2008

Charlesgate Connection

Bicycling Around the Back Bay
"The Babbs"

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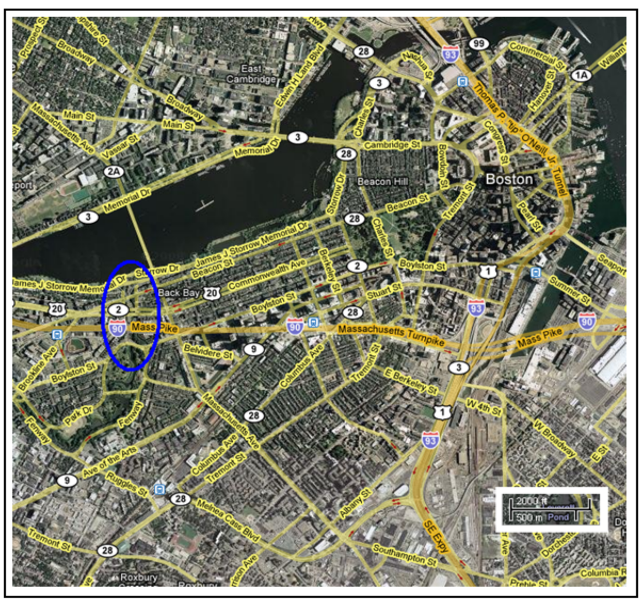
1.0 INTRODUCTION TO PROJECT

1.1 Introduction

There is a great need for providing a continuous, shared-use path from the Back Bay Fens to The Charles River Esplanade that has challenged engineers and planners for years *(figure 1.1a,b).*

This report will introduce a feasible design to connect existing bike paths in the City of Boston to unused green areas in order to encourage bicycling and recreational activity The Project scope covers the design of a multiuse path that will be utilized by commuters and recreationalists alike.

Figure 1.1A: Overview of Parkland



The Charlesgate connection will eliminate a major gap in the bicycling network connecting three high traffic existing bike and pedestrian paths, those being the Back Bay Fens, the Charles River Esplanade, and the Massachusetts Avenue Bridge.

The connections created in this project will offer superior pedestrian and bicycle routes compared to the existing conditions while serving residents of the Back Bay, Cambridge, South Boston, and Roxbury.

Figure 1.1B: Locus Map

1.1.1 Purpose of the Report

At the request of Nicole Freedman, Bicycle Planner for the City of Boston, Herb Nolan, Associate Director of The Solomon Fund, and Dr. Peter Furth of Northeastern University, the *Biking around Back Bay (BaBB)* senior student design team designed a multiuse path connecting the existing paths in Boston's Back Bay Fens to the Charles River Esplanade and Massachusetts Avenue Bridge. The team also conducted transportation analysis of the surrounding street network. The Charlesgate Connector project includes the following:

- Design of multiuse path including ADA compliant ramps and curb cuts
- Conceptual design of a pedestrian/bike bridge over Storrow Drive. and ramp connection to Massachusetts Avenue
- Definition and presentation of existing traffic conditions including bicycle and pedestrian circulation
- Design access and layout for proposed future parks on existing green areas throughout path alignment
- Evaluation of the project's long-term impacts on traffic, bicycle, and pedestrian circulation

Figure 1.1C: Boston Bike Paths

1.2 Study Area

The study area is generally bounded by:

- Charles River to the north
- Massachusetts Avenue to the east
- Boylston Street to the south
- Charlesgate West to the west *(figure 1.2A)*.

Figure 1.2A: Site Boundaries

This site consists of seven intersections *(figure 1.2B)*, existing green areas, a historic gate house, and the Bowker Overpass hovering over the majority of the site.

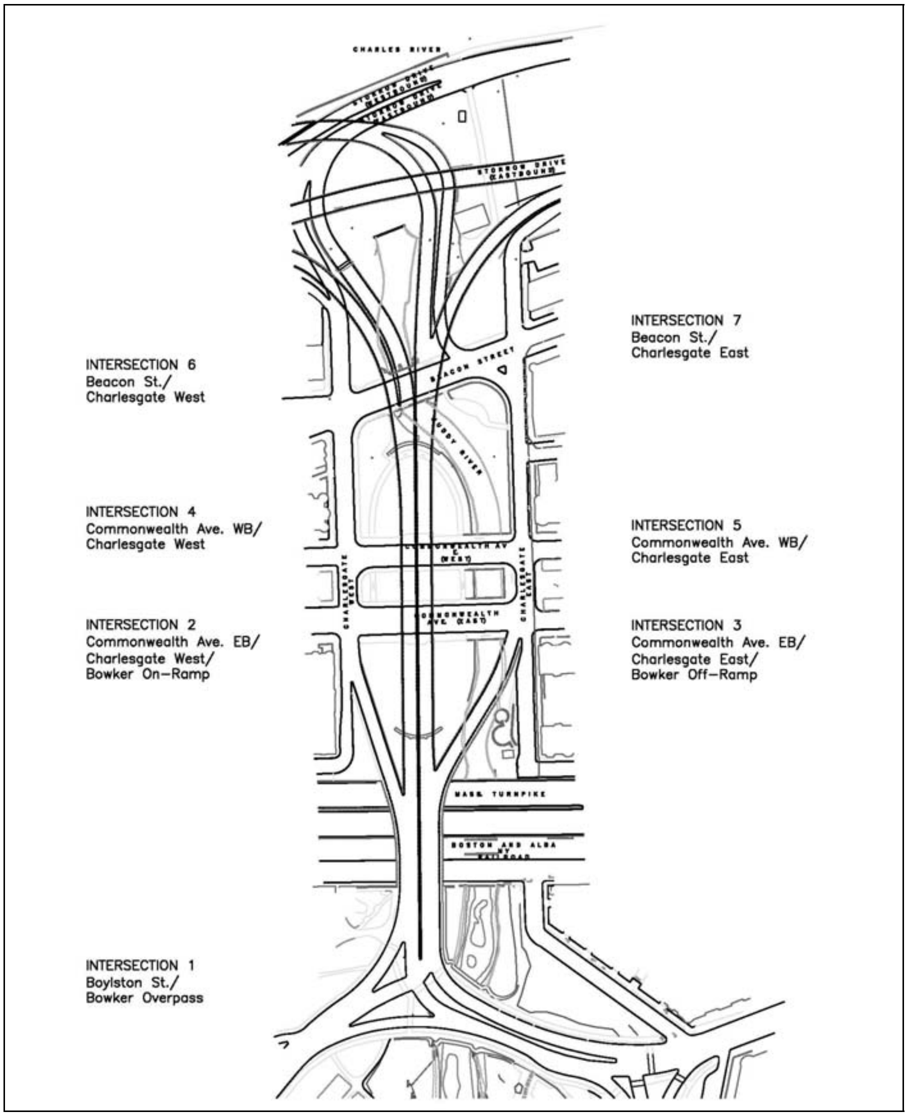


Figure 1.2B

1.3 Report Layout

This report takes the reader on a journey through the proposed path starting at the southern most point, the Fens, and ending at the northern most point, the Charles River. The report begins with the historical background. It is then broken into sections, each with a specific problem to be solved. Generally, each section of the report is divided into the physical changes and the impact on pedestrian and vehicular traffic. The report culminates with closing and acknowledgements.

2.0 CONTEXT

The Charlesgate connection is the missing link between the two most important bicycling networks in the Boston area: the Charles River and the Emerald Necklace. There have been several past planning efforts to link these networks as far back as 1989 with the Emerald Necklace Master plan, and the most recently, the Bicycle Summit plan in 2007, but none have made it past the conceptual phase.

Currently pedestrians and bicyclists are able to cross over the Bowker Overpass on its narrow sidewalks, but once they arrive in the Kenmore area, the path terminates. There are no nearby connections to the Charles River path or to the Massachusetts Avenue Bridge. Also an abundant amount of parkland remains unused, hidden in the shadows of the overpass. In order to better understand this area, you must first know the history.

2.1 History

Figure 2.1A: Commonwealth Ave/Charlesgate 1950's
The landscape of this area was destroyed with the construction of the Bowker overpass.

In the latter half of the 1800's, the area that is now known as the Back Bay Fens was a vast tidal marsh that became a sanitary concern due to the city's tremendous growth. Frederick Law Olmsted Sr., father of American landscape architecture, developed a plan that would not only solve a major drainage/sewage problem, but would also create a stunning park system known as the Emerald Necklace (Open Space Plan) [1].

This linear system of parks and parkways was designed to connect the Boston Common and Public Garden to Franklin Park. The project began in 1878, and was designed with the vision of a linear park with walking paths along the Muddy River.

In the beginning of the 1900's, further parkland was created by the Charles River Basin Commission. They were authorized to expand the esplanade west on the Boston side from Longfellow bridge to Charlesgate. The new parkland would be created as part of the dam and conduit projects through the use of material generated from dredging north of the seawall. This parkland would later be displaced with the construction of a parkway.

In 1946, the Metropolitan District Commission was directed to prepare plans for the construction of what is now known as “Storrow Drive”; named after James J. Storrow which was inappropriate given the family’s interest in creating parkland along the Back Bay. With the construction of this parkway, a barrier was created to this once beautiful area, with little or no connections.

In 1966, Olmsted’s vision was further shattered with the construction of the Bowker Overpass. The overpass not only destroyed Olmsted’s landscaped area known as the “Beacon Entrance,” but also divided the neighborhoods with a maze of overhead ramps. Additionally, in the 1980’s, with the reconstruction of the Harvard Bridge, an on-ramp to Storrow Drive was removed west of the bridge. This created additional parkland between the eastbound and westbound lanes of Storrow Drive, but still remains unused (Cultural Landscape Report)[2].

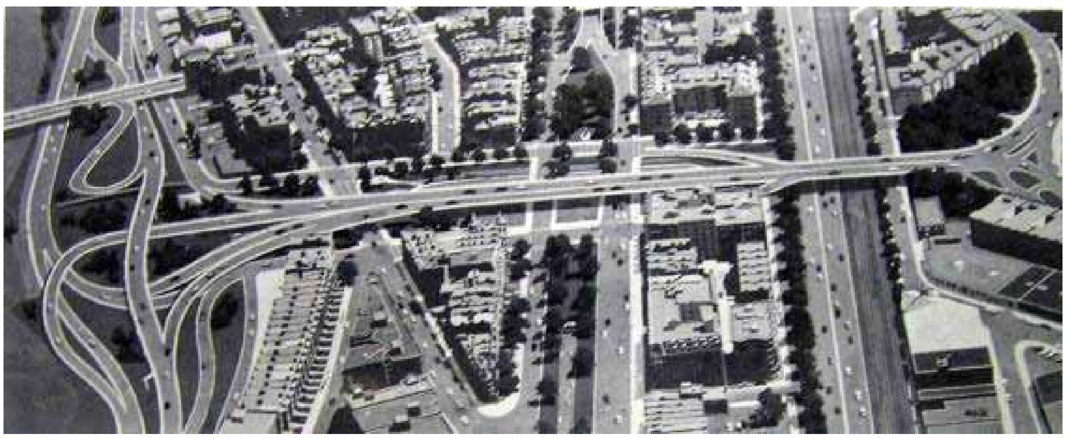


Figure 2.1B: Bowker Overpass 1970’s
Notice the on-ramp that connects into Storrow Drive Eastbound from the Massachusetts Avenue Bridge.

2.2 Need for Greenway Connection

The construction of Storrow Drive and the Bowker overpass severed the connection that once existed to the Charles River Esplanade. The need for this connection has long been established through the series of several previous plans:

- Emerald Necklace Master Plan (1989). This plan is a balanced, comprehensive and technically detailed park advocacy document that sets forth specific and realistic goals that are to be realized in phases over the near to long-term.
- Muddy River Delta Proposal (1996). This plan detailed two initiatives. The first to deal with the potential revitalization of a pedestrian bridge linking the Charles, Beacon Street, Commonwealth Avenue, Newbury Street, and the Back Bay Fens. The second was to ameliorate the problems on the south bank of the Charles River.
- Charlesgate Interchange Park Charrette (1998). A community design event that was organized by the Community Outreach Group, Inc. Participants were asked to explore ways of restoring beauty and dignity to the Charlesgate Interchange Park.

- The Emerald Necklace Greenway Plan (2001). An updated Emerald Necklace Master Plan by Pressley Associates, Inc.

- The MDC Charlesgate Connection Plan (2002). This plan was done by Rizzo Associates to minimize cost by using existing roadways for bikes.

- The Boston Bicycle Summit (2007). At this 3-day meeting of national and local bicycling leaders, a consensus began to form that Charlesgate was the most critically needed connection in the city's bicycle network.

As far back as 1989, the Emerald Necklace Master Plan recognized the need for a connection from the Back Bay Fens to the Charles River Esplanade with a pedestrian bridge crossing over Storrow Drive. This plan also suggested a future connection crossing the muddy river near Marlborough Street. Unlike future plans, the original plan realized the need to remove bikes from the busy roadways of Charlesgate and use existing parkland to bring users to the Esplanade.

This connection will link several destinations and increase ridership six fold. Some sample destinations are listed below:

- Harvard University with Harvard Medical
- Boston University with Boston University Medical
- MIT University with Longwood Medical Area and Jamaica Plain
- Massachusetts General Hospital with Longwood Medical Area and Jamaica Plain
- Downtown to Fenway/Jamaica Plain

2.2.1 Support

A common U.S. practice is to weigh the interests of motor vehicles over those of pedestrians and bicyclists. This has led to gaps in the system and has become impossible for pedestrians and bicyclists to get from one part of the system to the other, and their safety has been compromised. The Emerald Necklace master plan calls for a restoration of this system that re-emphasizes the continuity and connectivity of the Charlesgate area.

The overall goal of restoring Olmsted’s plan has made three major advances: the award of $1 million in federal/state transportation enhancement grant that was received for the Connecting the Corridors project, combined with over $700,000 in city capital funding; the planned improvements with the Sear’s rotary; and the advocacy of the Emerald Necklace Greenway concept by BikeBoston, the local chapter of the Massachusetts Bicycle Coalition (Open Space Plan 2002-2006).This is just some of the support that has rallied behind these recent projects.

The Charlesgate connector project has already received extreme interest in the community and The Solomon Fund has offered to continue the design of this project. With a completed design, the Charlesgate connection can be submitted for The TEA-21 Transportation Enhancement program and should receive the funding it needs to be completed.

3.0 BOYLSTON/BOWKER OVERPASS

3.1 Overview of the Section

Cyclists and pedestrians starting in the Back Bay Fens attempting to reach the Charles River first encounter the intersection of Boylston Street and the Bowker Overpass. Currently, the average delay for pedestrians crossing Boylston is over one minute and an individual delay can reach upwards of two minutes. Once across Boylston Street pedestrians are forced onto narrow 6’ wide sidewalks that are not buffered from the nearby traffic. The situation on the Bowker Overpass is even worse for cyclists. Since there is no designated bicycle lane, cyclists are forced to either ride in the roadway, which involves dangerous weaves through traffic, or up on the narrow pedestrian walkway. This situation is presented in *figure 3.1B*. The solution to the problem is two-fold.

1. The median will be moved to the east to provide the necessary room for a multi-use path

2. The traffic signals at the Bowker/Boylston intersection will be better coordinated providing a pedestrian green wave across Boylston Street.

Figure 3.1A: Site Map
This figure shows the location of this section in reference to the project as a whole.

A green wave will allow users to cross over Boylston Street in one phase without the need to stop at the center island. Once across the Boylston Street the space needed for the path will be created by shifting the center median to the east and deleting one lane of northbound traffic on the Bowker Overpass. More information on shifting the median is provided in Section 1.2. The 12.0’ path on the west side of the overpass would accommodate both pedestrians and cyclists alike. The path will be buffered from the traffic on the overpass through a 3.0’ wide hardscape buffer. The new configuration is shown in *figure3.1C*.

Figure 3.1B: Existing Conditions
This is an image taken from the Bowker/Boylston Intersection looking at the southbound lanes of the Bowker Overpass.

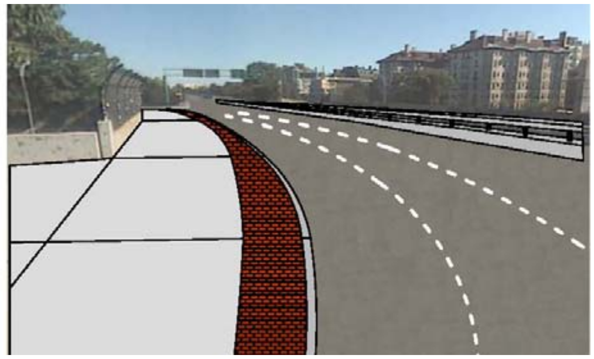


Figure 3.1C: Proposed Conditions
This is a rendering of what the southbound lanes of the Bowker Overpass will look like.

