expected to minimize project costs by introducing construction process efficiencies, and the guaranteed price will offset inflationary increases associated with phased development. (The Route 3 North Project discussed in more detail in Appendix D).

Super Turnkey is a further variation that relies on the private sector to provide initial funding to design, construct and operate a transit system. Under Super Turnkey, a private entity provides partial or full project funding in exchange for real estate development rights along the project right-of-way, at station areas, and potentially at off-corridor locations.

Turnkey offers the opportunity to rely on the private sector to supplement the operational skill base or staff level of an existing public agency. Roles and responsibilities for transit operations and maintenance traditionally carried out by the public agency are often assigned to the turnkey contractor under new start turnkey procurements. This approach may be especially useful for agencies, which are implementing a new form of transit service, and lack the existing organization or skill base to initiate it. An inherent goal may be to rely on outsourced expertise to handle the first several years of operations and maintenance, develop the capability locally through technology transfer, and consider transferring to public operations in the future.

8 Institutional Issues

The purpose of this report was to undertake the technical feasibility of expanding the Lowell trolley service. It provides a starting point in the expansion of the Lowell Historic Trolley system. Moving from the conceptual design outlined in this report to environmental impacts, preliminary engineering, final engineering, construction and operation will require cooperation by a large number of stakeholders. It will also require identifying funding, and addressing regulatory requirements such as the Americans with Disability Act (ADA). Most importantly, it will require cooperation and approval from the public at large.

This project has come this far with the active participation of a number of stakeholders including the National Park Service, the City of Lowell, the LRTA, UMASS-Lowell, NMCOG, and the Seashore Trolley Museum. Moving beyond this conceptual design will require involvement by a number of other partners including Federal, State, and Regional agencies, Lowell residents, businesses, and property owners and community and business organizations.

Federal funding for planning and implementing transportation projects depends upon the projects being derived from a continuing, comprehensive, and cooperative (3C) planning process. The U.S. Department of Transportation, FTA, and FHWA must certify that a 3C planning process has and is being carried out on projects receiving federal funding. Part of the certification is the preparation of three documents: a Unified Planning Work Program, a Long Range Transportation Plan (LRTP), and a Transportation Improvement Plan (TIP). NMCOG, as the Metropolitan Planning Organization (MPO) for this metropolitan area, will need to include this project on the metropolitan LRTP and the TIP. Projects associated with the development of the trolley routes such as reconstruction or replacement of any state-owned bridges would also need to be included in the TIP and the LRTP.

Identifying funds to build and operate the system will likely require cooperation and assistance from Federal agencies. The National Park Service as owner and operator of the existing system has funded project development to this point, and will likely continue to fund elements of this project. The primary source of funding for mass transportation systems is the Federal Transit Administration (FTA). The FTA New Starts program, described in the Funding Section of this report, is the primary source of federal capital funds for developing and expanding transit systems. In the short-term partners in the Lowell trolley transit expansion project must work with FTA to secure a "Letter of No Prejudice." This letter will allow for the use of NPS funds as part of the local match for New Starts funds. In the long-term, local partners need to secure

significant resources to match New Starts funds, at minimum on a one-for-one basis.

If there were an interest in seeking most sources of federal transportation funds, a multi-modal transportation planning process would need to be undertaken. To qualify for New Starts funding, an alternatives analysis study must be conducted that evaluates various modal and alignment options for addressing the mobility needs in the corridor (e.g., No Build, Bus, Trolley, etc.). This analysis would include benefits, costs and impacts of each transportation option. Funding sources for the implementation, construction, operation and maintenance of the project should be identified and evaluated. The alternatives analysis study should be developed with a wide range of stakeholders and the general public. This study is complete when the locally preferred alternative is selected and is adopted by the metropolitan planning organization in the fiscally constrained long-range regional transportation plan. The project sponsor would then submit to FTA the project justification and local financial commitment criteria, and request FTA's approval to enter into preliminary engineering. Upon approval to enter preliminary engineering, the project proponent would then proceed with the environmental process. Approval to enter final design is requested once the environmental process is completed and the financial plan is implemented.

Other sources of federal funding may include the Federal Highway Administration (FHWA) and the US Department of Housing and Urban Development. FHWA funds include CMAQ funding, which is available to areas designated as non-attainment for air quality under the Clean Air Act Amendments. It is a potential source of funds that requires identifying air quality improvements that will result from this project.

The City's designation as a U.S. Department of Housing and Urban Development (HUD) Renewal Community may also provide a source of funds, particularly if joint development or transit oriented development opportunities are available. Partners in this project should begin working with HUD to identify opportunities to coordinate development of this trolley expansion project with HUD supported development activities in Lowell.

State and regional agencies, including the Massachusetts Executive Office of Transportation and Construction (EOTC) and NMCOG, will also have significant involvement in the development of this system. UMASS-Lowell has also indicated that it could potentially provide funding for project elements that directly benefit the school.

Meeting regulatory requirements, such as the EIS and inclusion on the LRTP and the TIP, will require public forums for presenting the planned project and opportunities for public comment. The success of this system will require that

people who live and work in Lowell use the system on a regular basis. Opportunities to inform and receive feedback from the public should be viewed as an opportunity to make improvements to the conceptual design, and create good will toward the proposed system. Existing community and business groups in the area, such as Coalition for a Better Acre, The Lowell Center City Committee Inc. and the Downtown Lowell Business Association should be identified and their involvement in this project should be solicited early in the next phase of this project.

APPENDIX A

LNHP Trolley Rail and Wheel Evaluations

Memorandum

U.S. Department
of Transportation

**Research and
Special Programs
Administration**

**Volpe National
Transportation
Systems Center**

Subject: INFORMATION: Lowell Trolley Car Frog Findings

Date: March 22, 2002

From: Terrence M. Sheehan, DTS-49

Reply to Attn. of: DTS-49

To: Chris Briggs, NPS LNHP
Jim Schantz, Seashore Trolley Museum

CC: Michael Jacobs, DTS-49

BACKGROUND:

Lowell National Historic Park is considering operating a variety of antique trolley cars on trackage within this park. The antique trolleys would be used to transport visitors throughout the park on approximately 3-1/2 miles of track which involves 7 switches of both transit (light rail), and standard freight rail(formerly Gilford RR) designs. In a review of the infrastructure, Volpe Center staff and Seashore Trolley members determined that the proposed historic trolleys could not safely operate on all track conditions encountered, especially at the frogs (Frogs are a device on intersecting railroad tracks that allows wheels to cross the junction). It then became necessary to evaluate all the options and costs to assure a safe operation, free of derailment potential especially at the switch frogs and switch points. This is especially important since the trolleys would have passengers aboard. Historically many different designs of wheels, wheel widths, back to back wheel gage mounting, and wheel tread profiles were applied to site specific trolley track systems. That is, there were no absolute standards applied to all track or wheel dimensions.

FINDINGS:

The bulk of the trackage contains 115# rail connected into special trackwork designs of switches, which under certain circumstances of wheel/rail interface can result in wheels dropping into the space at the point of frog. In addition to the design characteristics of switch frogs and points, but the variety of wheel sets on various antique trolleys also pose problems. Currently there are three Park owned trolley vehicles (Gamaco Trolley Company) that operate over this trackage without difficulty. These trolley cars are replica cars and satisfy the American Disabilities Act (ADA). Primary source for the antique trolley cars would be the Seashore Trolley Museum in Kennebunkport, ME. Those cars, in most cases, can be modified to comply with ADA requirements. The cars that have narrow width wheels can drop through the frog point area of the existing trackwork at Lowell. There are special trackwork vendors that can provide switches and frogs specifically for such applications, some of which are noted in the exhibit material. Present studies on flange bearing frogs are in progress at TTCI in Pueblo, Colorado. Wheelset modifications can be designed and machined to accommodate the existing track, but could be evaluated on a case-by-case basis. Most transit or railroad wheel shops have the capability to not only machine wheelsets, but they can also press on wheels and gears to axles.

FACTS:

Fact #1: The present frogs and switch point arrangements at Lowell will not accommodate all variations of antique trolley wheelsets.