3.2 Boylston Street / Bowker Overpass Intersection Design Alternatives

3.2.1 An introduction to the Design

Lane elimination and the resulting median relocation are needed in order to accommodate pedestrians and cyclists. All subsequent changes in layout are a result of this move. The median is pushed 10’ east eliminating one lane of northbound traffic on the east side of the overpass. The lane elimination will have a minimal affect to motorists as discussed later in Section 3.3. Three additional alternatives (Alternatives A, B, & C) were investigated. Two of these alternatives did not require an elimination of a traffic lane. However, as explained in section 3.2.2, all three alternatives had substantial flaws which disproved their viability.

3.2.2 Alternatives Considered

Alternative A: Eliminate One Northbound Lane and Create a Path on the East Side

This alternative is similar to the chosen design described later in that both require one lane of northbound traffic (Bowker East) to be removed. This alternative leaves the median location intact and uses the space left from the deleted lane to create the path on the east side of the overpass.

Viability

This alternative requires the path to follow the Bowker northbound off-ramp to the intersection with Commonwealth Avenue Eastbound. This alternative is not viable because the off exit ramp does not have the required width for the path. As seen in *figure 3.2A*, there are currently two lanes of traffic and a small 6’ sidewalk. Eliminating one lane on the off-ramp is not an option. Both lanes are necessary to provide queue space at the traffic light. Additionally, the off-ramp is a fixed bridge structure making the process of expanding the off-ramp nearly impossible. For this reason it would be extremely costly to expand the off-ramp to accommodate bicycle and pedestrian users.

Figure 3.2A: Design Alternative A
A view of the Bowker off-ramp from the intersection of Commonwealth Avenue EB and the Bowker off-ramp. The two lanes are necessary to provide storage space for cars in queue. Notice the narrow 6' sidewalks.

Alternative B: Divide Path Users

In this alternative it was proposed that pedestrians be limited to walking on the west side of the overpass. The space currently being used for a pedestrian sidewalk on the northbound side could then be converted into a northbound bike lane *(figure 3.2B)*.

Viability

This alternative had numerous flaws:

1. The alternative provides only a northbound bicycle path. Cyclists traveling south would have no way of getting across.

2. The design is not in keeping with the overall design of a mixed use path separated from the traffic.

3. Enforcement of pathway restrictions would be difficult.

4. Without adding more space to either side the pathways would continue to be narrow (6' wide) and un-buffered from the traffic.

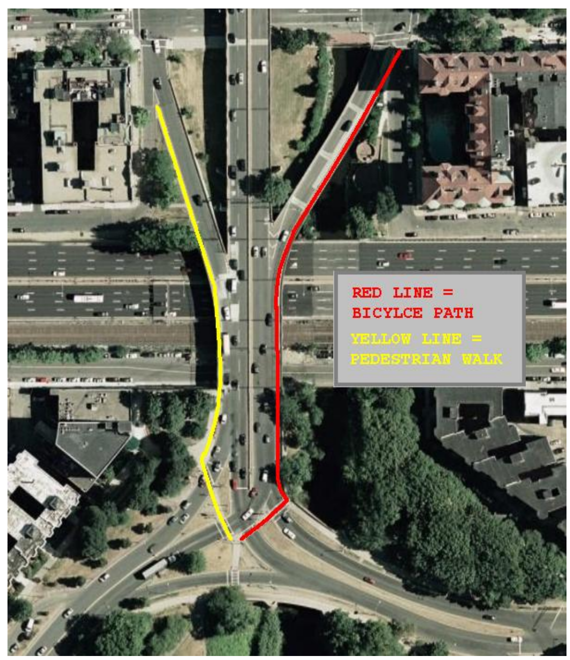


Figure 3.2B: Design Alternative B
This image shows the proposed separation of bicycles and pedestrians.

Alternative C: Lane Diet

This alternative proposed that each lane on the Bowker Overpass be narrowed. Narrowing each lane from the existing 11.5' to a modest 10.5' would produce 6 extra feet which can then be used for expanding the walk on the east side of the overpass. *Figure 3.2C* provides a cross section for this alternative.

Viability

This alternative allows for 6 feet to be added to the existing sidewalk on the west side of the overpass. This option is not preferable for two reasons. The main reason the alternative is not viable is that there is not an adequate path width. The physical width of the path would be 12', however after taking into account a 3.5' hardscape buffer and curb between the path and the roadway and a 1' shy distance from the overpass wall the effective width of the path would only be 7.5 feet. A width of 7.5 feet is simply not enough to provide a two way bicycle and pedestrian path

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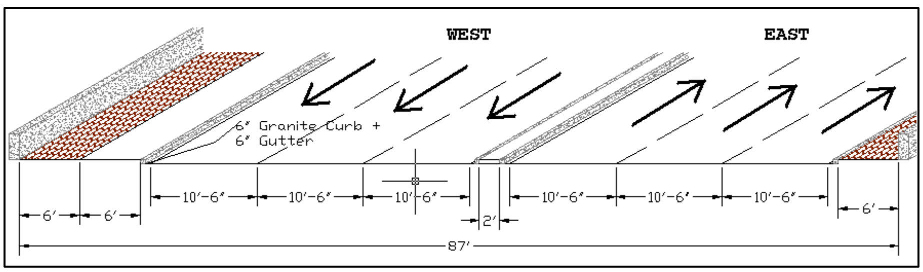
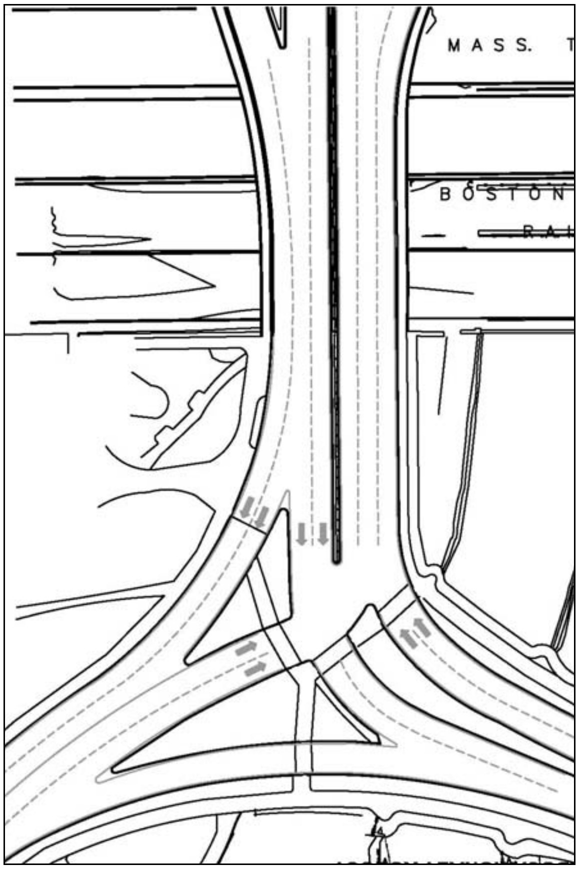


Figure 3.2C: Cross Section
This is a typical cross section for the Bowker Overpass as proposed in Alternative C: Lane Diet

3.3 The Selected Design

Currently there are three southbound and three northbound lanes of traffic on the overpass as seen in *figure 3.3A*. The three southbound lanes are critical to the function of the overpass. The three lanes of northbound traffic function as two lanes because only two lanes of traffic feed the overpass at one time allowing the designers the freedom to eliminate one lane of northbound traffic *(figure 3.3B)*. Once the lane is eliminated, the median will be moved 10.0' east and started 9.5' further north *(figure 3.3C)*. Pushing the median 9.5' north is necessary to provide the turning radius needed for traffic making the turn from Boylston Street Eastbound to the Bowker Overpass.



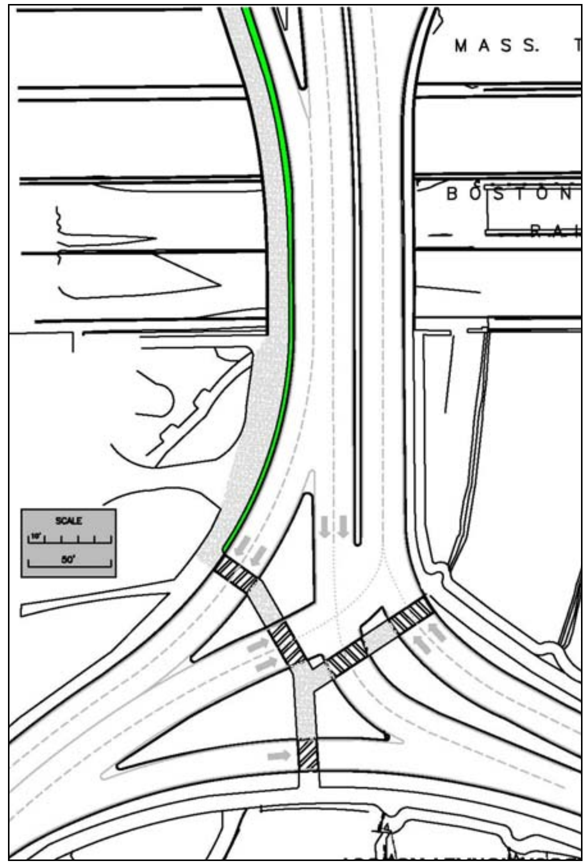


Figure 3.3A: Existing Conditions
The intersection of the Bowker Overpass and Boylston Street as it currently stands. Notice only two lanes of traffic ever feed into the Bowker Overpass NB

Figure 3.3B: Proposed Design
The intersection of the Bowker Overpass and Boylston Street as it currently stands. Notice only two lanes of traffic ever feed into the Bowker Overpass NB

The median is not moved the full 12.0’ that was gained from the elimination of the northbound lane. 10 feet is given to the west side to accommodate pedestrians and cyclists and the other two feet is used to expand the remaining two lanes of northbound traffic. This allows for extra room for those motorists entering the overpass. The three lanes of southbound traffic are all subsequently moved 10.0’ east.

The sidewalk area on the west side of the overpass is extended by 10.0’ to a total physical width of 16.0’. Half a foot is taken up by the curb and 3.0’ is allotted for a hardscape buffer. Functionally the hardscape buffer provides path users separation from the roadway making a physical barrier such as a fence unnecessary. Additionally, the buffer provides space for snow storage without infringing on the path. The remaining 12.5’ will be a concrete sidewalk. After taking into consideration a 1.0’ shy distance from the bridge wall the effective width of the path is 11.5’. This is adequate room for a multi-use path.

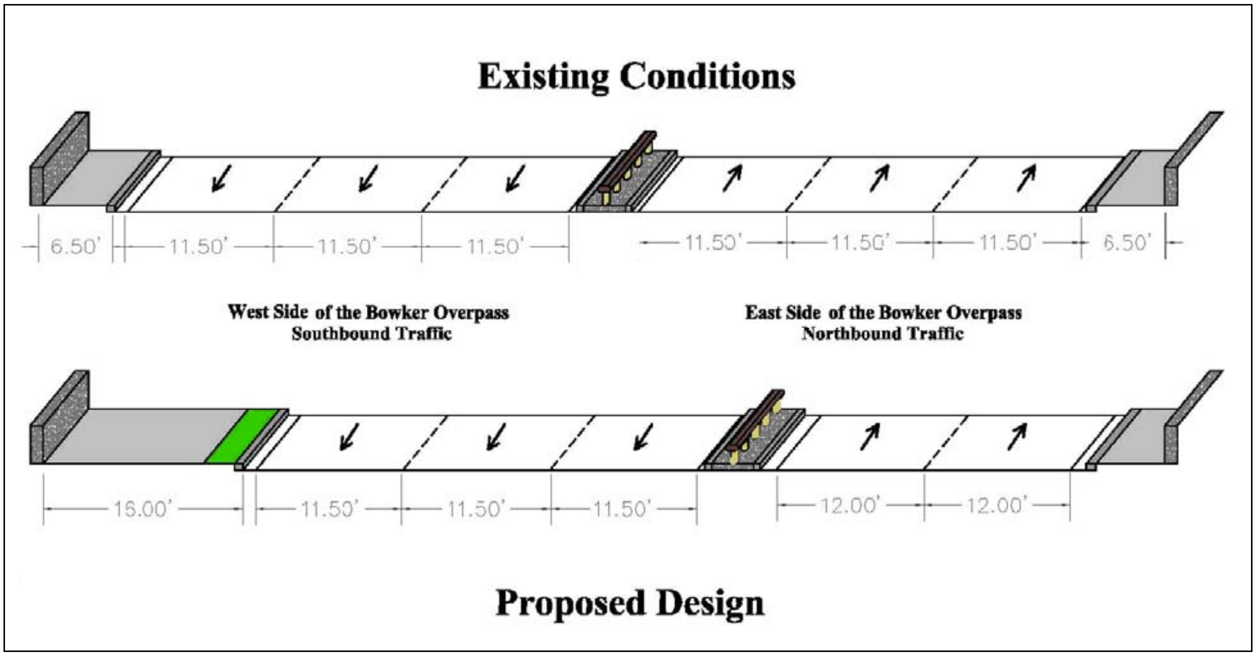


Figure 3.3C: Existing and Proposed Cross Section of the Bowker Overpass
Notice the median is moved to the east eliminating one lane of northbound traffic. This allows for the creation of a 12.5' path buffered from the traffic on the west side of the overpass.

The physical changes continue south into the intersection of the Bowker Overpass and Boylston Street. The westernmost curb line is extended to continue the curb line created when bumping the sidewalk out. The narrow 22.5 ft. southbound right approach is expanded to 25 ft. allowing it to fully function as two lanes improving the capacity of the approach. The widths of the other legs of the intersection have been unchanged. Below in *figure 3.3D* is the design overlaid on the existing conditions. The intersection as a whole functions in the same capacity as before.

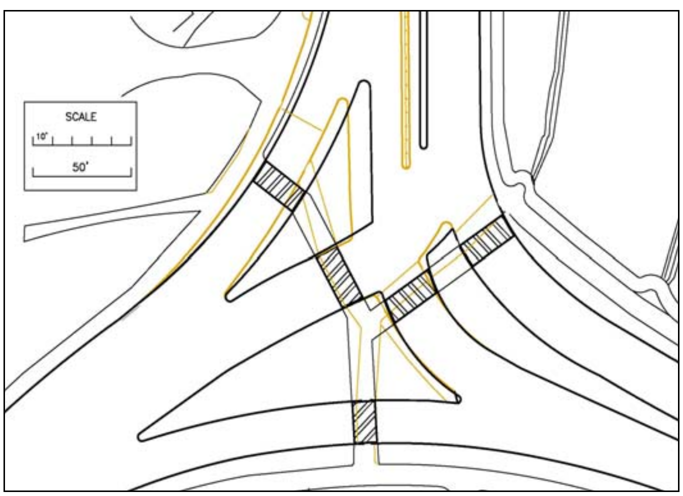


Figure 3.3D: Proposed Design Overlaid on Existing Conditions
The intersection of the Bowker Overpass and Boylston St. The current conditions are in orange the proposed design is in black.

All cross walks at the intersection are 12.0’ wide and feature 8.0’ curb cuts. The 8.0’ curb cuts allow the path to be functional for high volumes of cyclists and pedestrians and keeps ADA compliancy. 12.0’ curb cuts were investigated as an alternative; however given the location of the crosswalks motorists may view a 12’ curb cut as a roadway and not a walkway.

Further north, after the Bowker Overpass northbound exit ramp to Commonwealth Avenue eastbound, the center median is transitioned back to its existing location. The median is shifted at a gentle radius of 1505 ft. This gentle radius will be nearly indistinguishable to drivers traveling in both directions. An image of the proposed layout overlaid on the current layout is provided in *figure 3.3E*. The utmost importance was given to providing drivers with a seamless transition from the section of the existing Bowker Overpass to the updated section.

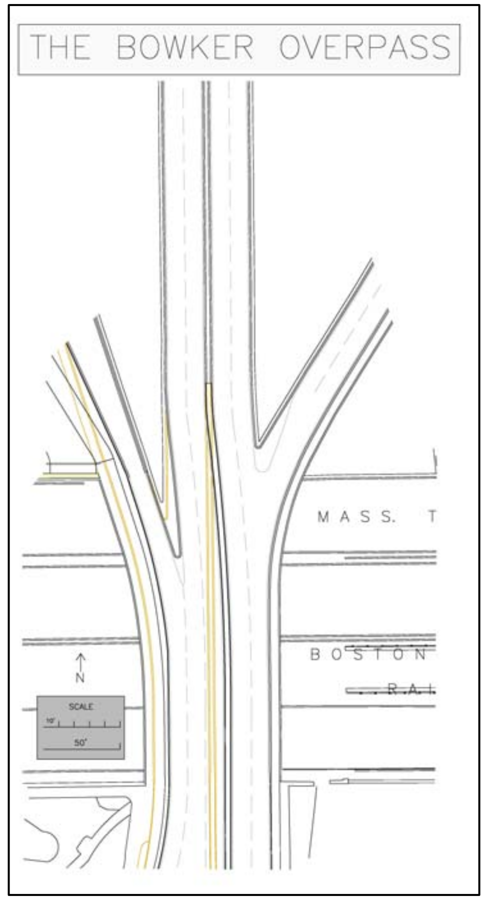


Figure 3.3E: Proposed Design Overlaid on Existing Conditions
The Bowker Overpass: The current conditions are in orange the proposed design is in black.

3.4 Existing Vehicular and Pedestrian Traffic Analysis

3.4.1 Field Measurements and Observation

To analyze the existing conditions, turning movement counts were conducted from 7:45-8:45 AM and 4:45-5:45 PM, field work was performed (intersection geometries, intersection phasing/timing), and City of Boston signal timings were obtained. Vehicular traffic conditions were analyzed and approach delay, volume capacity ratio, and 95th percentile queue length were calculated using Trafficware’s Synchro 6 software, which applies equations from the *Highway Capacity Manual*[3]. The approach’s average delay per vehicle determined the approach’s Level of Service. See Appendix A or vehicular Level of Service Criteria and Pedestrian Level of Service Criteria for parameters.

While performing field work, it was clear that the Bowker Overpass southbound right approach was not functioning properly. The Bowker Overpass is limited to three lanes in the southbound direction. Because of this limited width before the intersection, the southbound right-turn lane group mainly functions as one lane. Only during red time when vehicles are queuing does this lane-group function as two lanes. This geometric glitch causes massive unnecessary congestion.

Another issue observed through field work was an overwhelming delay for pedestrians traveling from the Back Bay Fens to the Charlesgate West side of the Bowker Overpass. Because of multiple islands and crosswalks to travel across and an inadequate pedestrian phasing, many pedestrians were observed waiting extended amounts of time to travel through the entire intersection.

3.4.2 Existing Conditions

The intersection of Boylston Street and Bowker Overpass is a three-way channelized intersection. The Boylston Street eastbound approach consists of two 12-foot left-turn lanes and one 17-foot through lane. The Boylston westbound approach consists of two 12-foot right-turn lanes. The Bowker overpass southbound consists of two 12-foot left-turn lanes and one 22.5-foot right-turn lane. Five crosswalks are located in this intersection and are labeled A-E for reference. A diagram of the intersection including cross walk labels is provided in *figure 3.4A*. The signal timing plan for the existing AM and PM Peak hours can be found below in *figure 3.4B* and *figure 3.4C* consisting of concurrent pedestrian phases.

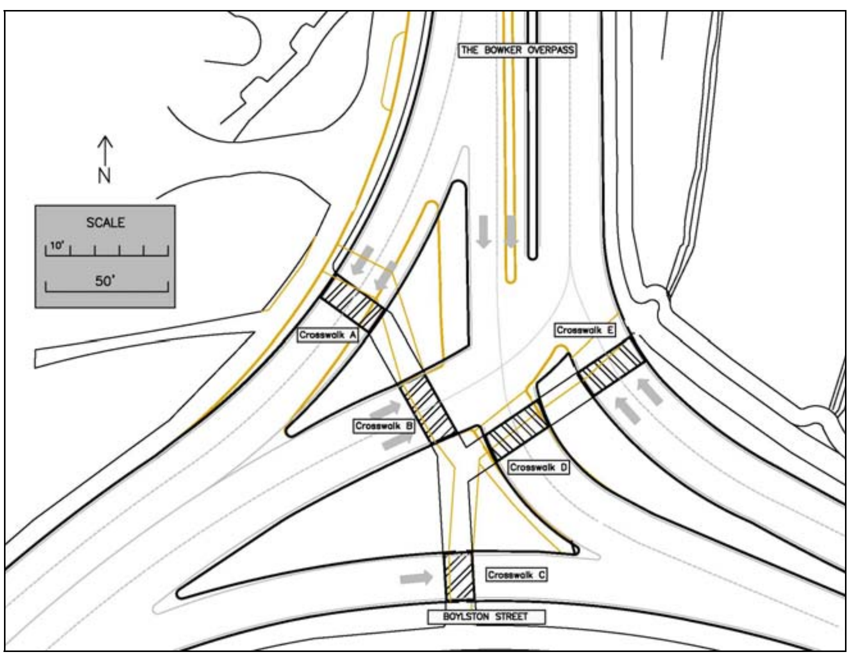


Figure 3.4A: Intersection Geometry
Proposed intersection geometry for intersection 1. The existing conditions are in orange and the proposed conditions are overlaid in black.

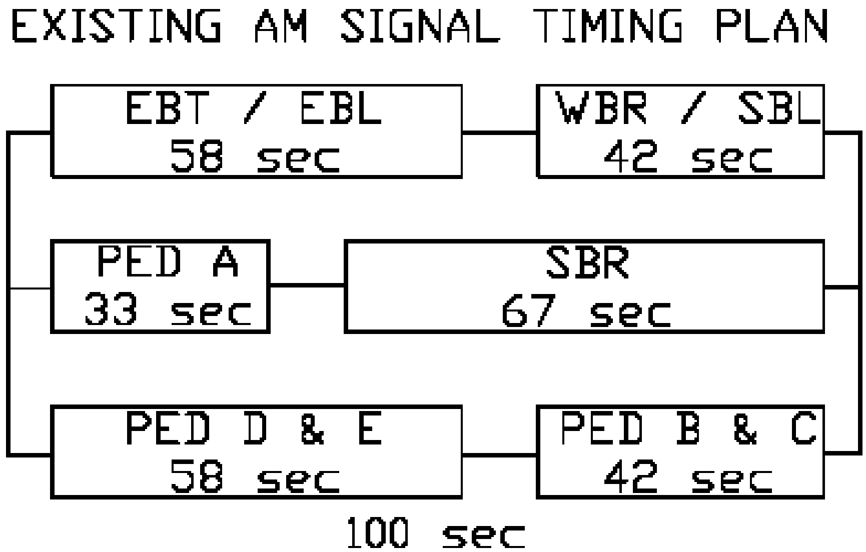


Figure 3.4B: Existing AM Signal Timing Plan

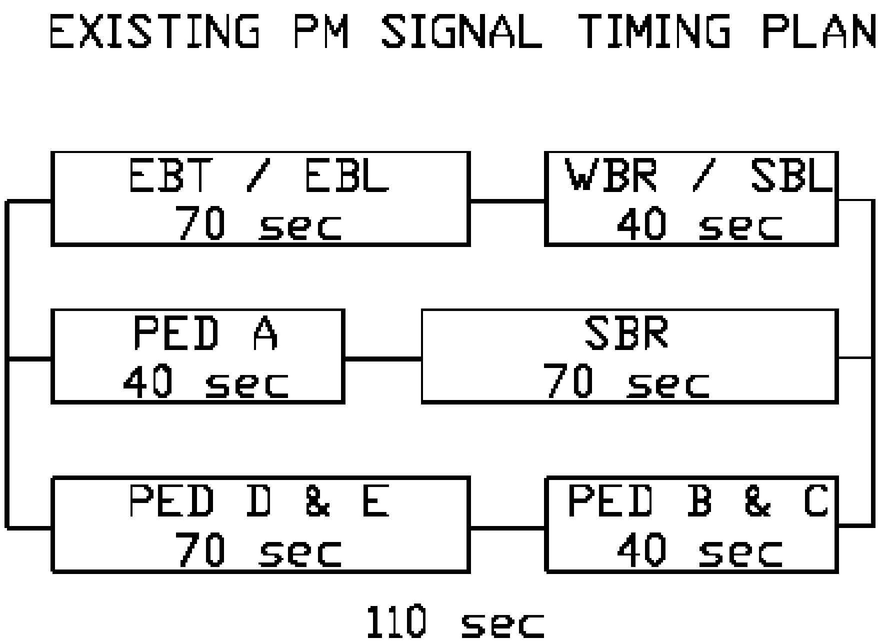


Figure 3.4C: Existing PM Signal Timing Plan

3.5 Modification of Vehicular and Pedestrian Traffic

3.5.1 Overpass Median and Island Modification

The main modification at this intersection is the shift of the Bowker Overpass median to the east. Shifting this median east will allow for the addition of a multi-use path on the west side of the Bowker Overpass.

Slight geometric modifications were made to the Boylston Street/Bowker Overpass intersection for two major reasons: to minimize pedestrian crossing distance when using the proposed multi-use path and to enhance the capacity of the Bowker Overpass southbound right-turn approach. The first is achieved by skewing the pathways on the multiple islands to be more direct and moving Crosswalk A (across southbound right approach) south, farther from the Bowker Overpass. This will not only make for a more direct pathway for pedestrians, but it also relocates the stop line for the Bowker Overpass southbound right approach. Moving this stop line south will also allow for more vehicles to queue in two lanes. The island separating the Bowker Overpass southbound right and left turn approaches is also expanding to the east and to the north. The island is also being reduced on the west side of the island. This will channelize these two approaches earlier, allowing both approaches to function as two lanes earlier in the approach. In order to increase this approach's lane utilization so that it will function more like two lanes instead of one, the southbound right approach will be widened, the approach will be channelized the farther from the intersection, and the stop line will be relocated. This will in turn minimize delay and heighten vehicle level of service at this approach.

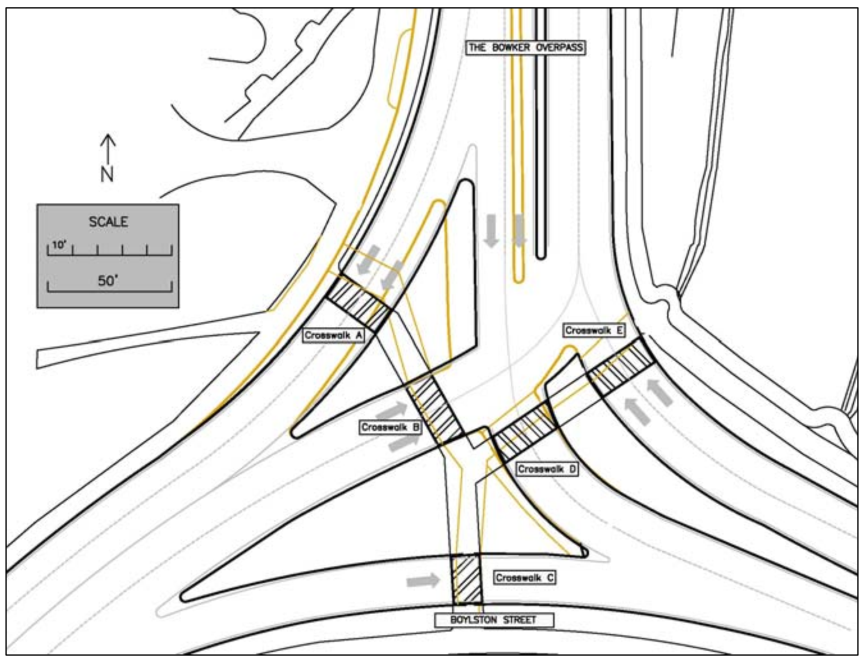


Figure 3.5A: Intersection Modification

3.5.2 *Signal Timing Modification-AM Peak Hour*

Signal timing modifications are proposed to first improve pedestrian level of service for the proposed multi-use path and to maintain or improve vehicular level of service in the intersection. The existing AM Peak hour results can be seen in the left half of *Table 3.5A*. The pedestrian level of service pathway is focused on our multi-use path across crosswalks A, B, and C in both directions.

Table 3.5A
Boylston Street and Bowker Overpass: AM Peak Hour Vehicular and Pedestrian Level of Service

	Existing				Proposed			
Intersection Approach	LOS	Delay (sec)	V/C Ratio	95th% Queue Length	LOS	Delay (sec)	V/C Ratio	95th% Queue Length
1:Boylston Street/Bowker Overpass	**D**	**46.2**	**0.89**		**C**	**26.0**	**0.89**	
Boylston EB Left	B	16.1	0.54	259	C	26.3	0.71	343
Boylston EB thru	B	12.1	0.18	92	B	19.4	0.24	122
Boylston WB right	E	62.7	0.93	#424	C	23.4	0.76	365
Bowker SB left	C	31.4	0.77	373	B	18.3	0.57	286
Bowker SB right	E	71.5	1.09	#1116	C	34.7	0.98	1068
Pedestrian Fens to Charlesgate West	E	41.2	-	-	D	38.7	-	-
Pedestrian Charlesgate West to Fens	F	69.0	-	-	D	38.1	-	-

= 95th percentile exceeds capacity.

As seen in the table above, the intersection of Boylston Street and the Bowker Overpass during the AM peak hour is operating at unsatisfactory levels, with an overall level of service of D. The Boylston street westbound right approach and the Bowker Overpass southbound right approach are the lowest functioning in the intersection, both with average delays of over a minute. Also, the average pedestrian delay in both directions is 41.2 and 69 seconds of delay in the northbound and southbound directions respectively. The northbound average delay is an acceptable delay, but the southbound approach delay is unsatisfactory. Pedestrian Delay calculations can be found in Appendix A. While the geometric modifications will aid in improving both vehicular and pedestrian delay, changing the signal timing plan for the intersection will have a much larger impact. See *figure 3.5B* below for proposed AM Peak Hour signal timing plan with pedestrian green waves shown.

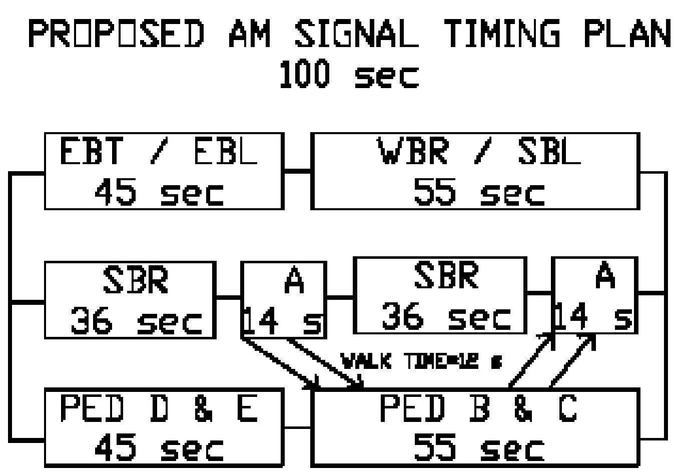


Figure 3.5B: Proposed AM Phasing/Timing

The Boylston Street westbound right approach and Bowker Overpass southbound left both had existing levels of service of E. By shifting green time from EBT/EBL to WBR/SBL (from an existing 42 seconds to a proposed 55 seconds), their levels of service were both improved to a C. The other signal timing plan modification is making the SBR/Crosswalk A conflict pair double cycle. This means that both the southbound right approach and crosswalk A will be given two green times each cycle (once every 50 seconds). By having two shorter pedestrian cycles (7 seconds of walk, 7 seconds of flashing don't walk), pedestrians will have more opportunities to cross crosswalk A and therefore decrease the average pedestrian delay. With the existing geometry, only four cars will be doubled up in queue at the southbound right approach, while the rest of the cars traveling through intersection use the approach as one lane giving the approach a lane utilization factor of .5625. With the proposed geometry changes, 6 cars will be able to double up in queue at this intersection. Also, with the new signal timing plan, this approach will have red time twice in each cycle, allowing cars to double up twice a cycle. With the added space for cars to double up, and the additional opportunity to double up each cycle, the proposed lane utilization is increased to .66. Pedestrian delay is also reduced because of the added green time for crosswalks B and C, as well as added opportunity for pedestrians to cross crosswalk A. Delay is reduced from 41.2 seconds to 38.7 seconds in the northbound direction, shaving a few seconds off an already fair delay. In the southbound direction, delay was reduced from 69 seconds to 38.1 seconds, almost cutting delay in half for pedestrians.