Fact #2: The existing Lowell track meets basic AREMA national U.S. standards for freight and passenger track.

Fact #3: Suitable second hand track material from light rail operations at the MBTA does not exist.

OPTIONS:

Option #1: Selectively limit operation to American Association of Railroads (AAR) and AREMA dimensional criteria for wheels, wheelsets and track.

Option #2: Change out all frogs to flange bearing and modify switch points, if necessary, to accommodate the antique trolley car wheel arrangements

Option #3: Change out wheelsets on non-compliant wheelsets (See Reference #1 above) on a trolley car specific consideration.

COSTS:

Option #1. Zero

Option #2. Est. $180,500 total. Material =$20,000 each for new complete switches and 165 labor hours to install @ approximately $35.00/Lhr.

Option #3: Est. $25,000 to $30,000 per trolley with 4 axles. No side frame modifications in this estimate.

EXHIBIT MATERIAL REFERENCES:

A. Rail / Wheel Interface Diagrams
B. Railway Track and Structures Article on frog research on going May 2002.
C. February 8,2002 letter report by Jeffery Sisson to Volpe detailing Lowell trolley information and drawings relevant to the issues.
D. E-mail correspondence file between Ross Gill , Jim Schantz and Jeffery Sisson January 7, 2002 thru February 15, 2002.
E. February 19 2002 letter from Jeffery Sisson to Volpe with further clarification and technical information current and historical.
F. Trains Magazine article February 2002 on Boston's PCC trolleys in service.
G. Dimensional layout of Lowell frogs for MBTA use to find used frogs for possible use at Lowell
H. Web site info on Cleveland Track Material Inc, a manufacturer of specialty frogs and switches.
I. Jim Schantz schematic on the Lowell switches for picture references.
K. MBTA wheel profiles faxed to Volpe January 23,2002
L. Fax of Jan 15, 2002 on Lowell wheel profiles from Will Lavallee (Lowell NHP).
M.Four photos of key track and wheel interfaces using the Jeffery Sisson profile gauge device.
N Fax of January 15, 2002 from Will Lavallee (Lowell NHP) supplementing information in "L" above
O.Historic Trolley Systems Best Practices 2001, Lessons for Lowell by Eric Plosky and Randy Clarke

APPENDIX B

Economic Impacts

APPENDIX B

Economic Impacts

An examination of the economic benefits of extending the trolley system focused on estimating the effects on sales, personal income, and job creation. The availability of the trolley system is expected to improve mobility. It is expected that improved mobility will then stimulate increases in park visitors, special event visitors, and residents living in downtown Lowell.

A range of these benefits is presented below in 2002 dollars for the period 2002 through 2022. Because benefits that occur sooner are valued more than those that occur later, it is necessary to discount future benefits to assess overall project value in the present. A higher estimate of benefits is based on a discount rate of 4.58 percent, which is consistent with the historical average rate for long-term U.S. government bonds.[1] The more conservative estimates provide a sensitivity measure. They are based on an interest rate of 6.58 percent.

Table B-1. Economic Benefits

Economic Measures[2]	2002-2022 Estimates (4.58% discount rate)	2002-2022 Estimates (6.58% discount rate)
Sales	$313,300,000	$277,800,000
Personal Income	$110,960,000	$98,390,000
Value Added	$174,060,000	$154,330,000
Jobs	8,800	8,800

The economic activity measures show the projected impact of the trolley system from several aspects. Business sales are forecasted to increase by more than $313 million over a twenty-year period. Personal income is expected to increase by more than $111 million, and the value added to final goods and services produced within the region is expected to grow by at least $174 million. In addition, the full build out of the system is expected to result in the creation of about 9,000 jobs as businesses expand to take advantage of increased visitor and residential spending.[3]

[1] Rates for 30-yr U.S. Treasury Bonds are currently 4.58%. Source: www.bloomberg.com.
[2] Present Values rounded to the nearest ten thousand dollars; Jobs rounded to the nearest hundred.
[3] Economic activity levels computed using the Money Generation Model (Version 2) developed to "estimate the impacts of NPS visitor spending on the local economy." For a description of the Model, see: Daniel J. Stynes and others, *Estimating National Park Visitor Spending and Economic Impacts: The MGM2 Model*, Michigan State University, May 2000.

Residential property values will also be affected by expanded trolley service, though the magnitude of the impact is difficult to quantify. The degree of improved accessibility, the desirability of locations surrounding stations, and general conditions in the local real estate market are all factors. Despite these difficulties, past studies have been conducted which suggest that, within a ½- to one-mile radius, residential property values increase $75 - $90 for every 100 feet closer the property is to a station.[4]

[4] Brinckerhoff, Parsons. *The Effects of Rail Transit on Property Values: A Summary of Studies*. Research carried out for Project 21439S, Task 7; NEORail II, Cleveland, Ohio. February 27, 2001.

Lowell NHP

Combined Projected Economic Impact of Visitors

Scenario 1: Cost of Capital = 4.58%

(arithmetic average long-term government bonds returns 1926~1987)

Note: To the extent that sources of funds other than long-term federal bonds are used, the weighted average cost of capital will be higher, resulting in lower present-value benefits.

	2002 - 2010	2002 -2015	2002 - 2022
Present Value (of total effects)			
Sales ($000s)	$126,709	$204,455	$313,300
Personal Income ($000s)	$44,876	$72,411	$110,960
Value Added ($000s)	$70,394	$113,586	$174,055
Jobs	3,199	5,524	8,778

Scenario 2: Cost of Capital = 5.58%

	2002 - 2010	2002 -2015	2002 - 2022
Present Value (of total effects)			
Sales ($000s)	$121,929	$193,976	$294,841
Personal Income ($000s)	$43,183	$68,700	$104,423
Value Added ($000s)	$67,738	$107,764	$163,801
Jobs	3,199	5,524	8,778

Scenario 3: Cost of Capital = 6.58%

	2002 - 2010	2002 -2015	2002 - 2022
Present Value (of total effects)			
Sales ($000s)	$117,443	$184,257	$277,795
Personal Income ($000s)	$41,595	$65,258	$98,386
Value Added ($000s)	$65,246	$102,365	$154,331
Jobs	3,199	5,524	8,778

Dollar figures converted from 1998 values to estimated 2002 values based on CPI figures obtained from the Federal Reserve Bank of Minneapolis
2002 Estimated CPI = 179.3
1998 Estimated CPI = 163.0

APPENDIX C

Travel Demand Methodology

APPENDIX C

Travel Demand Methodology

C.1 Background

Trolley use is a function of the supply of the service provided and the demand generated by the people and places that it serves. The supply component consists of the trolley service, the number of stops, its frequency, run time, and the cost of providing the service. The demand is based on the characteristics of the people and the areas the trolley serves. The travel demand analysis conducted for this study pivoted off the traditional four-step travel demand modeling process in order to understand how the supply and demand in Lowell would generate boardings on the trolley.

The stages of construction for the trolley line are represented by four phases:

1. Base: The trolley usage for the year 2000 (called Year 1) for which data is available.

2. Phase A will connect the existing line at Swamp Locks to the Gallagher Intermodal Transportation Center, double-track part of the existing right-of-way, extend the current past the Tsongas Arena to LeLacheur Park, and initiate design for replacing the bridge over the Northern Canal (Pawtucket Street).
3. Phase B will complete the Arena/Ballpark/Acre Loop by extending the transit system from the track at the ballpark constructed under Phase A by building track along Perkins Street, across the Northern Canal, along Pawtucket Street to Fletcher Street, down Fletcher Street to the connection to the Gallagher Center.
4. Phase C will create the Museum/JAM/Downtown Loop by extending the trolley line at the National Streetcar Museum at Lowell site built in Phase A to Middlesex Street, Central Street, Prescott Street, and Bridge Street connecting to the existing trolley line at the Boott Mills. The loop would then return to the Gallagher Center on the Boott Mills track to the double tracked right of way on Dutton Street. Completion of this loop will also allow for service on a third loop, the Central Lowell Loop that would continue west at the intersection of the Dutton Street and Boott Mills tracks to the Arena/Ballpark/Acre Loop.