By making these phase changes seen in figure *3.5.B*, the Level of Service for the Boylston Street/Bowker Overpass was improved from a D to a C and pedestrian delay is nearly cut in half. See Appendix A for Synchro reports and pedestrian delay calculations.

3.5.3 Signal Timing Modification-PM Peak Hour

Just like the AM Peak Hour modifications, signal timing modifications are proposed to improve pedestrian level of service for the proposed multi-use path and to maintain or improve vehicular level of service in the intersection. The existing PM Peak hour results can be seen in the left half of *Table 3.5B*. The pedestrian level of service pathway focused on our multi-use path across crosswalks A, B, and C in both directions.

Table 3.5B
Boylston Street and Bowker Overpass: PM Peak Hour Vehicular and Pedestrian Level of Service

	Existing				Proposed			
Intersection Approach	LOS	Delay	V/C Ratio	95th% Queue Length	LOS	Delay	V/C Ratio	95th% Queue Length
1:Boylston Street/Bowker Overpass	F	93.7	0.93		**C**	**30.2**	**0.80**	
Boylston EB Left	B	13.1	0.48	235	C	27.3	0.66	359
Boylston EB thru	A	9.7	0.12	65	B	19.6	0.17	100
Boylston WB right	F	237.3	1.43	#737	D	39.3	0.94	#581
Bowker SB left	D	38.5	0.78	371	B	19.0	0.51	262
Bowker SB right	D	51.0	1.01	#931	C	32.9	0.92	445
Pedestrian Fens to Charlesgate West (NB)	E	39.0	-	-	D	34.4	-	-
Pedestrian Charlesgate West to Fens (SB)	F	76.2	-	-	E	42.4	-	-
# = 95th percentile exceeds capacity.								

As seen in *Table 3.5B* above, the overall level of service is F, signifying the failure of the intersection. Also, the Boylston street westbound right approach and the pedestrians traveling on the multi-use path in the southbound direction both have a level of service of F with delays of over a minute. With such low delays for the eastbound left/eastbound through approaches and overwhelming delays in the westbound right/southbound left approaches, it can be determined that there is an imbalance of green time for the existing signal timing plan. This can be improved by altering the signal timing plan of the intersection. See *figure 3.5C* below is the proposed signal timing plan for the PM peak hour with pedestrian green waves shown.

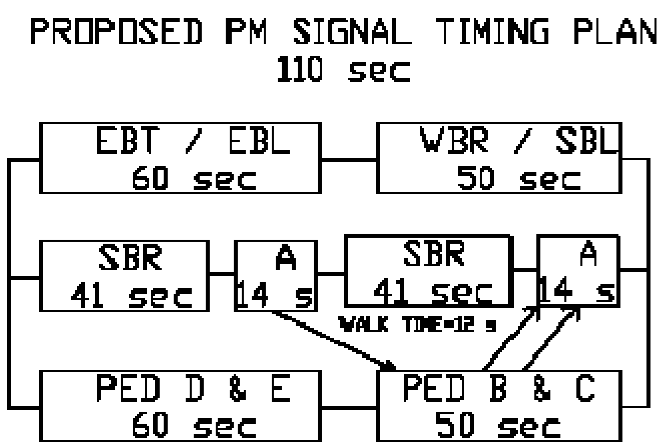


Figure 3.5C: Proposed PM Phasing/Timing

By modifying the signal timing plan, both vehicular and pedestrian levels of service improve greatly. The westbound right and southbound left approaches were given more green time because of their large existing volumes and poor levels of service. By giving these two approaches an extra 10 seconds of green time, delay for both approaches was reduced. The overall intersection level of service was improved from an F to a C, reducing delay from 93.7 seconds to 30.2 seconds. This huge improvement is a direct result of the westbound right, southbound left, and southbound right approaches decreasing their delay. Westbound right and southbound left approaches improved from being given 10 more seconds of split time while the southbound right approach improved because of geometric and signal timing changes. The geometric changes allowed the approach to function more like a two-lane approach instead of one wide lane. Signal timing changes gave the approach more split time, even if the green time is split into two 55-second cycles.

To improve pedestrian delay, crosswalk A and the southbound right approach conflict pairs was once again given half-cycles. This allows two opportunities for pedestrians to cross crosswalk A during each 110-second cycle. This new half-cycle for crosswalk A cuts the delay for pedestrians traveling in the southbound direction from 76.2 seconds to 42.4 seconds, but makes little improvements for the northbound direction (from 39 seconds to 34.4 seconds).

By analyzing the existing conditions of this intersection, it is clear that it is not functioning to its full capacity. By making these timing/phasing changes to both AM and PM peak hour timing and phasing, pedestrians can be accommodated. Because of the multiple-crosswalk route that our multi-use will be taking, it is key to look at the signal timing plan as a whole for pedestrians instead of looking at each crosswalk separately. The other goal of modifying this intersection was to maintain vehicular capacity when trying to improve pedestrian level of service. Through geometric and signal timing modifications, the intersection will be fully functional and will operate at or below capacity.

4.0 ON-RAMP

4.1 Overview of the Section

The main goal of this section of path is to get users down from the Bowker Overpass to Commonwealth Avenue. Three major concerns that need to be addressed are:

1. Keeping the connection to Charlesgate West and Newbury Street
2. Providing a handicap accessible route in compliance with the Americans with Disabilities Act standards
3. Minimal affect to motorists

The main change to the layout of this section is reducing the on-ramp from two lanes of traffic to one before it connects to the overpass. This is done by moving the curb line.

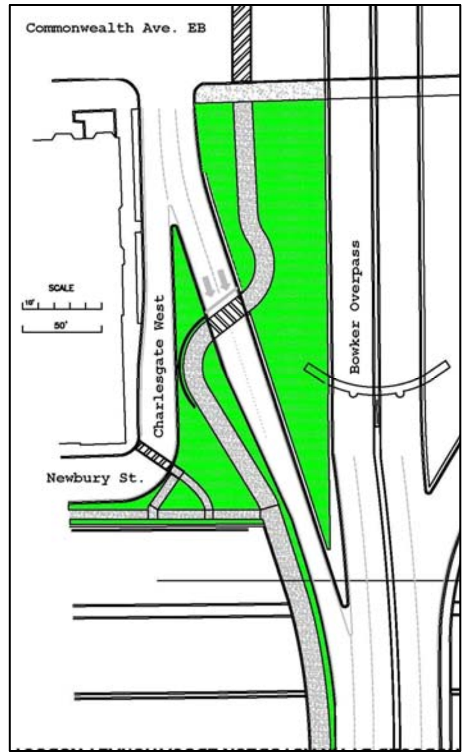


Figure 4.1A: Design

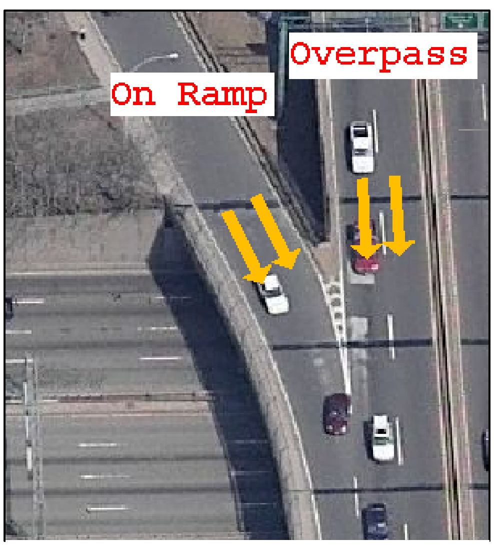


Figure 4.1B: Merging Nightmare

As the configuration currently stands, two lanes of the on-ramp traffic merge into one lane while merging with one lane of the overpass traffic. There is just over 50 ft. for these movements to be made. That means drivers traveling 30 mph have less then 1.5 seconds to merge. The new configuration breaks the two merging phases into two distinct phases. First the two lanes of the on-ramp traffic merge down to one lane. This merge is done over a length of 100 ft. providing drivers twice the time to merge. The two lanes are narrowed to one lane through the use of multiple visual cues including lane markings, signage, but most importantly curb lines. Drivers can ignore signage and lane markings; however it is impossible to ignore a curb. The major problem with the existing configuration is that it relies on only lane markings to merge traffic. The byproduct of narrowing the on-ramp as it approaches the overpass is that is provides the necessary space required for the multi-use path.

4.2 Bowker Overpass On-ramp Design Alternatives

The objective of this section is to get the path down off of the Bowker Overpass to Commonwealth Avenue on the east side of the Charlesgate East and Commonwealth Avenue Eastbound intersection. Six alternatives were considered before one was ultimately chosen for design. The six alternatives are:

- **(A)** A path that crossed over Charlesgate West then back over the on-ramp.
- **(B)** A path that continued down to the intersection.
- **(C)** A path that looped around and under the on-ramp
- **(D1, 2, 3)** The final three alternatives were paths that crossed over the on-ramp at different locations. *Figure 4.2A* shows conceptually where each alternative would lie.

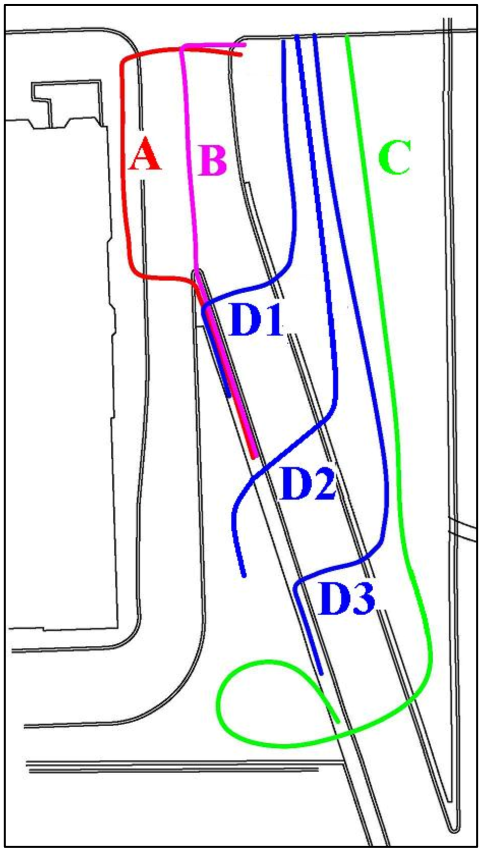


Figure 4.2A: Conceptual Layout
This figure shows the six alternative path locations.

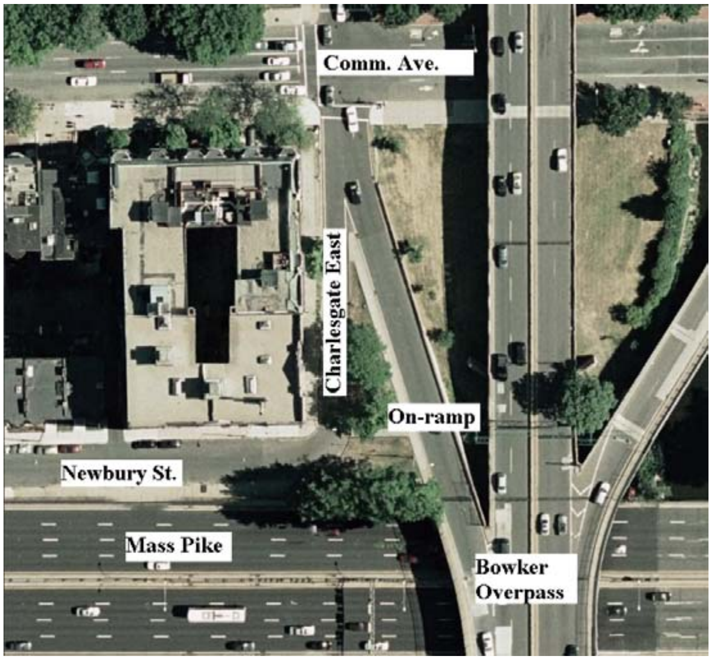


Figure 4.2B: Area Map
This image is presented to give the reader an idea as to the location of the conceptual alternatives.

4.2.1 Feasibility Issues with Each Alternative

Alternative A

Alternative A is the most cost effective of all alternatives. It only requires that curb cuts and striping be added. However this design is unacceptably dangerous. It would be impossible to provide the low grade approach and level landings required to allow users a safe place to stop. It requires that path users cross over the Charlesgate East traffic stream twice in order to continue on the path. Secondly, it requires the use of the existing sidewalk on the west side of Charlesgate West; however this sidewalk is has only 6.5' of effective width which is not in keeping with the necessary 12' needed to support a multi-use path. Lastly, crossing Charlesgate West at this point relies on the existing sidewalk down the west side of the on-ramp. This sidewalk does not have the needed length to provide a level landing at the base. Without such a landing users would be at risk of careening into the intersection.

Alternative B

This alternative looked to extend the median down to the intersection. This idea was not feasible. There is simply not enough width (35.5') to allow for two lanes of on-ramp traffic, one lane of Charlesgate West traffic and a median wide enough to support the path. Furthermore, even if one lane of traffic could be eliminated to provide space, bringing the median all the way down to the intersection would create a double intersection creating confusion for drivers.

Alternative C

This alternative looked to loop the path underneath the on-ramp. This is the least feasible of all alternatives. The cost of tunneling under the overpass would be immense. Additionally, there is not enough room available to make the loop. Lastly, the elevation of the on-ramp is not sufficient to allow for a pathway underneath without dropping down several feet below the grade of Charlesgate East / Newbury Street.

Alternatives D1, 2, 3

These alternatives are very similar to the one chosen for the design. Alternative D1 was too far north. It would not allow for adequate room to stack cars in the queue. D3 is too far south. It would require excessive fill to create the ramp down to Commonwealth Avenue. Furthermore it did not leave motorists enough room to get up to speed for the oncoming merge with the Bowker Overpass. Alternative D2 became the basis for the design. It found the medium between adequate queue space, minimizing fill, and providing the distance needed for cars to get up to speed.

4.2.2 The Chosen Design for the Bowker Overpass On-ramp

The current configuration has a steep, narrow path that runs down the west side of the on-ramp (*figure 4.2B*). This path abruptly ends where the on-ramp splits with Charlesgate East. At this point pedestrians are dumped out into the middle of the road. The situation is even worse for those with a physical disability. Where the sidewalk ends at the split there is no consideration for the handicapped. Further south there is a ramp connecting down to Charlesgate East, but the slope is far too steep and it does not provide the necessary landings to be ADA compliant. A design was created to alleviate all these problems. The layout is presented below.

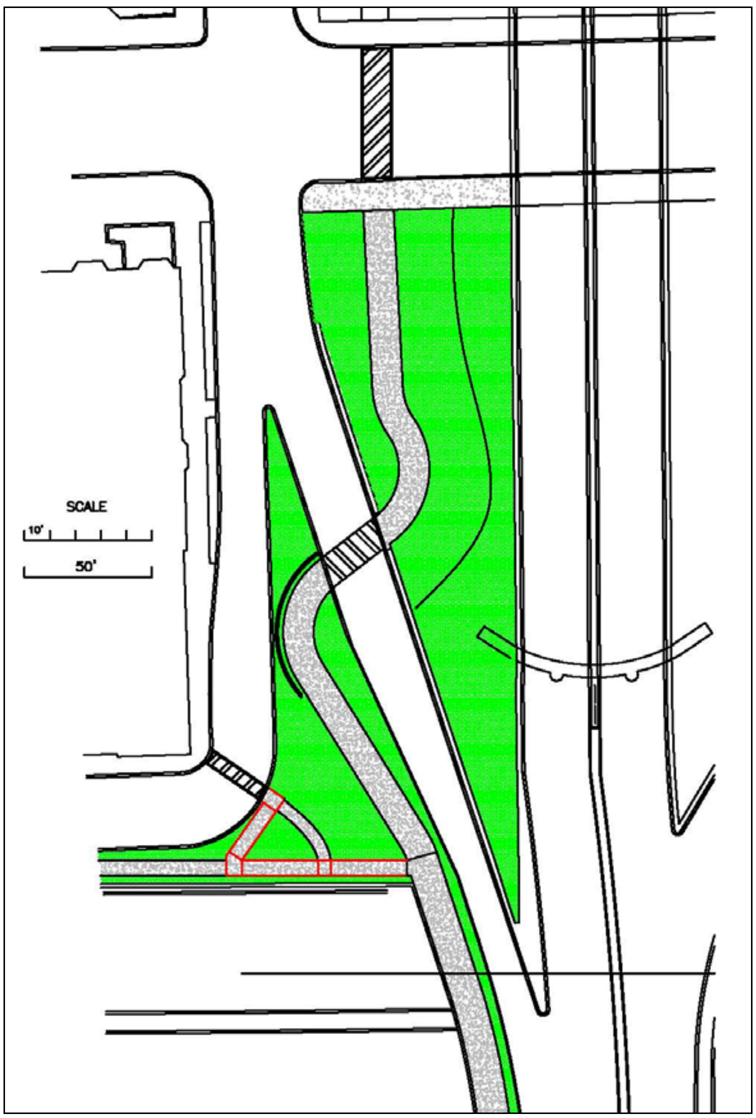


Figure 4.2C: Design Alignment.