These construction phases are consistent with what has been described in the body of the report. The variation in demand over the year due to change in park visitation is accounted for by analyzing three timeframes: the summer, the extended summer and the entire year. Four main sources of demand are

considered: park visitation, local residents, special events, and new development. Applying the concept of elasticity to the individual rider-types captured ridership sensitivity to headway and fare. It was assumed there would be no competing mode of public transportation in the trolley service area.

C.2 Model Approach

The four steps of the travel demand modeling process are Trip Generation, Trip Distribution, Mode Split, and Trip Assignment.

The first step of the process, Trip Generation, identifies the number of trips to and from the service area. In this case, the trips are generated from the four sources identified earlier: park visitors, local residents, special event visitors and future development. The Trip Distribution step organizes the trips generated into origin-destination pairs. The Mode Split step divides the identified trips among travel modes. The Trip Assignment step allocates these trips among discrete routes.

Since the objective of this model is to provide a guideline for assessing the feasibility of the trolley system, this process has been simplified to give an aggregate picture. The analysis restricts itself to the trip generation and subsequent mode split between the trolley and other modes. To better visualize the feasibility of providing the service, a capacity utilization and cost recovery analysis is carried out. These estimates may be used as a guideline for planning the service. All forecasts were based upon a base scenario: the current ridership and population in the year 2000.

C.3 Sources of Demand

C.3.1 Park Visitation

LNHP visitation data for the past 20 years were obtained from the National Park Service. This data were aggregated by month to calculate demand during each operational time frame considered. Future growth was forecast based upon data obtained for Year 1, 0.2% predicted natural growth, and induced demand from new developments planned for the horizon years. Induced demand was assumed to be 1% between Years 1-3, 3% between Years 4-6, 6% between Years 7-9, and 12% in Year 10[1]. Trips were distributed within each year in the same proportion by month as they have been in past years. Table C-1 shows the number of trips generated by LNHP in the three operational timeframes specified above, as well as forecasted trolley trips. The prevailing 20% trolley usage among park visitors is assumed to remain constant during the horizon years, for the 15 minute headway and $.50 fare scenario.

[1] Annual visitation climbed to a high of 802,000 in 1986, and remained between 700,000 and 800,000 until 1993 when it declined to just over 600,000. The higher visitation in the 1980's was probably due in part to the novelty effect, as well as a significant advertising budget that has not been available in recent years. The induced demand percentages assume a similar circumstances once the trolley system is implemented.

Table C1. Park Visitation and Trolley Ridership

		Base	Phase A			Phase B			Phase C		
Park Visitors (Yearly)											
Headway (Minutes)		15	10	15	20	10	15	20	10	15	20
Park Visits (Total for Year)		605,000	623,000	623,000	623,000	661,000	661,000	661,000	908,000	908,000	908,000
	Summer (4 Months)	392,700	404,600	404,600	404,600	429,200	429,200	429,200	589,700	589,700	589,700
	Shoulder (2 months)	68,800	70,900	70,900	70,900	75,200	75,200	75,200	103,300	103,300	103,300
	Off-season (6 months)	143,500	147,500	147,500	147,500	156,700	156,700	156,700	215,300	215,300	215,300
	Induced Demand	-	-	-	-	18,000	18,000	18,000	95,700	95,700	95,700
Trolley Trips (Summer)		80,800	90,133	83,200	78,578	95,658	88,300	83,394	131,408	121,300	114,561
Trolley Trips (Shoulder)		-	15,817	14,600	13,789	16,792	15,500	14,639	22,967	21,200	20,022
Trolley Trips (Yearly)		-	138,775	128,100	120,983	147,333	136,000	128,444	202,367	186,800	176,422

C.3.1.2 Local Residents

Local residents' trolley usage was forecast by estimating the population within a quarter mile radius of the trolley line and then applying standard Institute of Transportation Engineers (ITE) daily trip generation rates for households[2]. Resident trips are assumed to spread equally throughout the year. The share of local resident trips taken on the trolley is assumed to be 0.25%. All future population growth in the horizon years was estimated in the "new development" category. Local Residents and Trolley Ridership is shown in Table C-2.

Table C-2. Local Residents and Trolley Ridership

		Base	Phase A			Phase B			Phase C		
Local Residents (Yearly)											
Headway (Minutes)		15	10	15	20	10	15	20	10	15	20
	Households in 1/4 mile	3,300	5,100	5,100	5,100	9,700	9,700	9,700	11,000	11,000	11,000
	Trips Generated	7,392,000	12,852,000	12,852,000	12,852,000	24,444,000	24,444,000	24,444,000	27,720,000	27,720,000	27,720,000
	Trolley Trips	18,500	32,100	32,100	32,100	66,192	61,100	57,706	75,075	69,300	65,450

[2] ITE: Institute of Transportation Engineers Trip Generation Handbook.

C.3.1.3 Special Events

Special event trip generation was based on data provided by the City of Lowell, Department of Planning and Development and various reports. Three special event locations were considered directly:

- Tsongas Arena: Summer 20%; Extended Summer 50%; Year 100%.
- LeLacheur Baseball Park: Summer 80%; Extended Summer and Year 100%.
- UMASS Hockey Arena: Summer and Extended Summer 0%; Year 100%.

Special events were attributed to the months that they were most likely to occur. The annual number of events and attained capacity at these three venues are presented in Table C-3.

Table C-3, Annual Events and Attained Capacity

	Base	Phase A			Phase B			Phase C		
	15	10	15	20	10	15	20	10	15	20
Tsongas Arena										
Attendance	320,000	328,000	328,000	328,000	357,000	357,000	357,000	387,000	387,000	387,000
# of Events	80	80	80	80	85	85	85	90	90	90
Seating Capacity Attained	4,000	4,100	4,100	4,100	4,200	4,200	4,200	4,300	4,300	4,300
Trolley Trips	-	35,533	32,800	30,978	38,675	35,700	33,717	41,925	38,700	36,550
UMass-Lowell Hockey										
Attendance	45,000	45,000	45,000	45,000	54,000	54,000	54,000	63,000	63,000	63,000
# of Events	18	18	18	18	18	18	18	18	18	18
Seating Capacity Attained	2,500	2,500	2,500	2,500	3,000	3,000	3,000	3,500	3,500	3,500
Trolley Trips	-	4,875	4,500	4,250	5,850	5,400	5,100	6,825	6,300	5,950
LeLacheur Baseball Park										
Attendance	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000	180,000
# of Events	36	36	36	36	36	36	36	36	36	36
Seating Capacity Attained	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Trolley Trips	-	19,500	18,000	17,000	19,500	18,000	17,000	19,500	18,000	17,000
Total Special Event Trolley Trips	**-**	**59,908**	**55,300**	**52,228**	**64,025**	**59,100**	**55,817**	**68,250**	**63,000**	**59,500**

Other special event generators like the Summer Music Series and the Merrimack Repertory Theater were indirectly included in the "local trip" category. Trips generated by special park programs, tours, and events at other museums were included in either the park or new development category, depending on event specifics.

C.3.1.4 Future Development

Future Development was identified from the 2001 Downtown Lowell Master Plan, various development plans, and the City of Lowell, Department of Planning and Development. Trips to and from new developments and special event venues, as well as trolley shares of the trips, are based on best-available data and standard ITE rates. The following Trolley shares of total trips are assumed:

- Trolley Museum: 30.0%
- Riverplace Center: 2.4%
- Dressing Mills Place: 2.4%
- John Street Development: 4.0%
- Massachusetts Mills Completion: 2.4%
- Moody Street Civic Center: 2.4%
- Lawrence Mills: 2.4%
- JAM Development Area: 2.4%
- Acre Neighborhood: 2.4%
- Arcand Marketplace: 2.4%
- Merrimack Street Infill: 4.0%
- Market Mills Place: 2.4%

C.4 Service Characteristics (Supply Side)

In order to facilitate the analysis, a base scenario with the following operational service characteristics was used:

- The existing trolley service has a 15-minute headway.
- The trolley charges a fare of $0.50 per rider.