The east side of the intersection was chosen as the cross point for Commonwealth Avenue for three main reasons:

1. Crossing at this point allowed for a concurrent pedestrian walk phase during the time in which Charlesgate West has a green light

2. It keeps the path users which at this point are comprised of mostly through users from becoming entwined with local pedestrians on the west side of the intersection

3. It allows for the utilization of the upcoming Olmsted's Charlesgate Park which not only provides the needed space for the path but also will re-invigorate the park

As the path comes off from the overpass it sweeps around in an S-curve to intersect the on-ramp at an angle of 70°. This S-curve and intersecting angle are of critical importance as they serve two major safety purposes. First, it slows down path users especially bicyclists before the intersection. Secondly, it provides a visual cue to drivers that they are about to intersect a crosswalk. This makes a driver conscious of the pedestrians and bicycles crossing.

The crossing will be done 145 ft. south of the intersection of Charlesgate East and Commonwealth Avenue Eastbound. At the crossing there will be a traffic signal which will provide pedestrians and cyclists a protected crossing. Specific details regarding the potential traffic implications are discussed later in Section 4.3. The 145 ft. distance from the intersection allows for 10 to 12 cars to be stacked in the queue without backing up into the intersection.

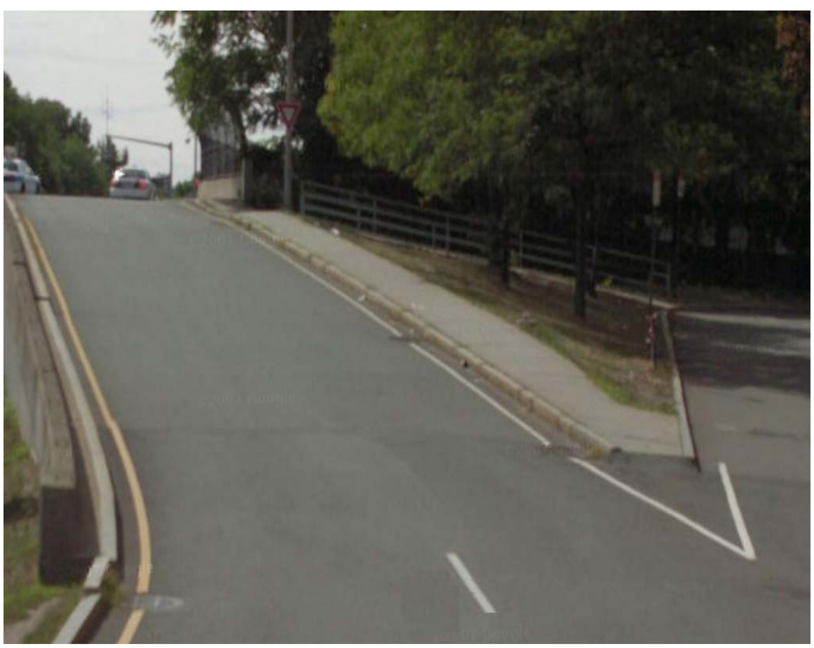


Figure 4.2D: Current Conditions
This is the current layout looking at the on-ramp from intersection 2. Notice the steep narrow 6' sidewalk that abruptly ends as the roadway splits. This dumps users into the middle of the roadway.

4.2.3 Olmsted's Park

Once across the on-ramp the path continues down into the southern most are of Olmsted's Charlesgate Park. The elevation difference between the height of the on-ramp crossing and the elevation of the park is 12 ft. This requires an earthen embankment to be constructed. A new grading plan for this section is available in *figure 4.2E*. The ramp continues down to the existing side walk on the south side of Commonwealth Avenue. The ramp slopes down at roughly a 6 % grade. The side slopes for the ram do not exceed 2:1 (2' run for every 1' of rise). Typical cross sections have been constructed and two are available in *figure 4.2D/E*.

Figure 4.2E: Re-grading
The proposed re-grading plan.

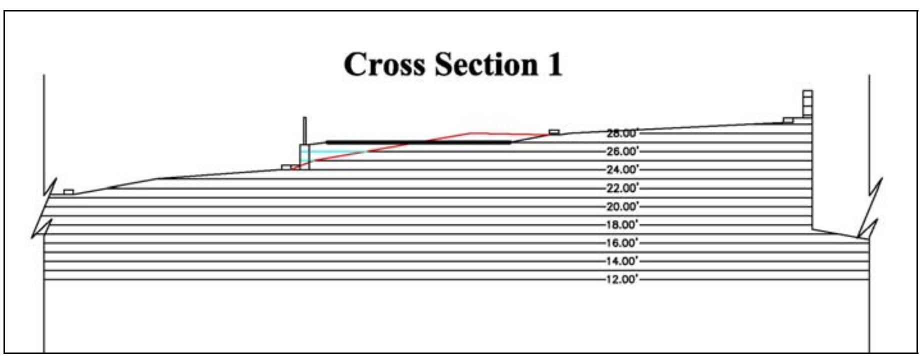


Figure 4.2F: Cross Section 1

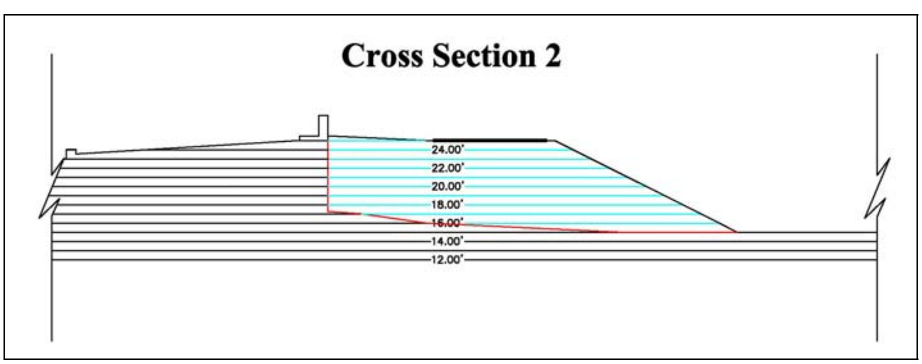


Figure 4.2G: Cross Section 2

4.2.4 ADA Ramp and Newbury Street Connection

As stated in the introduction to this section creating an ADA compliant connection is of the upmost importance. To create this the current non-compliant ramp is removed. It is replaced with a ramp that starts near the connection to the overpass. This ramp is designed at a 1/12 slope with landings ever 30 linear feet. As seen in *figure 4.2F* the ramp takes users coming from the overpass to corner where Charlesgate East turns into Newbury Street. It ends at a crosswalk on the corner to ensure that users will have a clear sight line to the oncoming traffic, while allowing drivers to easily see the crosswalk. This is the ideal place for the crosswalk for two reasons:

1. Drivers are slowing down to make the sharp turn onto Newbury
2. The crosswalk width would be 25’

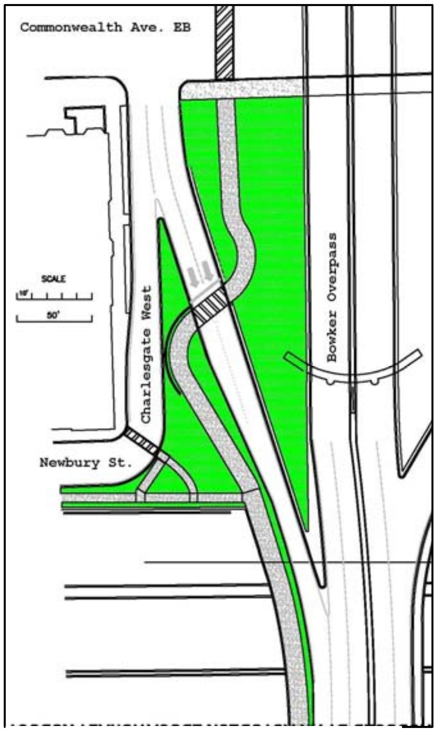


Figure 4.2H: Locus Map of ADA Ramp

The slow speed of drivers coupled with the long sightlines allows this crossing to only be marked (painted striping in street) without the need of a stoplight or stop sign to protect users. This ramp will additionally connect down to the existing sidewalk on the south side of Newbury Street.

The main path down to Commonwealth Avenue is not ADA compliant. It is gentler then 1/12 slope but it does not have the space needed for landings and it does not include ADA handrails. Furthermore, where the path crosses the onramp the side slope is in excess of 8% which greatly exceeds the maximum 2% as laid out by ADA guidelines. It is the opinion of this group that the ADA path discussed above is an acceptable alternative to not having the main path be completely compliant. This opinion was formed based on the assumption that most handicap users would be making local trips and a ramp down to Newbury and Charlesgate East would better serve their needs. Furthermore, if a handicap user wishes to continue on to the esplanade they can rejoin the path where it intersects with Commonwealth Avenue Eastbound, only adding

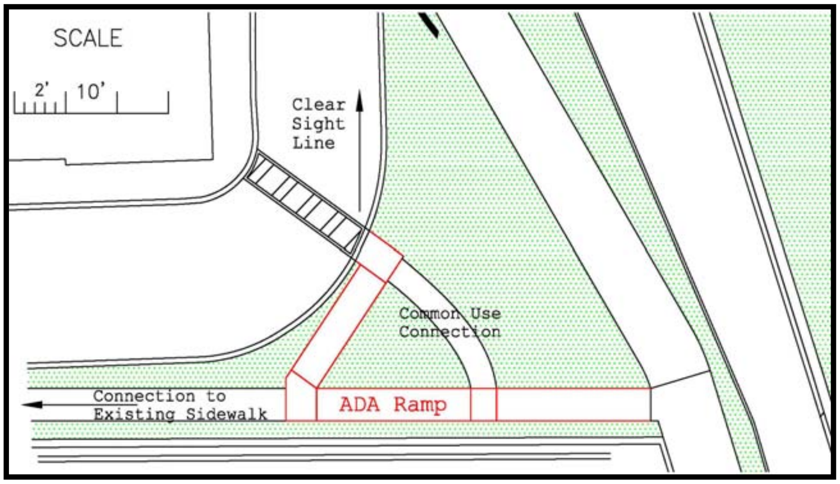


Figure 4.2I: ADA Ramp

4.3 Traffic Impact and Level of Service

This intersection is critical from a traffic standpoint because the designed multi-use path crosses two legs of the intersection. It crosses (1) at the on-ramp to the Bowker Overpass south of the intersection and (2) at Commonwealth Avenue Eastbound, east of the intersection. Additionally the proposed design introduces a new signal on the on-ramp that will be part of the Commonwealth Avenue Eastbound/Charlesgate west intersection analysis. Simultaneously, bike lane plans for Commonwealth Avenue Eastbound call for the road to be reduced to three travel lanes at this intersection. Therefore, intersection was analyzed to determine the impact of all proposed modifications.

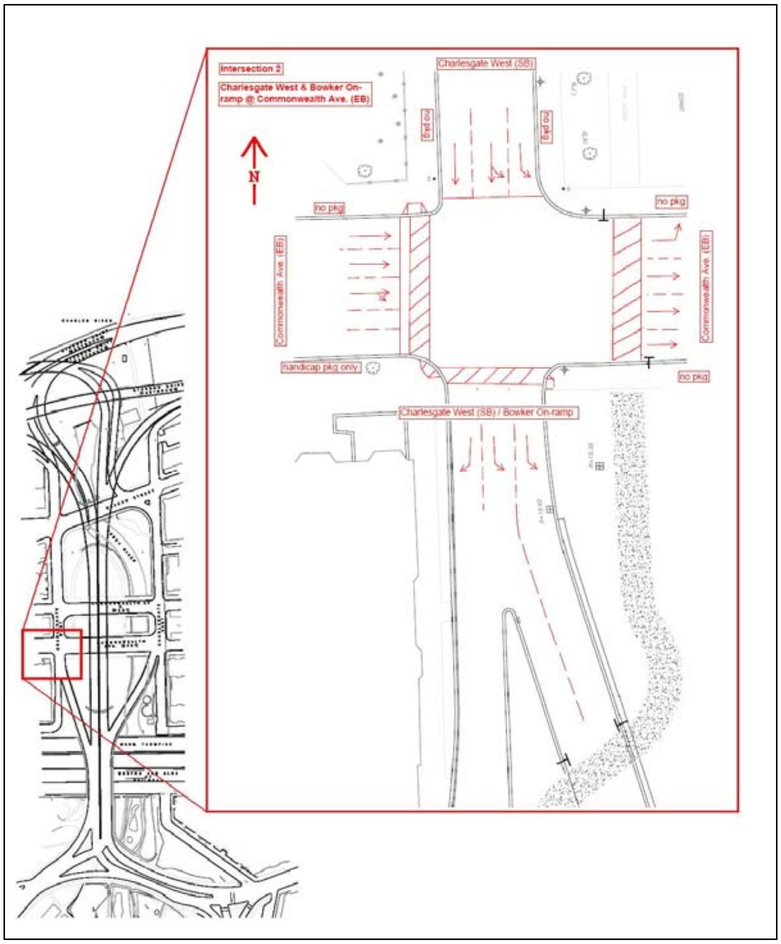


Figure 4.3A: Charlesgate West and Commonwealth Avenue Eastbound (Intersection 2)

4.3.1 Field Measurements and Observations

To analyze existing conditions, intersection geometries, intersection signal timing, and turning movement counts were conducted from 7:45-845 AM and 4:45-5:45 PM. The City of Boston provided signal timing plans. Event recording style counts were conducted to determine the vehicle activity on the on-ramp to the Bowker Overpass. In order to determine when during the signal timing plan there was the lowest activity on the on-ramp, so that the path could be given the right of way at this time. A concern to take into account is that Boston University has buses routinely entering the intersection at Commonwealth eastbound and turning right onto the on-ramp. These buses must be considered because of their length for queuing on the on-ramp to Bowker Overpass.

Fewer cars are traveling on the on-ramp during the eastbound through/right phase. See detailed car counts in Appendix A.

4.3.2 Existing Conditions

See *figure 4.3A* for existing layout. The intersection of Commonwealth Avenue Eastbound and Charlesgate West is a 4-way intersection consisting of two one-way approaches. The Commonwealth Avenue Eastbound approach contains four 10-foot through lanes and one 10-foot right-turn lane. The eastern leg of the intersection consists of one 13.5-foot right-turn lane and three 12-foot through lanes. The Charlesgate West Southbound approach consists of two 11-foot through lanes, and one 10.5-foot left-turn lane. The southern leg of the intersection splits into one 15-foot lane continuing as Charlesgate West and two 11-foot wide on-ramp lanes to the Bowker Overpass. There is an 8-foot wide crosswalk across the Commonwealth Avenue Eastbound approach as well a 7.5-foot wide crosswalk spanning the southern leg of the intersection. Handicapped parking is available on the southern side of the Commonwealth Avenue Eastbound approach. Parking is not permitted on any other roads adjacent to the intersection. This intersection functions very well at a level of service of B and an average delay of 13.4 seconds and 13.2 seconds during the AM peak and PM peak respectively. Because the bike path will be traveling through this intersection, the goal is to maintain the intersection's level of service once introducing the bike lane to the network.