The analysis was performed for alternative scenarios with headways of ten (10) and twenty (20) minutes, and fares of $0.00, $1.00, $1.50, and $2.00. The physical service characteristics of speed, number of trolley cars, number of stops and run time are summarized in the following table[3]. The last row of the Table C-4 shows the number of 45-person capacity trolleys required to meet demand based on the specified service assumptions.

[3] It is pertinent to note that currently the trolley only runs within the park for free and has no fixed headway or schedule.

Table C-4: Service Characteristics

	Base	Phase A			Phase B			Phase C		
Headway (minutes)	15	10	15	20	10	15	20	10	15	20
Track Mileage	1.3	2.5	2.5	2.5	4	4	4	5	5	5
Route Miles*	2.6	5	5	5	5	5	5	6.5	6.5	6.5
Number of Stops	5	8	8	8	14	14	14	19	19	19
Total Run Time **	15.5	29	29	29	32	32	32	42.5	42.5	42.5
Trolley Cars Required	2	3	2	2	4	3	2	5	3	3

* Assuming complete coverage of entire track: For loops, round-trip equals track length; for non-loop segments, round-trip equals twice track length.

** Including both travel time and dwell time at each stop (0.5 minute, including slowdown speed recovery).

C.5 Analysis

The travel demand model was developed as a spreadsheet model, utilizing a mid-point elasticity of demand formula, which determined the demand based on proximity to the trolley service, service characteristics, and fare structure. The analysis used a base case with a 15-minute headway and a fare of $0.50 per rider. A headway elasticity of -0.21[4] was then applied to the initial demand estimate to approximate the impact of changes in headway time on ridership.

C.5.1 Ridership Sensitivity Analysis: Fare and Headway Changes

The trolley ridership forecasts given above assume the base headway and fare scenario. To plan for an optimal service, it is important to analyze ridership sensitivity to changes in the headway and fare. Elasticities were used to estimate this sensitivity.

The analysis assumed constant elasticity demand curves. There are two types of demand curves that have constant elasticities: the mid-point and the arc elasticity curves. The mid-point elasticity curve was chosen for, among other reasons, having the ability to perform analysis of a change to zero fare. The formula used to calculate ridership sensitivity to fare is given below:

$$E_f = \frac{(F_b + F_a) \times (V_a - V_b)}{(V_b + V_a) \times (F_a - F_b)}$$

[4] Based on Estimating Patronage for Community Transit Services, UMTA 1984, pg. 47, Patronage Impacts of Changes in Transit Fares and Services by Mayworm, Lago and McEnroe, 1980, as well as various ITE case studies.

where, E_f = Elasticity of ridership with respect to fare *f.*
V_b = Ridership before the change
V_a = Ridership after the change
F_b = Fare level before change
F_a = Fare level after change

C.5.2 Headway Elasticity

The formula used to calculate ridership sensitivity to service levels (headways) is given below:

$$E_m = \frac{(M_b + M_a) \times (V_a - V_b)}{(V_b + V_a) \times (M_a - M_b)}$$

where, E_m = Elasticity of ridership with respect to service measure *m.*
V_b = Ridership before the change
V_a = Ridership after the change
M_b = Service level before change
M_a = Service level after change

Three headways were considered: 10 minute, 15 minute and 20 minutes.

C.5.3 Fare Elasticity

Different elasticities were used for the four trip categories to reflect differences in rider characteristics. The Park Visitors were considered less sensitive to price changes than other riders. Thus, the absolute value of their elasticities is lower. Local residents were perceived as being more sensitive to changes in fare and so their elasticity was assumed to be considerably higher than that of park visitors. Special event and future development riders were considered to be between park visitors and local residents. The following elasticities ranges were used:

Park Visitors:	-0.10 to -0.20
Local Residents	-0.50 to -0.70
Special Event Visitors	-0.25 to -0.40
Future Development	-0.25 to -0.40

Applying the above elasticities to the base ridership forecasts yielded the results for different fare and headway scenarios. These findings are presented in Table C-5 thought C-7 for the high end elasticites (i.e., -0.20 for Park Visitors) and in Table C-8 through C-10 for the low end elasticities (i.e., -0.10 for Park Visitors). Note that Summer is assumed to be June through September, and Extended Summer is assumed to be May through October. The Full Year is assumed to be January through December.

Table C-5 10 Minute Headway, High Elasticity

Fare	$0.00	$0.50	$1.00	$1.50	$2.00
Phase A					
Summer	**247,100**	**123,233**	**102,690**	**92,464**	**86,301**
Park Visitors	135,200	90,133	78,867	72,800	69,008
Local Residents	58,933	10,400	6,465	4,877	4,019
Special Events	52,967	22,700	17,359	14,787	13,274
Future Development	-	-	-	-	-
Extended	**344,558**	**160,650**	**132,046**	**118,032**	**109,654**
Park Visitors	158,925	105,950	92,706	85,575	81,118
Local Residents	98,600	17,400	10,816	8,160	6,724
Special Events	87,033	37,300	28,524	24,298	21,812
Future Development	-	-	-	-	-
Year	**545,007**	**233,458**	**188,857**	**167,420**	**154,720**
Park Visitors	208,163	138,775	121,428	112,088	106,250
Local Residents	197,058	34,775	21,617	16,307	13,438
Special Events	139,786	59,908	45,812	39,025	35,033
Future Development	-	-	-	-	-
Phase B					
Summer	**341,421**	**152,058**	**123,983**	**110,371**	**102,272**
Park Visitors	143,488	95,658	83,701	77,263	73,238
Local Residents	112,767	19,900	12,370	9,332	7,690
Special Events	54,367	23,300	17,818	15,178	13,625
Future Development	30,800	13,200	10,094	8,599	7,719
Extended	**492,975**	**204,150**	**163,781**	**144,520**	**133,153**
Park Visitors	168,675	112,450	98,394	90,825	86,095
Local Residents	187,567	33,100	20,576	15,522	12,790
Special Events	90,533	38,800	29,671	25,275	22,689
Future Development	46,200	19,800	15,141	12,898	11,579
Year	**837,742**	**317,092**	**249,261**	**217,505**	**198,943**
Park Visitors	221,000	147,333	128,917	119,000	112,802
Local Residents	375,086	66,192	41,146	31,040	25,577
Special Events	149,392	64,025	48,960	41,707	37,440
Future Development	92,264	39,542	30,238	25,758	23,123
Phase C					
Summer	**456,679**	**210,508**	**172,251**	**153,559**	**142,402**
Park Visitors	197,113	131,408	114,982	106,138	100,610
Local Residents	127,500	22,500	13,986	10,551	8,694
Special Events	56,000	24,000	18,353	15,634	14,035
Future Development	76,067	32,600	24,929	21,236	19,064
Extended.	**652,663**	**281,275**	**226,754**	**200,509**	**184,963**
Park Visitors	231,563	154,375	135,078	124,688	118,193
Local Residents	212,500	37,500	23,311	17,585	14,491
Special Events	94,500	40,500	30,971	26,382	23,683
Future Development	114,100	48,900	37,394	31,854	28,596
Year	**1,116,231**	**443,408**	**350,655**	**306,769**	**281,000**
Park Visitors	303,550	202,367	177,071	163,450	154,937
Local Residents	425,425	75,075	46,668	35,206	29,010
Special Events	159,250	68,250	52,191	44,459	39,911
Future Development	228,006	97,717	74,725	63,654	57,142

Table C-6 15 Minute Headway, High Elasticity

Fare	$0.00	$0.50	$1.00	$1.50	$2.00
Phase A					
Summer	**228,200**	**113,800**	**94,826**	**85,382**	**79,690**
Park Visitors	124,800	83,200	72,800	67,200	63,700
Local Residents	54,400	9,600	5,968	4,502	3,710
Special Events	49,000	21,000	16,059	13,680	12,280
Future Development	-	-	-	-	-
Extended	**318,200**	**148,300**	**121,889**	**108,951**	**101,216**
Park Visitors	146,700	97,800	85,575	78,992	74,878
Local Residents	91,233	16,100	10,008	7,550	6,221
Special Events	80,267	34,400	26,306	22,409	20,116
Future Development	-	-	-	-	-
Year	**503,083**	**215,500**	**174,330**	**154,542**	**142,818**
Park Visitors	192,150	128,100	112,088	103,465	98,077
Local Residents	181,900	32,100	19,954	15,053	12,404
Special Events	129,033	55,300	42,288	36,023	32,338
Future Development	-	-	-	-	-
Phase B					
Summer	**314,783**	**140,300**	**114,409**	**101,854**	**94,383**
Park Visitors	132,450	88,300	77,263	71,319	67,605
Local Residents	103,700	18,300	11,376	8,582	7,071
Special Events	50,167	21,500	16,441	14,005	12,573
Future Development	28,467	12,200	9,329	7,947	7,134
Extended	**455,567**	**188,600**	**151,294**	**133,495**	**122,991**
Park Visitors	155,700	103,800	90,825	83,838	79,472
Local Residents	173,400	30,600	19,022	14,350	11,824
Special Events	83,767	35,900	27,453	23,386	20,993
Future Development	42,700	18,300	13,994	11,921	10,701
Year	**773,300**	**292,700**	**230,087**	**200,774**	**183,639**
Park Visitors	204,000	136,000	119,000	109,846	104,125
Local Residents	346,233	61,100	37,981	28,652	23,610
Special Events	137,900	59,100	45,194	38,499	34,560
Future Development	85,167	36,500	27,912	23,777	21,344
Phase C					
Summer	**421,617**	**194,300**	**158,985**	**141,731**	**131,433**
Park Visitors	181,950	121,300	106,138	97,973	92,870
Local Residents	117,867	20,800	12,930	9,754	8,037
Special Events	51,567	22,100	16,900	14,396	12,924
Future Development	70,233	30,100	23,018	19,608	17,602
Extended.	**602,883**	**259,700**	**209,346**	**185,110**	**170,754**
Park Visitors	213,750	142,500	124,688	115,096	109,102
Local Residents	196,633	34,700	21,570	16,272	13,409
Special Events	87,267	37,400	28,600	24,363	21,871
Future Development	105,233	45,100	34,488	29,379	26,373
Year	**1,030,367**	**409,300**	**323,681**	**283,172**	**259,385**
Park Visitors	280,200	186,800	163,450	150,877	143,019
Local Residents	392,700	69,300	43,078	32,498	26,778
Special Events	147,000	63,000	48,176	41,039	36,841
Future Development	210,467	90,200	68,976	58,758	52,747

Table C-7 20 Minute Headway, High Elasticity

Fare	$0.00	$0.50	$1.00	$1.50	$2.00
Phase A					
Summer	**215,633**	**107,478**	**89,553**	**80,632**	**75,256**
Park Visitors	117,867	78,578	68,756	63,467	60,161
Local Residents	51,567	9,100	5,657	4,267	3,516
Special Events	46,200	19,800	15,141	12,898	11,579
Future Development	-	-	-	-	-
Extended	**300,517**	**140,067**	**115,122**	**102,903**	**95,597**
Park Visitors	138,550	92,367	80,821	74,604	70,718
Local Residents	86,133	15,200	9,449	7,128	5,873
Special Events	75,833	32,500	24,853	21,171	19,005
Future Development	-	-	-	-	-
Year	**475,134**	**203,528**	**164,645**	**145,956**	**134,884**
Park Visitors	181,475	120,983	105,860	97,717	92,628
Local Residents	171,794	30,317	18,845	14,217	11,715
Special Events	121,865	52,228	39,939	34,022	30,542
Future Development	-	-	-	-	-
Phase B					
Summer	**297,325**	**132,494**	**108,042**	**96,185**	**89,130**
Park Visitors	125,092	83,394	72,970	67,357	63,849
Local Residents	98,033	17,300	10,754	8,113	6,685
Special Events	47,367	20,300	15,524	13,224	11,871
Future Development	26,833	11,500	8,794	7,491	6,725
Extended	**430,050**	**178,033**	**142,821**	**126,021**	**116,106**
Park Visitors	147,050	98,033	85,779	79,181	75,057
Local Residents	163,767	28,900	17,965	13,552	11,167
Special Events	79,100	33,900	25,924	22,083	19,824
Future Development	40,133	17,200	13,153	11,204	10,058
Year	**730,339**	**276,439**	**217,304**	**189,620**	**173,437**
Park Visitors	192,667	128,444	112,389	103,744	98,340
Local Residents	326,998	57,706	35,871	27,061	22,298
Special Events	130,239	55,817	42,683	36,360	32,640
Future Development	80,435	34,472	26,361	22,456	20,158
Phase C					
Summer	**397,942**	**183,461**	**150,125**	**133,836**	**124,114**
Park Visitors	171,842	114,561	100,241	92,530	87,711
Local Residents	111,067	19,600	12,184	9,191	7,574
Special Events	48,767	20,900	15,982	13,615	12,222
Future Development	66,267	28,400	21,718	18,500	16,608
Extended.	**568,942**	**245,183**	**197,658**	**174,782**	**161,230**
Park Visitors	201,875	134,583	117,760	108,702	103,040
Local Residents	185,300	32,700	20,327	15,334	12,636
Special Events	82,367	35,300	26,994	22,995	20,643
Future Development	99,400	42,600	32,576	27,750	24,911
Year	**973,124**	**386,561**	**305,699**	**267,440**	**244,974**
Park Visitors	264,633	176,422	154,369	142,495	135,073
Local Residents	370,883	65,450	40,685	30,692	25,291
Special Events	138,833	59,500	45,500	38,759	34,794
Future Development	198,774	85,189	65,144	55,493	49,816

Table C-8 10 Minute Headway, Low Elasticity

Fare	$0.00	$0.50	$1.00	$1.50	$2.00
Phase A					
Summer	**179,196**	**123,233**	**110,955**	**104,468**	**100,437**
Park Visitors	110,163	90,133	84,318	81,012	78,878
Local Residents	31,200	10,400	7,429	6,078	5,306
Special Events	37,833	22,700	19,208	17,378	16,253
Future Development	-	-	-	-	-
Extended	**243,861**	**160,650**	**143,105**	**133,952**	**128,303**
Park Visitors	129,494	105,950	99,115	95,228	92,720
Local Residents	52,200	17,400	12,429	10,169	8,878
Special Events	62,167	37,300	31,562	28,556	26,706
Future Development	-	-	-	-	-
Year	**373,786**	**233,458**	**205,353**	**190,918**	**182,081**
Park Visitors	169,614	138,775	129,822	124,731	121,446
Local Residents	104,325	34,775	24,839	20,323	17,742
Special Events	99,847	59,908	50,692	45,864	42,893
Future Development	-	-	-	-	-
Phase B					
Summer	**236,782**	**151,658**	**134,247**	**125,244**	**119,713**
Park Visitors	116,916	95,658	89,487	85,978	83,713
Local Residents	59,700	19,900	14,214	11,630	10,153
Special Events	38,167	22,900	19,377	17,532	16,396
Future Development	22,000	13,200	11,169	10,105	9,451
Extended	**332,572**	**203,050**	**177,492**	**164,434**	**156,465**
Park Visitors	137,439	112,450	105,195	101,070	98,408
Local Residents	99,300	33,100	23,643	19,344	16,888
Special Events	62,833	37,700	31,900	28,862	26,992
Future Development	33,000	19,800	16,754	15,158	14,176
Year	**547,469**	**314,817**	**270,816**	**248,652**	**235,230**
Park Visitors	180,074	147,333	137,828	132,423	128,936
Local Residents	198,575	66,192	47,280	38,683	33,771
Special Events	102,917	61,750	52,250	47,274	44,212
Future Development	65,903	39,542	33,458	30,272	28,311
Phase C					
Summer	**320,944**	**209,608**	**186,133**	**173,901**	**166,359**
Park Visitors	160,610	131,408	122,930	118,110	114,999
Local Residents	67,500	22,500	16,071	13,149	11,480
Special Events	38,500	23,100	19,546	17,685	16,539
Future Development	54,333	32,600	27,585	24,958	23,341
Extended.	**446,181**	**278,875**	**244,816**	**227,272**	**216,521**
Park Visitors	188,681	154,375	144,415	138,752	135,098
Local Residents	112,500	37,500	26,786	21,916	19,133
Special Events	63,500	38,100	32,238	29,168	27,279
Future Development	81,500	48,900	41,377	37,436	35,011
Year	**741,409**	**438,750**	**379,427**	**349,254**	**330,894**
Park Visitors	247,337	202,367	189,311	181,887	177,097
Local Residents	225,225	75,075	53,625	43,875	38,304
Special Events	105,986	63,592	53,808	48,684	45,530
Future Development	162,861	97,717	82,683	74,809	69,963