4.3.3 Intersection Modifications - Additional Signal

For the multi-use path, pedestrians and bicyclists on the on-ramp need a right-of-way to cross safely. To facilitate this, a traffic light with pedestrian signals will be installed 140 feet from the intersection. The 25-second pedestrian phase will be activated during the Commonwealth Eastbound through/right phase because it was determined be time when the lowest activity was on-ramp. Through use of detailed car counts, timing/phasing, and headway times it was determined that the optimal time to give the bike lane right-of-way is 10 seconds after Commonwealth Avenue Eastbound Thru/Right Turn phase is given green. Once the Commonwealth Avenue Eastbound queue clears (approximately 10s) the number of cars making a right turn onto the overpass is negligible. See *figure 4.3B* for proposed AM peak hour signal timing plan for Commonwealth Avenue Eastbound and Charlesgate West with coordinated signal timing plan for proposed signal on the on-ramp. There will also be an unrelated geometric modification seen in the proposed design. Another proposed bike lane for another group has proposed the design of a bike lane on the south side of Commonwealth Avenue Eastbound.

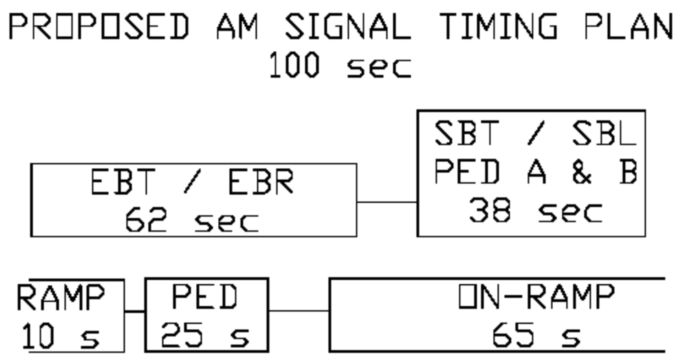


Figure 4.3B: Proposed AM Peak Hour Signal Timing Plan

Through analysis, it was determined that the 95th percentile queue would be 11 feet and 30 feet in the AM and PM peak hours respectively See *table 4.3.A and 4.3.B* for AM and PM Peak Hour Vehicular and Pedestrian Level of Service. This analysis was especially important because it proved that adding a signal on the on-ramp would not produce a queue long enough to spill back into intersection 2. This new intersection will have a level of service of A, showing it will not reduce delay or level of service to the network.

Table 4.3A
Commonwealth Avenue Eastbound and Charlesgate West: AM Peak Hour Vehicular and Pedestrian Level of Service

	Existing				Proposed			
Intersection Approach	LOS	Delay	V/C Ratio	95th% Queue Length	LOS	Delay	V/C Ratio	95th% Queue Length
2:Commonwealth Avenue EB/Charlesgate West	**B**	**13.8**	**0.36**		**B**	**18.5**	**0.41**	
Commonwealth EB thru	A	5.6	0.28	128	A	4.6	0.33	118
Commonwealth EB right	A	4.9	0.11	31	A	-	-	-
Charlesgate West SB left/thru	C	31.9	0.61	113	D	48.6	0.75	187
8:On-Ramp to Bowker Overpass/Bike Path	**-**	**-**	**-**	**-**	**A**	**1.1**	**0.20**	
On-Ramp SB thru	-	-	-	-	A	1.1	0.20	10
Pedestrian Ramp Crossing	-	-	-	-	C	32.8		

Table 4.3B Commonwealth Avenue Eastbound and Charlesgate West: PM Peak Hour Vehicular and Pedestrian Level of Service								
	Existing				Proposed			
Intersection Approach	LOS	Delay	V/C Ratio	95th% Queue Length	LOS	Delay	V/C Ratio	95th% Queue Length
2:Commonwealth Avenue EB/Charlesgate West	**C**	**25.3**			**B**	**16.8**	**0.56**	
Commonwealth EB thru	C	34.5	0.78	223	A	6.1	0.50	246
Commonwealth EB right	C	29.2	0.30	87	-	-	-	-
Charlesgate West SB left/thru	A	6.6	0.21	72	C	28.1	0.72	253
8:On-Ramp to Bowker Overpass/Bike Path	**-**	**-**	**-**	**-**	**A**	**2.8**		
On-Ramp SB thru	-	-	-	-	A	2.8	0.14	30
Pedestrian Ramp Crossing	-	-	-	-	C	28.1		

4.3.4 Concurrent Pedestrian Phase

A crosswalk will be added to the eastern leg of the intersection of Commonwealth Avenue Eastbound and Charlesgate West. A concurrent pedestrian phase will be added to the signal timing plan during the southbound through/right phase. This will make the proposed Commonwealth Avenue eastbound approach loses a lane, leaving 2 through lanes and one shared through/right turn lane. This explains the gap found in the proposed LOS tables for eastbound right. This will cause cars turning left right from Charlesgate West Southbound to yield to pedestrians, but will not add delay to the approach.

5.0 OLMSTEAD'S PARKLAND

5.1 Park Layout

A key focal point in the design of the shared-use path alignment was to enhance the existing park land in, what is now known as, the Charlesgate area. *Figure 5.1A* shows how there currently are four patches of park land divided by Commonwealth Avenue Eastbound and Commonwealth Avenue Westbound. This park land is quaint, but hardly ever occupied, so it is appropriate to make it more accessible by using the space for the Charlesgate Connector.

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5.1.1 Patch 2

Patch 2 lies in between Commonwealth Avenue Eastbound and Westbound and in between Charlesgate West and the Muddy River *(figure 5.1B)*. There is an existing brick sidewalk along the east side of Charlesgate West and a brick walkway 17 feet to the east. That walkway will be replaced by the shared-use path making it wider and smoother to ride a bicycle or wheelchair on. Also, the 26 foot buffer will totally separate the path from traffic on Charlesgate East, making it more comfortable for vehicles traveling on Charlesgate East and cyclists and pedestrians traveling on the shared-use path *(figure 5.1C)*.

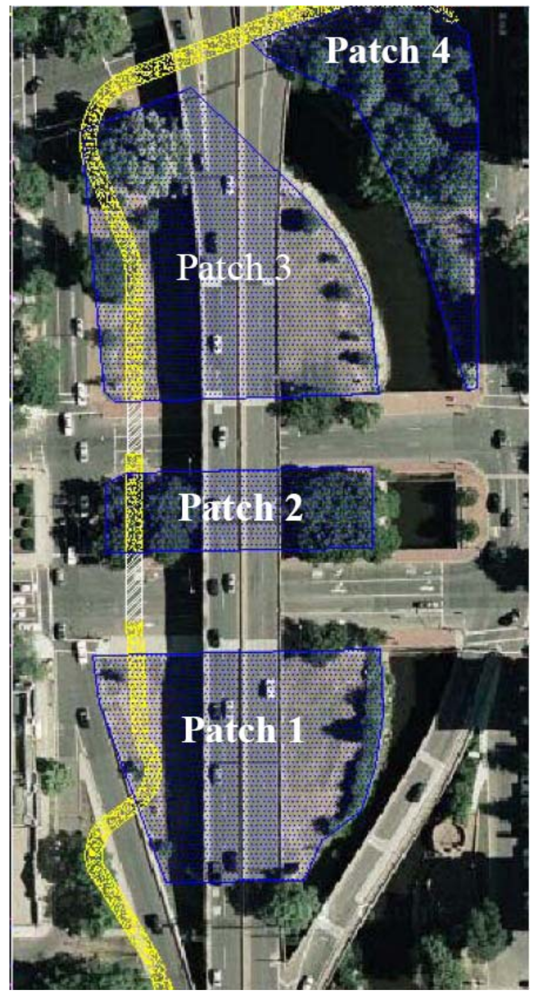


Figure 5.1A: 4 Patches
Patch 1 is discussed in chapter 4 *(figure 4.2H)* and patches 2-4 will be discussed in this chapter

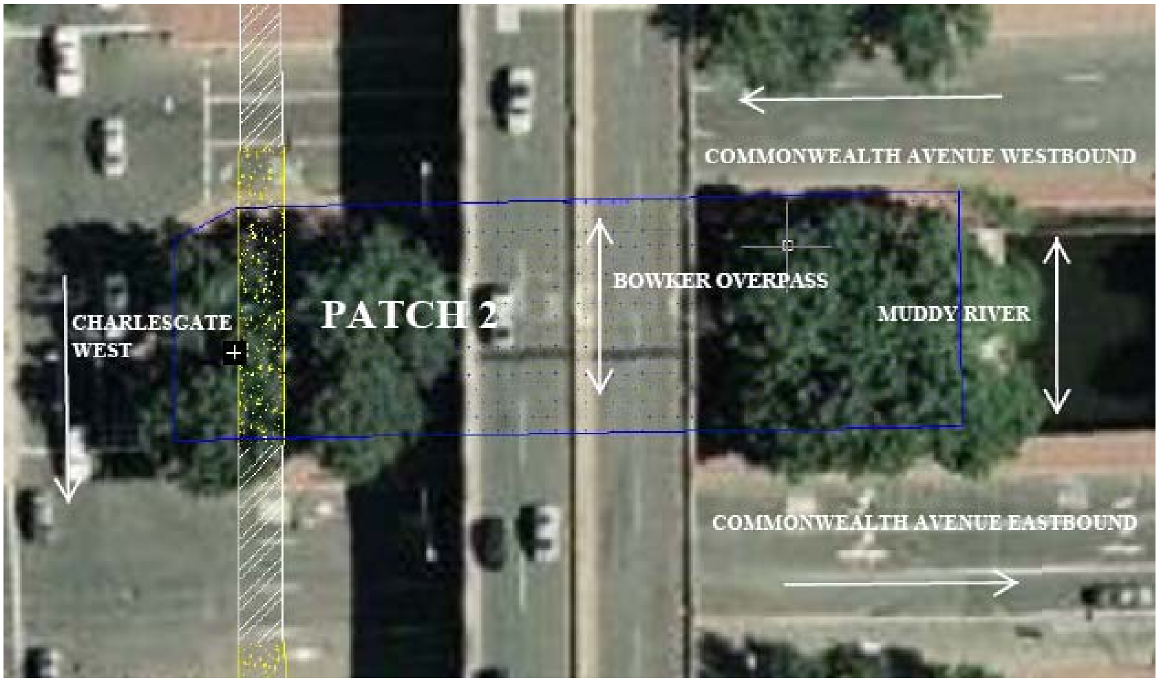


Figure 5.1B: Patch 2

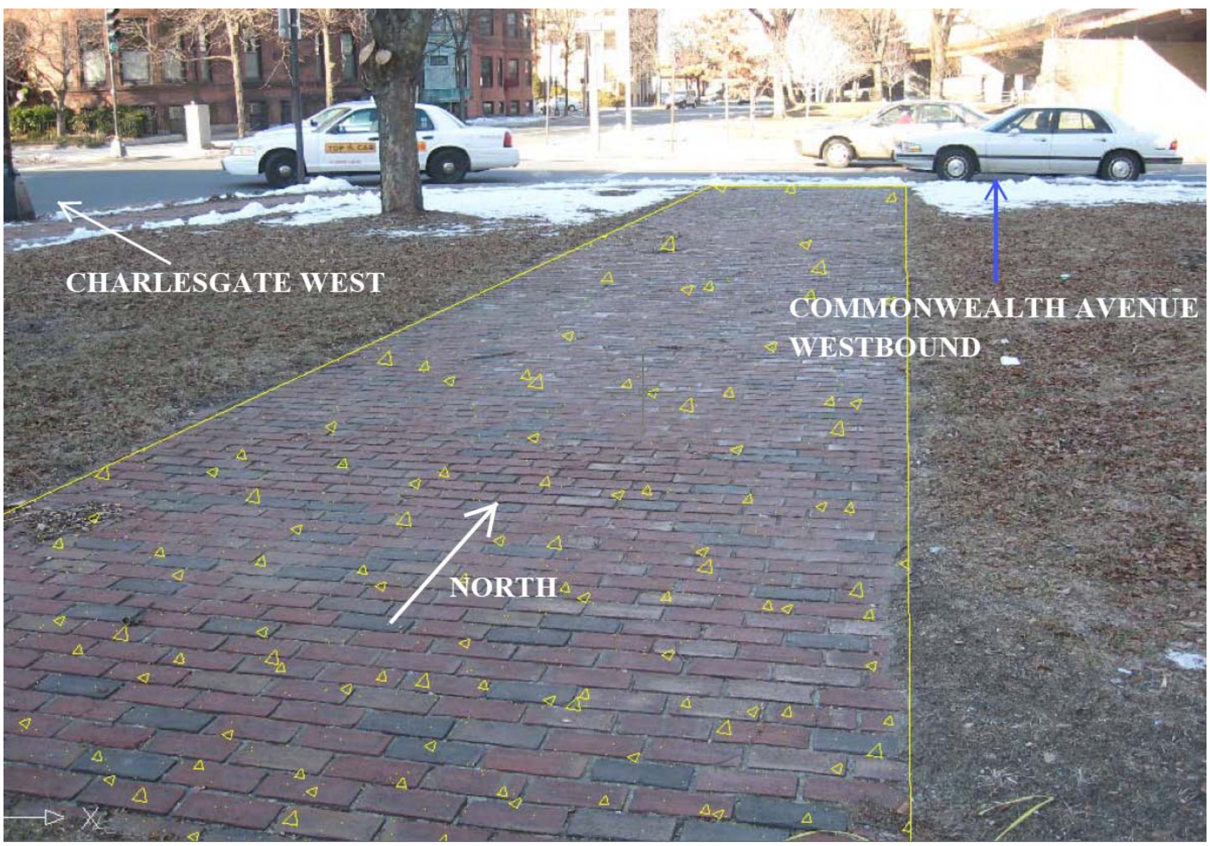


Figure 5.1C: Patch 2
The proposed path will replace uncomfortable existing brick walkway with smoother asphalt.

5.1.2 Patch 3

Patch 3 lies in between Commonwealth Avenue Westbound and Beacon St *(figure 5.1D)*. The brick sidewalk along Charlesgate West continues on the east side as it did in patch 2, but the walkway to the east does not. The shared-use path will continue due north, parallel to the existing sidewalk as it does in patch 2, then go right along the south sidewalk of Beacon Street. It is recommended that the existing sidewalk along Charlesgate West be deconstructed for maximum green space since the proposed path will provide adequate service for pedestrians and cyclists.

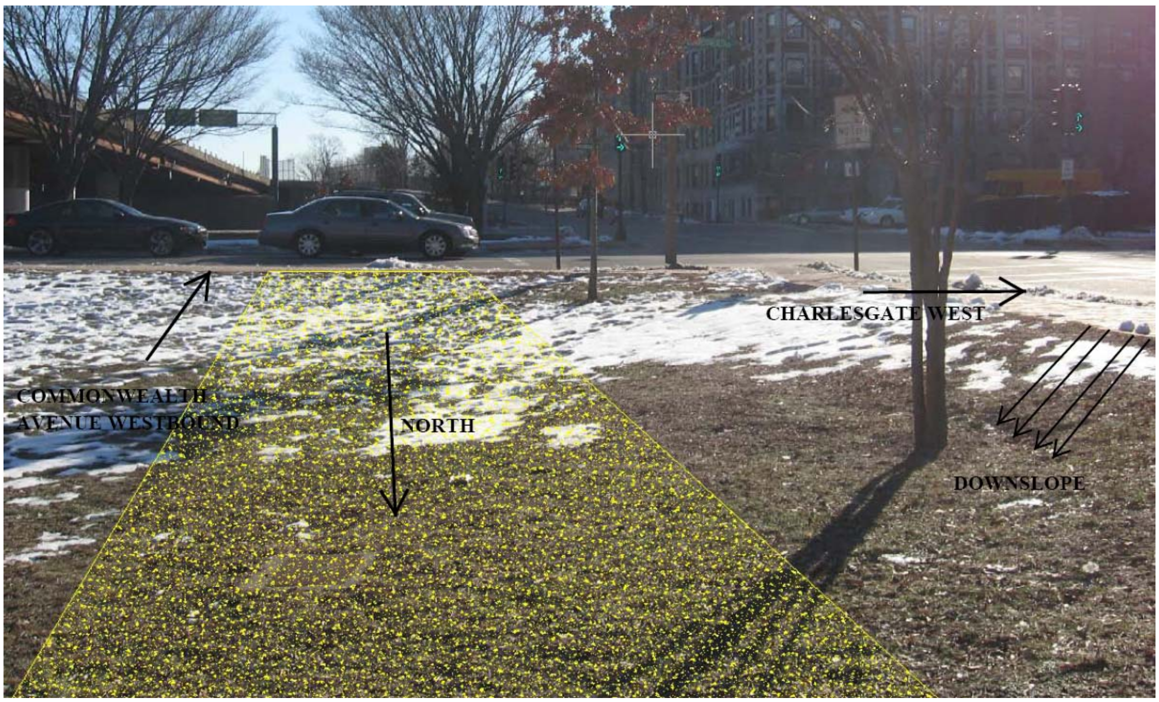


Figure 5.1D: Patch 3
Looking south from Beacon Street on the west section of patch 3

Since the terrain of this area dips down a significant amount below Commonwealth Avenue Westbound, Charlesgate West, and Beacon Street, there is concern for proper drainage *(figure 5.1D)*. This problem is resolved by constructing the proposed path and the land between the proposed path and sidewalk at or slightly above the sidewalk elevation. This will prevent any excess water buildup because all water runoff will drain into existing catch basins on Charlesgate Wast or down the bank to the east of the proposed path.