Table C-9 15 Minute Headway, Low Elasticity

Fare	$0.00	$0.50	$1.00	$1.50	$2.00
Phase A					
Summer	**165,489**	**113,800**	**102,459**	**96,467**	**92,744**
Park Visitors	101,689	83,200	77,832	74,780	72,811
Local Residents	28,800	9,600	6,857	5,610	4,898
Special Events	35,000	21,000	17,769	16,077	15,036
Future Development	-	-	-	-	-
Extended	**225,167**	**148,300**	**132,098**	**123,647**	**118,432**
Park Visitors	119,533	97,800	91,490	87,902	85,588
Local Residents	48,300	16,100	11,500	9,409	8,214
Special Events	57,333	34,400	29,108	26,336	24,630
Future Development	-	-	-	-	-
Year	**345,033**	**215,500**	**189,556**	**176,232**	**168,075**
Park Visitors	156,567	128,100	119,835	115,136	112,104
Local Residents	96,300	32,100	22,929	18,760	16,378
Special Events	92,167	55,300	46,792	42,336	39,593
Future Development	-	-	-	-	-
Phase B					
Summer	**218,322**	**139,900**	**123,852**	**115,552**	**110,453**
Park Visitors	107,922	88,300	82,603	79,364	77,274
Local Residents	54,900	18,300	13,071	10,695	9,337
Special Events	35,167	21,100	17,854	16,153	15,107
Future Development	20,333	12,200	10,323	9,340	8,735
Extended	**307,167**	**187,500**	**163,891**	**151,830**	**144,469**
Park Visitors	126,867	103,800	97,103	93,295	90,839
Local Residents	91,800	30,600	21,857	17,883	15,612
Special Events	58,000	34,800	29,446	26,642	24,916
Future Development	30,500	18,300	15,485	14,010	13,102
Year	**505,356**	**290,600**	**249,984**	**229,525**	**217,135**
Park Visitors	166,222	136,000	127,226	122,237	119,018
Local Residents	183,300	61,100	43,643	35,708	31,173
Special Events	95,000	57,000	48,231	43,637	40,811
Future Development	60,833	36,500	30,885	27,943	26,133
Phase C					
Summer	**296,322**	**193,500**	**171,824**	**160,530**	**153,567**
Park Visitors	148,256	121,300	113,474	109,024	106,153
Local Residents	62,400	20,800	14,857	12,156	10,612
Special Events	35,500	21,300	18,023	16,307	15,250
Future Development	50,167	30,100	25,469	23,044	21,551
Extended.	**412,100**	**257,500**	**226,038**	**209,833**	**199,903**
Park Visitors	174,167	142,500	133,306	128,079	124,706
Local Residents	104,100	34,700	24,786	20,279	17,704
Special Events	58,667	35,200	29,785	26,948	25,202
Future Development	75,167	45,100	38,162	34,527	32,291
Year	**684,378**	**405,000**	**350,241**	**322,389**	**305,440**
Park Visitors	228,311	186,800	174,748	167,896	163,474
Local Residents	207,900	69,300	49,500	40,500	35,357
Special Events	97,833	58,700	49,669	44,939	42,028
Future Development	150,333	90,200	76,323	69,054	64,581

Table C-10 20 Minute Headway, Low Elasticity

Fare	$0.00	$0.50	$1.00	$1.50	$2.00
Phase A					
Summer	**156,340**	**107,478**	**96,762**	**91,102**	**87,585**
Park Visitors	96,040	78,578	73,508	70,626	68,766
Local Residents	27,300	9,100	6,500	5,318	4,643
Special Events	33,000	19,800	16,754	15,158	14,176
Future Development	-	-	-	-	-
Extended	**212,659**	**140,067**	**124,765**	**116,783**	**111,857**
Park Visitors	112,893	92,367	86,408	83,019	80,833
Local Residents	45,600	15,200	10,857	8,883	7,755
Special Events	54,167	32,500	27,500	24,881	23,269
Future Development	-	-	-	-	-
Year	**325,865**	**203,528**	**179,025**	**166,441**	**158,738**
Park Visitors	147,869	120,983	113,178	108,740	105,876
Local Residents	90,950	30,317	21,655	17,718	15,468
Special Events	87,046	52,228	44,193	39,984	37,394
Future Development	-	-	-	-	-
Phase B					
Summer	**206,160**	**132,094**	**116,941**	**109,104**	**104,289**
Park Visitors	101,927	83,394	78,014	74,955	72,981
Local Residents	51,900	17,300	12,357	10,110	8,827
Special Events	33,167	19,900	16,838	15,235	14,248
Future Development	19,167	11,500	9,731	8,804	8,234
Extended	**290,019**	**177,033**	**154,744**	**143,357**	**136,407**
Park Visitors	119,819	98,033	91,709	88,112	85,792
Local Residents	86,700	28,900	20,643	16,890	14,745
Special Events	54,833	32,900	27,838	25,187	23,556
Future Development	28,667	17,200	14,554	13,168	12,315
Year	**477,280**	**274,456**	**236,096**	**216,774**	**205,072**
Park Visitors	156,988	128,444	120,158	115,446	112,406
Local Residents	173,117	57,706	41,218	33,724	29,442
Special Events	89,722	53,833	45,551	41,213	38,543
Future Development	57,454	34,472	29,169	26,391	24,681
Phase C					
Summer	**279,652**	**182,661**	**162,209**	**151,552**	**144,981**
Park Visitors	140,019	114,561	107,170	102,967	100,256
Local Residents	58,800	19,600	14,000	11,455	10,000
Special Events	33,500	20,100	17,008	15,388	14,391
Future Development	47,333	28,400	24,031	21,742	20,334
Extended.	**388,924**	**243,083**	**213,396**	**198,104**	**188,733**
Park Visitors	164,491	134,583	125,901	120,963	117,778
Local Residents	98,100	32,700	23,357	19,110	16,684
Special Events	55,333	33,200	28,092	25,417	23,770
Future Development	71,000	42,600	36,046	32,613	30,501
Year	**646,357**	**382,500**	**330,783**	**304,478**	**288,471**
Park Visitors	215,627	176,422	165,040	158,568	154,392
Local Residents	196,350	65,450	46,750	38,250	33,393
Special Events	92,398	55,439	46,910	42,442	39,693
Future Development	141,981	85,189	72,083	65,218	60,993

C.6 Capacity Utilization

Ridership estimates for different fare and headway combinations provide some information on the sensitivity of riders with respect to headway and fare. However, planning the optimal service levels requires more information on the ability of the various supply scenarios to meet the demand. The first step is to calculate the capacity utilization for the fare and headway combinations outlined above. Tables C-11 and C-12 show the service capacity utilized in the different fare and headway scenarios, based on constant supply and demand levels throughout the service period, as well as high and low elasticities. To reach higher utilization levels, headway may be increased, fare decreased, or both.

Table C-11 Capacity Utilization for Fare and Headway Scenarios by Phase, High Elasticities

	$0.00			$0.50			$1.00			$1.50			$2.00		
Headway (minutes)	**10**	**15**	**20**	**10**	**15**	**20**	**10**	**15**	**20**	**10**	**15**	**20**	**10**	**15**	**20**
Phase A															
Summer	67%	93%	117%	33%	46%	58%	28%	39%	48%	25%	35%	44%	23%	32%	41%
Extended Summer	62%	86%	108%	29%	40%	51%	24%	33%	42%	21%	29%	37%	20%	27%	35%
Year	49%	68%	86%	21%	29%	37%	17%	24%	30%	15%	21%	26%	14%	19%	24%
Phase B															
Summer	92%	128%	161%	41%	57%	72%	34%	46%	59%	30%	41%	52%	28%	38%	48%
Extended Summer	89%	123%	155%	37%	51%	64%	30%	41%	52%	26%	36%	45%	24%	33%	42%
Year	76%	105%	132%	29%	40%	50%	22%	31%	39%	20%	27%	34%	18%	25%	31%
Phase C															
Summer	124%	171%	215%	57%	79%	99%	47%	65%	81%	42%	58%	72%	39%	53%	67%
Extended Summer	118%	163%	205%	51%	70%	89%	41%	57%	71%	36%	50%	63%	33%	46%	58%
Year	101%	139%	176%	40%	55%	70%	32%	44%	55%	28%	38%	48%	25%	35%	44%

* Assuming 45 seats per trolley.

Table C-12 Capacity Utilization for Fare and Headway Scenarios by Phase, Low Elasticities

	$0.00			$0.50			$1.00			$1.50			$2.00		
Headway (minutes)	**10**	**15**	**20**	**10**	**15**	**20**	**10**	**15**	**20**	**10**	**15**	**20**	**10**	**15**	**20**
Phase A															
Summer	49%	67%	85%	33%	46%	58%	30%	42%	52%	28%	39%	49%	27%	38%	47%
Extended Summer	44%	61%	77%	29%	40%	51%	26%	36%	45%	24%	33%	42%	23%	32%	40%
Year	34%	47%	59%	21%	29%	37%	19%	26%	32%	17%	24%	30%	16%	23%	29%
Phase B															
Summer	64%	89%	112%	41%	57%	72%	36%	50%	63%	34%	47%	59%	32%	45%	56%
Extended Summer	60%	83%	105%	37%	51%	64%	32%	44%	56%	30%	41%	52%	28%	39%	49%
Year	49%	68%	86%	28%	39%	50%	24%	34%	43%	22%	31%	39%	21%	29%	37%
Phase C															
Summer	87%	120%	151%	57%	79%	99%	50%	70%	88%	47%	65%	82%	45%	62%	79%
Extended Summer	81%	112%	140%	50%	70%	88%	44%	61%	77%	41%	57%	72%	39%	54%	68%
Year	67%	93%	117%	40%	55%	69%	34%	47%	60%	32%	44%	55%	30%	41%	52%

* Assuming 45 seats per trolley.

C.7 Operation & Maintenance Costs, Revenues, and Cost Recovery

The cost of operating the trolley service and cost recovery are issues of concern for stakeholders, and the public at large. The fare scenarios and ridership forecasts yield different combinations of operation costs and revenues. The following tables show the costs, revenues and cost recovery ratios for various fare and headway scenarios for the three construction phases.

Table C-13. Operation and Maintenance Cost Recovery from Fare Revenues, 10 Minute Headway, High Elasticities

	Fare								
		$0.50		$1.00		$1.50		$2.00	
	O&M Costs	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered
Phase A									
Summer	$494,700	$61,617	12%	$102,690	21%	$138,696	28%	$172,603	35%
Extended Summer	$742,000	$80,325	11%	$132,046	18%	$177,049	24%	$219,307	30%
Year Round	$1,484,000	$116,729	8%	$188,857	13%	$251,130	17%	$309,440	21%
Phase B *									
Summer	$494,700	$76,029	15%	$123,983	25%	$165,557	33%	$204,545	41%
Extended Summer	$742,000	$102,075	14%	$163,781	22%	$216,780	29%	$266,305	36%
Year Round	$1,484,000	$158,546	11%	$249,261	17%	$326,258	22%	$397,885	27%
Phase C									
Summer	$643,100	$105,254	16%	$172,251	27%	$230,338	36%	$284,804	44%
Extended Summer	$964,600	$140,638	15%	$226,754	24%	$300,764	31%	$369,926	38%
Year Round	$1,929,300	$221,704	11%	$350,655	18%	$460,154	24%	$562,000	29%

* Phase B includes more track than phase A, but because some of the track forms a loop the total VMT does not increase. Therefore, O&M costs remain the same.

Table C-14. Operation and Maintenance Cost Recovery from Fare Revenues, 15 Minute Headway, High Elasticities

	Fare								
		$0.50		$1.00		$1.50		$2.00	
	O&M Costs	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered
Phase A									
Summer	$329,800	$56,900	17%	$94,826	29%	$128,072	39%	$159,380	48%
Extended Summer	$494,700	$74,150	15%	$121,889	25%	$163,426	33%	$202,431	41%
Year Round	$989,400	$107,750	11%	$174,330	18%	$231,813	23%	$285,637	29%
Phase B *									
Summer	$329,800	$70,150	21%	$114,409	35%	$152,780	46%	$188,766	57%
Extended Summer	$494,700	$94,300	19%	$151,294	31%	$200,242	40%	$245,982	50%
Year Round	$989,400	$146,350	15%	$230,087	23%	$301,161	30%	$367,279	37%
Phase C									
Summer	$428,700	$97,150	23%	$158,985	37%	$212,597	50%	$262,866	61%
Extended Summer	$643,100	$129,850	20%	$209,346	33%	$277,665	43%	$341,508	53%
Year Round	$1,286,200	$204,650	16%	$323,681	25%	$424,757	33%	$518,769	40%

* Phase B includes more track than phase A, but because some of the track forms a loop the total VMT does not increase. Therefore, O&M costs remain the same.

Table C-15. Operation and Maintenance Cost Recovery from Fare Revenues, 20 Minute Headway, High Elasticities

	Fare								
		$0.50		$1.00		$1.50		$2.00	
	O&M Costs	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered
Phase A									
Summer	$247,300	$53,739	22%	$89,553	36%	$120,948	49%	$150,512	61%
Extended Summer	$371,000	$70,033	19%	$115,122	31%	$154,354	42%	$191,194	52%
Year Round	$742,000	$101,764	14%	$164,645	22%	$218,934	30%	$269,768	36%
Phase B *									
Summer	$247,300	$66,247	27%	$108,042	44%	$144,277	58%	$178,259	72%
Extended Summer	$371,000	$89,017	24%	$142,821	38%	$189,031	51%	$232,212	63%
Year Round	$742,000	$138,219	19%	$217,304	29%	$284,430	38%	$346,874	47%
Phase C									
Summer	$321,500	$91,731	29%	$150,125	47%	$200,754	62%	$248,228	77%
Extended Summer	$482,300	$122,592	25%	$197,658	41%	$262,172	54%	$322,460	67%
Year Round	$964,600	$193,281	20%	$305,699	32%	$401,160	42%	$489,949	51%

* Phase B includes more track than phase A, but because some of the track forms a loop the total VMT does not increase. Therefore, O&M costs remain the same.

Table C-16. Operation and Maintenance Cost Recovery from Fare Revenues, 10 Minute Headway, Low Elasticities

	Fare								
		$0.50		$1.00		$1.50		$2.00	
	O&M Costs	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered
Phase A									
Summer	$448,200	$61,617	14%	$110,955	25%	$156,702	35%	$200,874	45%
Extended Summer	$672,200	$80,325	12%	$143,105	21%	$200,928	30%	$256,607	38%
Year Round	$1,344,500	$116,729	9%	$205,353	15%	$286,376	21%	$364,163	27%
Phase B *									
Summer	$448,200	$75,829	17%	$134,247	30%	$187,867	42%	$239,427	53%
Extended Summer	$672,200	$101,525	15%	$177,492	26%	$246,651	37%	$312,930	47%
Year Round	$1,344,500	$157,408	12%	$270,816	20%	$372,978	28%	$470,459	35%
Phase C									
Summer	$582,600	$104,804	18%	$186,133	32%	$260,852	45%	$332,718	57%
Extended Summer	$873,900	$139,438	16%	$244,816	28%	$340,908	39%	$433,042	50%
Year Round	$1,747,800	$219,375	13%	$379,427	22%	$523,881	30%	$661,787	38%

* Phase B includes more track than phase A, but because some of the track forms a loop the total VMT does not increase. Therefore, O&M costs remain the same.