5.1.3 Patch 4

Patch 4 lies between Charlesgate West and East along Beacon Street. The geometry of Beacon Street roadway supports two eighteen-foot lanes and one ten-foot lane, which is much more than the necessary width of a common city street. Reducing the travel lanes to twelve feet wide allows for an additional buffer zone to be added to the shared-use path design, which will be located on the south side of Beacon St between Charlesgate West and Charlesgate East.

This buffer zone will make the proposed shared-use path more comfortable for its users by totally separating it from Beacon Street traffic, similar to the plan for the Charlesgate West green area alignment mentioned above. The decrease in lane width will not affect the flow of traffic or capacity on Beacon Street.

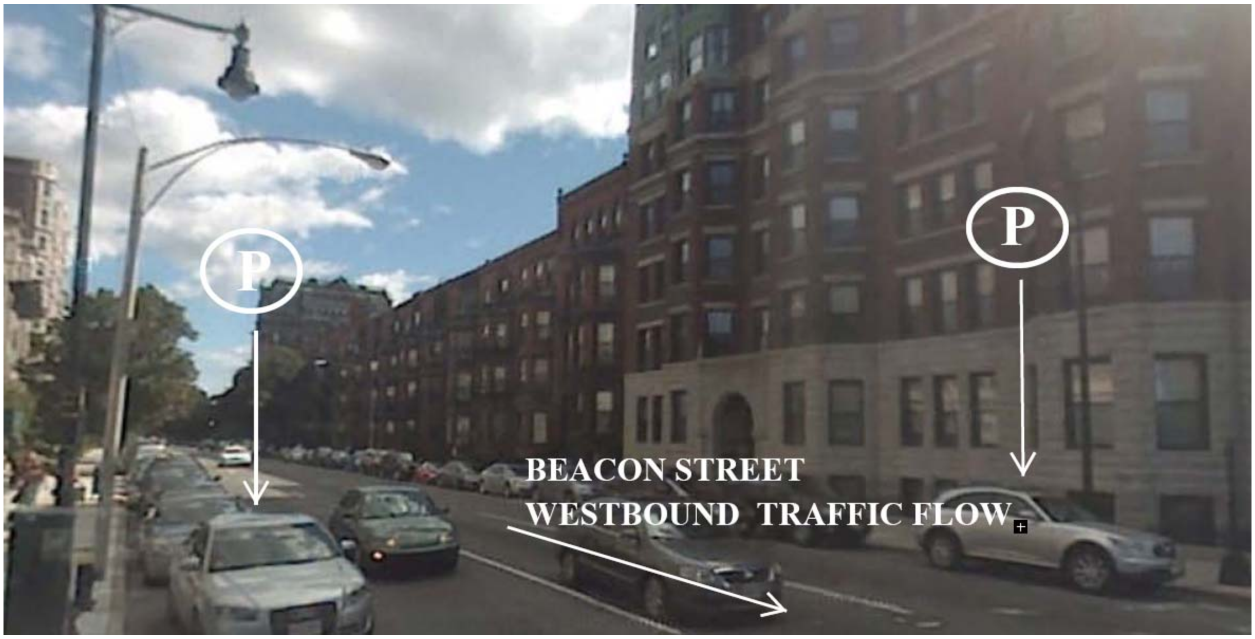


Figure 5.1E: View of Beacon Street Just East of the Intersection with Charlesgate East

An existing geometric feature to consider is that there is a parking lane before the intersection of Charlesgate East and Beacon St that exists east of the intersection on Beacon Street *(figure 5.1E)*. The proposed path will match up with this parking lane to create a more consistent vehicular travel lane on the left side of Beacon Street, eliminating any confusion that may exist in that particular redesigned section of Beacon Street.

While the proposed path will be traveling through the intersection of Beacon Street and Charlesgate East, there will be no change to the timing or phasing. The existing AM peak hour level of service is an acceptable B. By using and expanding the existing island between Charlesgate East Northbound left-turn lane and Northbound thru lane, bicyclists and pedestrians will have a refuge to wait to cross Beacon Street and continue on the shared use path. Bicyclists will first cross onto the island when they have the right-of-way (a concurrent 32-second pedestrian phase when Beacon Street is green) and, then, cross Beacon Street when given the right-of-way (an added 58-secont concurrent pedestrian phase when Beacon Street is red). Once the user crosses Beacon St, they can follow the path that will lead them under the raised on-ramp

5.2 Traffic Analysis of Beacon Street and Beacon Street/Charlesgate East

5.2.1 Field Measurements and Observations

In order to analyze existing conditions the following were conducted: measuring intersection geometries, obtaining intersection signal timing, taking turning movement counts from 7:45-845 AM and 4:45-5:45 PM. The City of Boston provided signal timing plans. Trafficware's Synchro software was used to analyze existing and proposed network.

5.2.2 Existing Conditions

The intersection of Beacon Street and Charlesgate East is a 4-way intersection with two one-way approaches. The Charlesgate northbound approach consists of two 11.5 -foot through lanes and one 24-foot channelized left turn lane. No parking is permitted on either side of the approach. The Beacon Street westbound approach consists of two 11- foot through lanes and one 10-foot shared through/right turn lane. Parking lanes are found on both sides of the approach. The northern leg of the intersection consists of two 16-foot lanes with no pavement markings with no parking permitted. The eastern leg of the intersection has three through lanes with widths 17.5 feet, 11 feet, and 18 feet from south to north. No parking is permitted on the eastern leg of Beacon Street as well. These lanes are much wider than needed, giving plenty of room add a bike lane by narrowing existing lanes.

5.2.3 Intersection Modifications

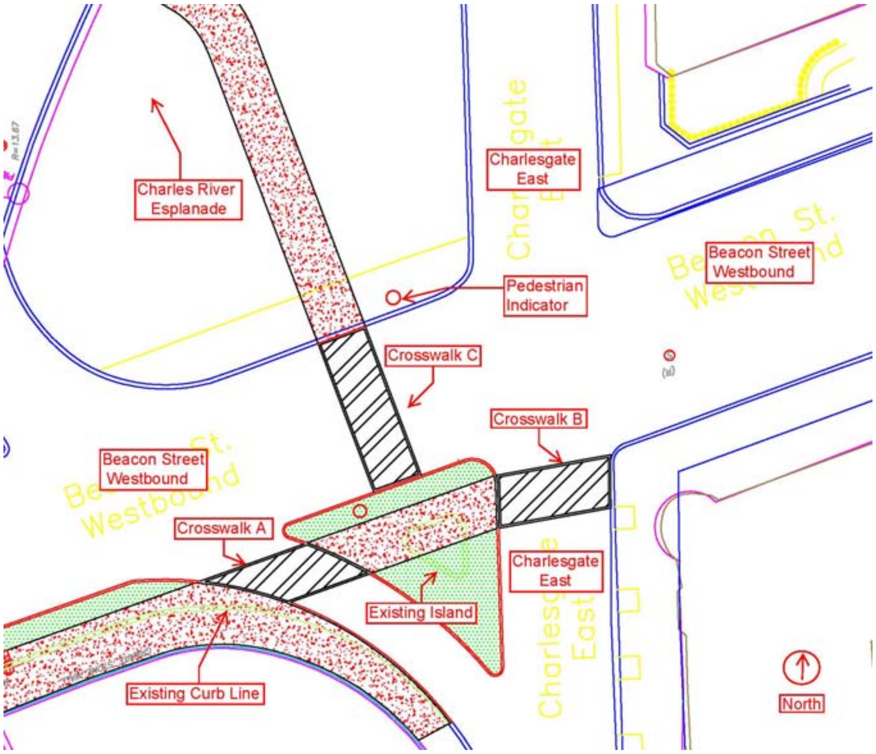


Figure 5.2A

Intersection 7 Existing and Proposed Geometry

The multiuse path will be constructed on the south side of Beacon Street between Charlesgate East and Charlesgate West. Once the bike lane is constructed, the three lanes on Beacon Street will be narrowed to 12 feet each. This will not affect the capacity because there are still three lanes with standard widths. There are minimal changes to the intersection of Beacon Street and Charlesgate East. The island channelizing Charlesgate East northbound right will be expanded to narrow the Charlesgate East northbound right turn lane and Beacon Street. See *figure 5.2A* for intersection geometry. The expansion into Beacon Street will keep the width of Beacon Street consistent with the future width of Beacon Street west of the intersection where the multiuse path will be inserted. By using and expanding the existing island, bicyclists and pedestrians will have a refuge to wait to cross Beacon Street and continue on the multiuse path.

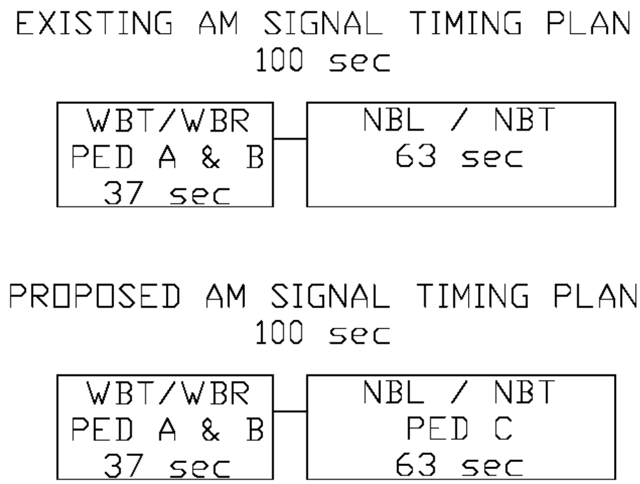


Figure 5.2B: Existing and Proposed AM Peak Hour Signal Timing Plans

A crosswalk from the new island will be constructed across Beacon Street to continue the multiuse path. This crosswalk will have a concurrent pedestrian phase during the Charlesgate East northbound left/through phase. See *figure 5.2B* above for existing and proposed signal timing plan. This will not affect the level of service of the intersection because no other signal timing modifications will be made. With very slight modifications to the intersection (lane width change for northbound left), analysis of proposed design is identical to existing analysis.

Table 5.2A
Beacon Street and Charlesgate East: AM Peak Hour Vehicular and Pedestrian Level of Service

	Existing				Proposed			
Intersection Approach	LOS	Delay	V/C Ratio	95th% Queue Length	LOS	Delay	V/C Ratio	95th% Queue Length
7:Beacon Street/Charlesgate East	**C**	**22.3**	**0.28**		**C**	**22.1**	**0.28**	
Beacon WB thru	D	43.3	0.71	181	D	43.3	0.71	181
Beacon WB slight right to ramp/right	D	39.7	0.52	91	C	39.7	0.52	91
Charlesgate East NB strong left/left	A	5.0	0.12	0	A	4.4	0.13	0
Charlesgate East NB thru	A	4.8	0.19	61	A	4.4	0.19	51

6.0 GATE HOUSE

Once the Charlesgate path crosses Beacon Street it enters an unused park space approximately 2.5 acres in area. It is at this point that the scope of the project changes. The path up to this point has run along side roadways and crossed busy intersections. The focus now shifts away from intersection analysis and curb line modification to re-grading the existing green area for gentle slopes throughout the rest of the shared-use path alignment. The re-grading plan proposed maximizes available green space allowing for the future design of the park.

6.1 Three Obstructions

There are three obstructions blocking the way to the lost park area *(figure 6.1A)*.

1. The Storrow Drive Eastbound on-ramp from the Bowker Overpass

2. The historic 1909 Gate House

3. An abandoned section of a retaining wall constructed for the old Storrow Drive Eastbound on-ramp from Massachusetts Avenue (Discussed in chapter 7)

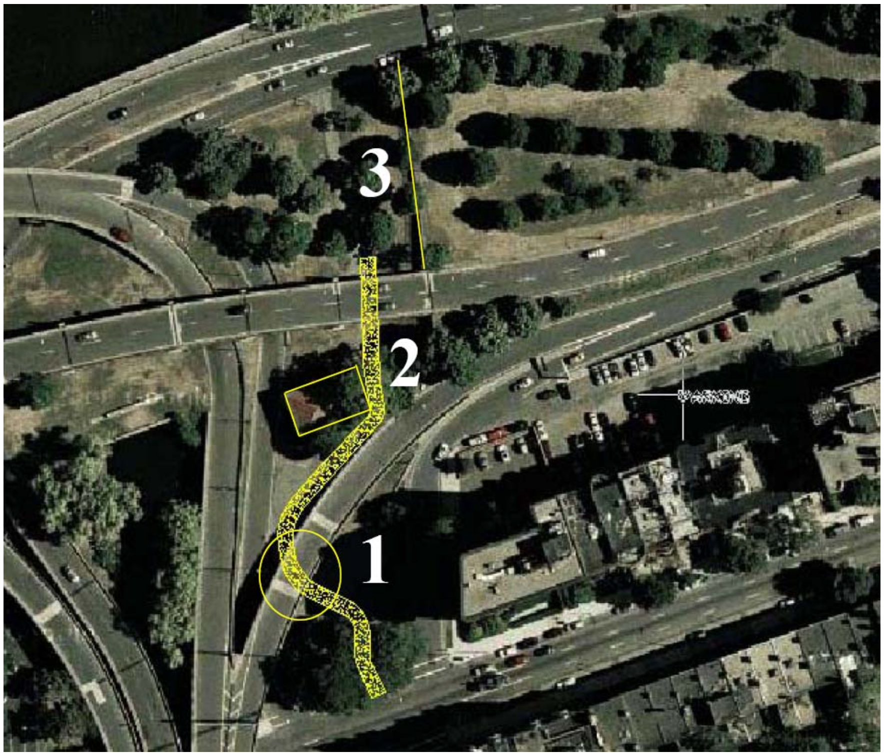


Figure 6.1A: Three Obstructions Outlined in Yellow

6.1.1 Storrow Drive Eastbound Overpass On-ramp

Getting to the other side of the on-ramp overpass safely was a challenge because of the close-by Storrow Drive Westbound on-ramp from Beacon Street that is at grade. Also, there is a structural pier for the overpass on-ramp that stands in the way. The design layout of the proposed path is one of two alternatives for avoiding these obstacles *(figure 6.1B)*. The one that was decided against would have brought the path around the west side of the pier, in between it and the Storrow Drive Westbound on-ramp. Although there would be plenty of overhead clearance for the proposed path this way, there is not enough space to fit a twelve-foot path, nor would there be any sort of buffer to separate path users from the at-grade on-ramp *(figure 6.1C)*.

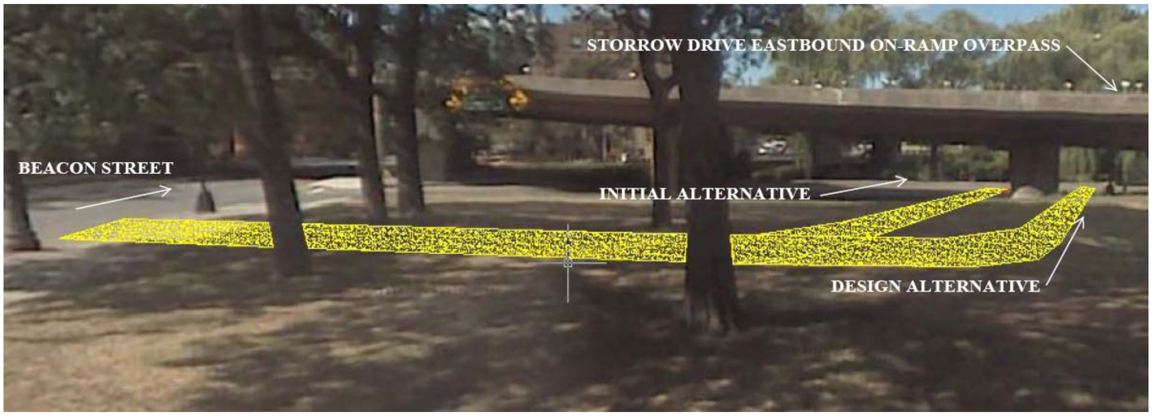


Figure 6.1 B: Looking Westward from Charlesgate East at the Storrow Drive Eastbound On-ramp Overpass from the Bowker Overpass

Figure 6.1C: Looking Northward from Beacon Street at the Storrow Drive Eastbound On-ramp Overpass from the Bowker Overpass and the Storrow Drive Westbound On-ramp Entrance from Beacon Street

The final design calls for the shared-used path to pass underneath the east side of the pier supporting the overpass on-ramp. This allows for the layout of the path to be totally separated from the traffic on the at-grade on-ramp and have a much gentler curve towards the old gate house. The one problem with this choice of alignment is that there currently is only six feet three inches of vertical clearance at the critical point of where the path is going to be. AASHTO requires at least eight feet of clearance for any sort of bike path, so there is a need for a small amount of excavation for a successful shared-use path *(figure 6.1D)*.