Table C-17. Operation and Maintenance Cost Recovery from Fare Revenues, 15 Minute Headway, Low Elasticities

	Fare								
		$0.50		$1.00		$1.50		$2.00	
	O&M Costs	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered
Phase A									
Summer	$298,800	$56,900	19%	$102,459	34%	$144,701	48%	$185,489	62%
Extended Summer	$448,200	$74,150	17%	$132,098	29%	$185,471	41%	$236,863	53%
Year Round	$896,300	$107,750	12%	$189,556	21%	$264,348	29%	$336,150	38%
Phase B *									
Summer	$298,800	$69,950	23%	$123,852	41%	$173,328	58%	$220,905	74%
Extended Summer	$448,200	$93,750	21%	$163,891	37%	$227,745	51%	$288,938	64%
Year Round	$896,300	$145,300	16%	$249,984	28%	$344,287	38%	$434,270	48%
Phase C									
Summer	$388,400	$96,750	25%	$171,824	44%	$240,795	62%	$307,133	79%
Extended Summer	$582,600	$128,750	22%	$226,038	39%	$314,750	54%	$399,806	69%
Year Round	$1,165,200	$202,500	17%	$350,241	30%	$483,583	42%	$610,881	52%

* Phase B includes more track than phase A, but because some of the track forms a loop the total VMT does not increase. Therefore, O&M costs remain the same.

Table C-18. Operation and Maintenance Cost Recovery from Fare Revenues, 20 Minute Headway, Low Elasticities

	Fare								
		$0.50		$1.00		$1.50		$2.00	
	O&M Costs	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered	Revenue	% Re-covered
Phase A									
Summer	$224,100	$53,739	24%	$96,762	43%	$136,653	61%	$175,170	78%
Extended Summer	$336,100	$70,033	21%	$124,765	37%	$175,175	52%	$223,714	67%
Year Round	$672,200	$101,764	15%	$179,025	27%	$249,662	37%	$317,475	47%
Phase B *									
Summer	$224,100	$66,047	29%	$116,941	52%	$163,656	73%	$208,578	93%
Extended Summer	$336,100	$88,517	26%	$154,744	46%	$215,035	64%	$272,814	81%
Year Round	$672,200	$137,228	20%	$236,096	35%	$325,160	48%	$410,144	61%
Phase C									
Summer	$291,300	$91,331	31%	$162,209	56%	$227,328	78%	$289,961	100%
Extended Summer	$437,000	$121,542	28%	$213,396	49%	$297,156	68%	$377,465	86%
Year Round	$873,900	$191,250	22%	$330,783	38%	$456,717	52%	$576,943	66%

* Phase B includes more track than phase A, but because some of the track forms a loop the total VMT does not increase. Therefore, O&M costs remain the same.

C.8 Comment

The Travel Demand Model developed is designed to give a preliminary idea of the pertinent demand and supply issues and considerations while planning the trolley service for Lowell. Several assumptions have been made in the process of constructing the model due to lack of adequate data. The assumptions not mentioned in the above sections are as follows:

C.9 Assumptions

The following assumptions were made while constructing the model, based on best professional judgment and experience:

1. In cases where new development plans do not include specific square footage, estimates were made.
2. The maximum distance a person would walk to get to the trolley is ¼ mile.
3. Given the proximity of some of the trolley lines to one another, there is some overlap of market areas that has not been subtracted out from total demand. However, since residents of UMASS dorms have not been added directly, this double counting can be considered to account for dorm residents.
4. The stops would be adequately spaced to satisfy the ½ mile walk zone around each route.
5. Scheduled service on all the routes would have the same level of service, and the level would remain the same throughout the annual period of operation.
6. There would be no capacity constraints due to parking or trolley load.
7. Trolley presence on public roads would have no significant impact on automobile traffic.

APPENDIX D

Route 3 North Design-Build Highway Project

APPENDIX D

Route 3 North Design-Build Highway Project

On October 6, 2000, the Massachusetts Highway Department (MassHighway) broke ground on construction of the Route 3 North Project, the first design-build-finance highway construction project in the Commonwealth of Massachusetts. Route 3 North is an existing 21-mile limited access highway running north and south between the Route I-95/128 circumferential highway around Boston and the New Hampshire border. The $385 million project is designed to alleviate a number of significant transportation problems on this heavily utilized highway through the phased construction over 42 months of several major improvements, including the addition of a travel lane in each direction, the addition of a median shoulder and a 30-foot clear zone, improvements to 13 interchanges, and the replacement of 40 bridges.

This new project delivery approach was authorized by the Massachusetts Legislature in August 1999, through a bill that enabled the creation of a public-private partnership to finance, design, build, operate, and maintain the Route 3 North Project. Through a competitive process, the MassHighway selected Modern Continental as the developer to finance, design, and build the project and then operate and maintain the facility for 30 years upon its completion.

The project encompasses a number of innovative features:

- Through the use of design-build procurement, project delivery is expedited and cost certainty is established early in the project's development. Developer selection was made on a "best value" basis, where the design-build price bid was a significant, but not the sole, criterion for selection. Other criteria considered in the best value determination included the proposed cost of operations and maintenance over a 30-year period; project schedule; approach to maintenance of traffic; the quality of design and the approach to construction quality assurance; the proposed plan of finance; and the planned approach to addressing environmental permitting issues. Price is guaranteed and secured by the developer.

- A special purpose, not-for-profit corporation - or 63-20 corporation - was formed by the MassHighway and the developer to issue $394.5 million in tax-exempt lease revenue bonds to finance the project on the Commonwealth's behalf. The bonds are secured by a 34-year lease of the facility between MassHighway and the 63-20 corporation known as the Route 3 North Transportation Improvements Association ("the Association"). MassHighway's rent payments to cover debt service and the

cost of operations and maintenance are subject to an annual appropriation of the Legislature.

- Three components of the project financing plan have reduced the Route 3 bond size by an estimated $54 million. First, the scheduling of annual lease payment due dates well into the Commonwealth's fiscal year eliminated the need for a liquidity debt service reserve, which would otherwise have been required to address risk associated with potential delays in adoption of the state budget. Second, an up-front payment was made by the project's senior banker (Salomon Smith Barney) to the Association of nearly $9 million in connection with an innovative forward purchase agreement. Third, project risk insurance was purchased, with the developer serving as a co-insurer. This requires the developer to establish a contingency fund to meet unexpected changes in the amount of 10 percent of the design-build price, or approximately $38 million.

- The bonds held underlying ratings of A+ by Fitch and Aa3 by Moody's. The Association's purchase of bond insurance from MBIA resulted in insured ratings of AAA by Fitch, Aaa by Moody's, and AAA by Standard & Poor's. By comparison, the Commonwealth's general obligation bond ratings are rated AA- by Fitch, Aa2 by Moody's, and AA- by Standard & Poor's. The project was thus financed at a lower interest rate than the Commonwealth could obtain on its own general obligation credit.

- The developer may pursue surface, sub-surface, and air rights development to generate non-project revenues. Planned development includes installation of fiber optic cable during construction with the developer sharing in the sale of fiber optic rights. Other potential plans include construction and sublease of a service plaza, which is estimated to result in non-project revenues of approximately $500,000 per year, and development on land adjacent to the highway and interchanges. The developer has a strong financial incentive to pursue development rights, receiving 40 percent of ancillary development revenues under the negotiated Development Agreement.

The combination of innovative contracting and financing approaches implemented for the Route 3 North Project will generate significant benefits, producing measurable economic advantages, cutting the project delivery time line in half, and saving dollars. Specifically, the design-build methodology will minimize project costs by introducing construction process efficiencies, and the guaranteed price will offset inflationary increases associated with phased development. From an economic perspective, the favorable financing terms and costs and the ancillary revenue potential further demonstrate the value of Massachusetts' innovative approach to project delivery.

As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our parks and historic places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-80 / July 2005