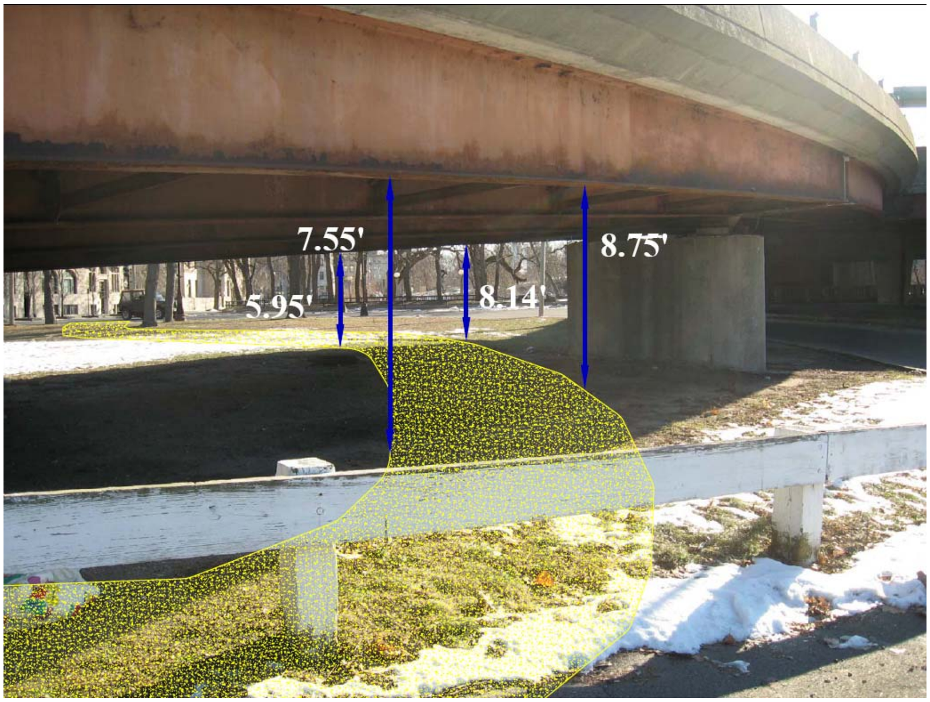


Figure 6.1D: Looking South Along the Storrow Drive Westbound On-ramp

Ideally, the 3-D design of this particular section of the proposed path would give ten feet or more of clearance for a more comfortable ride for the tallest of cyclists. The excavation needed to accommodate this would bring the elevation of the path and a lot of the surrounding area beneath the elevation of an existing catch basin near-by on the at-grade on-ramp. This would require expensive installation of underground drainage piping and a catch basin on the proposed path to prevent hazardous path flooding. A better solution was to allow for only the required eight feet of clearance, which brought the elevation of the path above that of the nearby catch basin for a cheaper, maintenance-free drainage system *(figure 6.1E)*. *Figure 6F* shows the profile view of four key sections on the proposed shared-use path and the location of those sections in plan view.

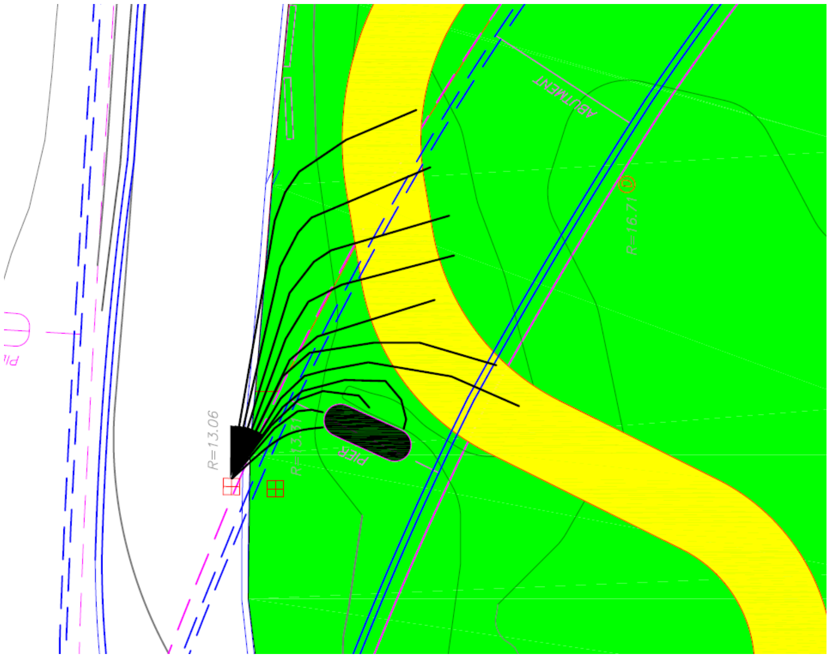
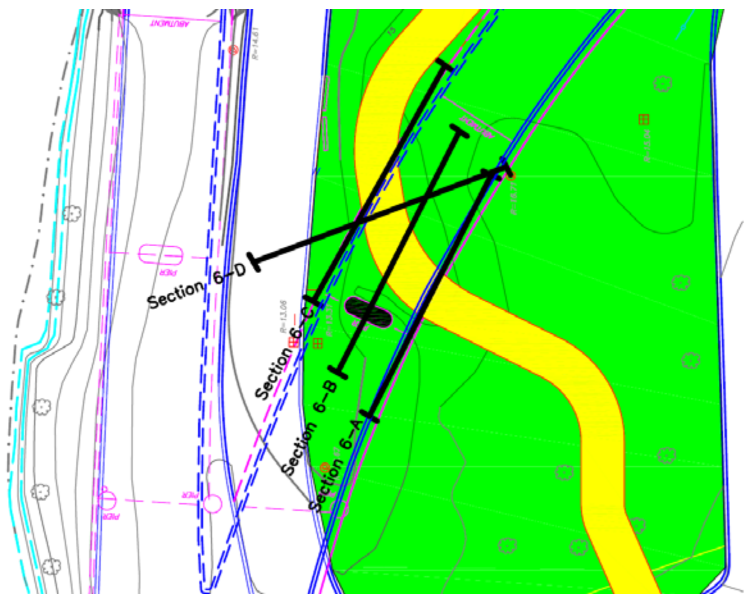
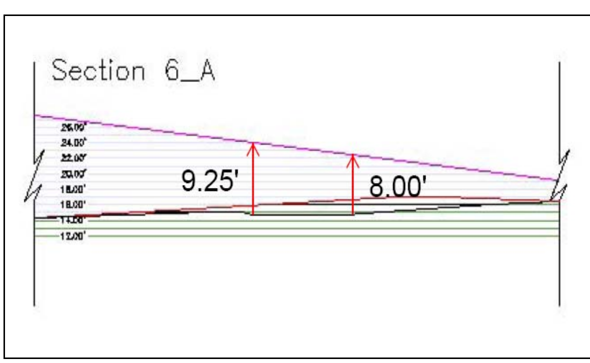
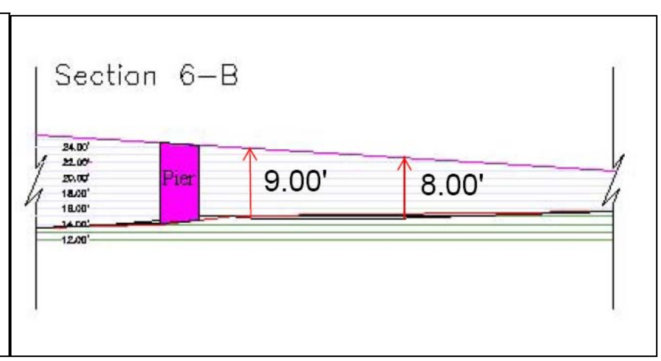


Figure 6.1E: Drainage Direction and Destination







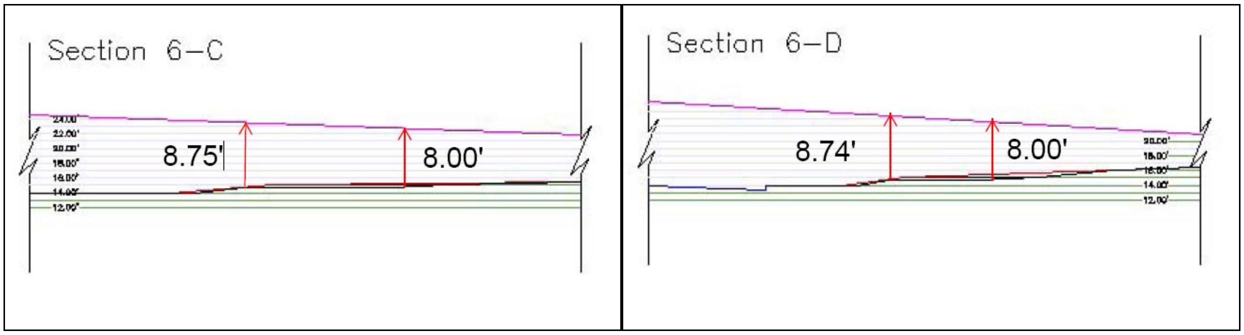


Figure 6.1F: Key Elevation Profile Views with Plan View for Section Orientation

The magenta represents the overhead overpass girder, the red represents existing grade, and the black represents proposed grade with the shared-use path

6.1.2 Gate House

There is 12 ft. of width to squeeze the shared-use path in between the old gate house and the wall supporting the Storrow Drive Eastbound on-ramp from the Bowker overpass. A buffer zone must be considered to prevent users from hitting the corner of the gate house and/or brushing up against the on-ramp wall. Allowing for a design shy distance of 18 inches at this point makes for 9 effective feet of width, which is adequate for a shared-use path. *(figure 6.1G)*.

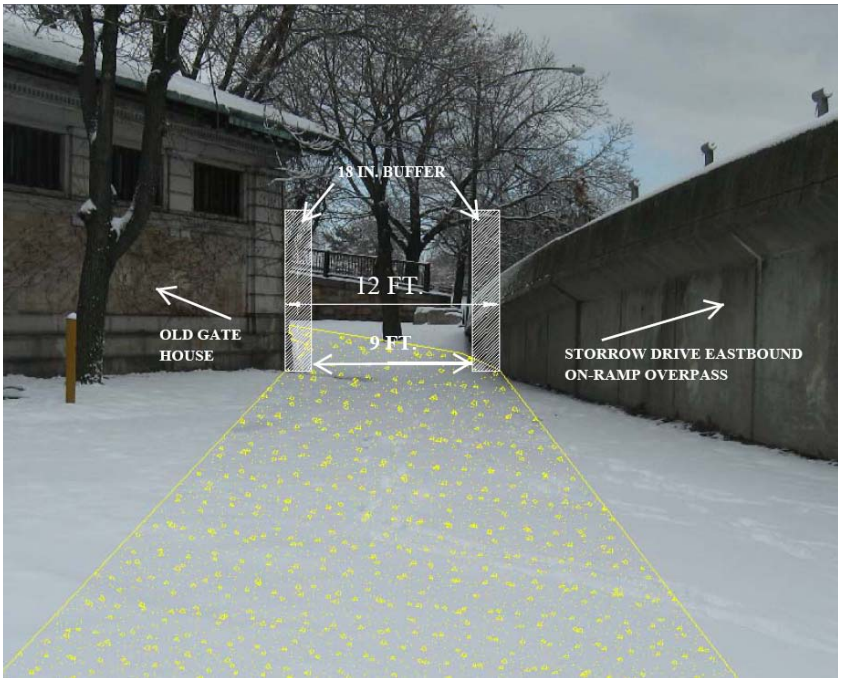


Figure 6.1G: Looking Northbound on the Proposed Shared-Use Path

One important issue to consider when designing a shared-use path around the old gate house is a vehicular access point for maintenance as well as emergency access to the proposed park space. The existing access points allow for emergency and maintenance vehicles to enter the area via Storrow Dr. Westbound *(figure 6.1H)* and the Newton on-ramp *(figure 6.1I.).* In order for there to be adequate separation between Storrow Drive traffic and path users, the access point on Storrow Drive Westbound needs to be either closed or gated. For the purposes of this design the Storrow Drive access point was eliminated. This provides the greatest safety for users because a continuous fence can be erected along Storrow Drive and creates the maximum space available for park use and enhances safety. The access point on the Newton on-ramp is a more appropriate place to enter the area. There is no fencing needed here *(see figure 6.1I).* Instead, a buffer zone and curb will be enough to provide users the illusion of separation from the Newton on-ramp. The curb should be high enough to deter cars from entering the area while still allowing for emergency or maintenance vehicles to drive over.

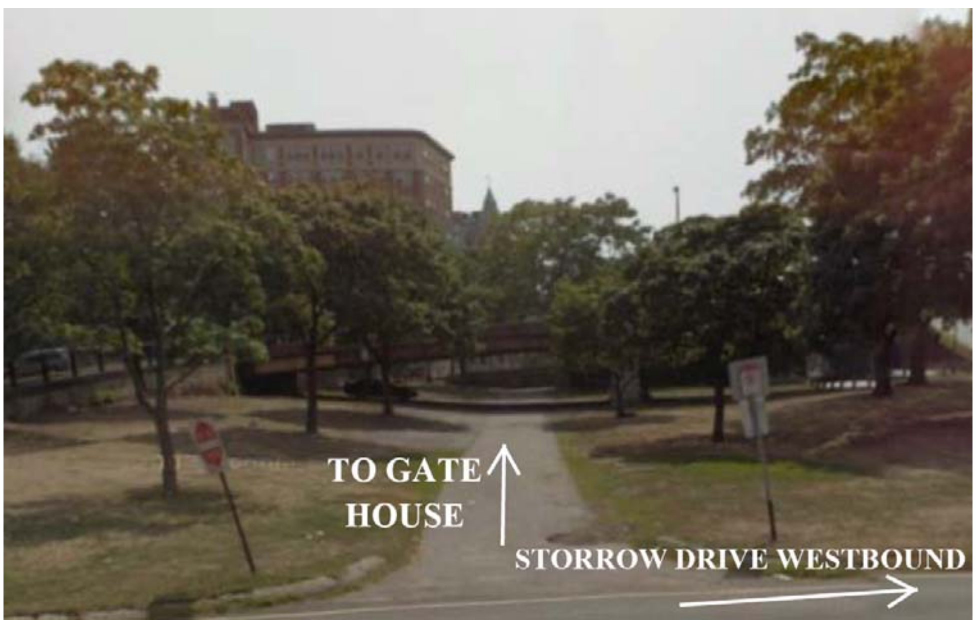


Figure 6.1H: Current Access Point for Vehicles to the Gate House Looking Southward from Storrow Drive Westbound

Figure 6.1I: Current Vehicular Access Point that will Still Remain Post-Construction of the Shared-Use Path

When designing the architectural aspects of the proposed park, this particular section of the green area should, then, only be used for cyclist and pedestrian thru traffic, and not for actual recreational space. This, once again, is to deter people from wandering onto the Newton on-ramp. Once the proposed shared-use path is constructed, maintenance and emergency vehicles will have an effective way to access any point of the park. Since they will not be traveling at speeds higher than five miles per hour and currently do not use the existing access points often, there is no safety hazard for pedestrians and cyclists sharing the path with them.

6.1.3 Pedestrian / Cyclist Safety of the Gate House Area

The proposed path will enhance the existing green area around the historic gate house with the safety of the cyclist and strolling pedestrian driving the design. Currently, there is no barrier that exists to keep wandering cyclists and pedestrians off of Storrow Dr. Westbound and the Newton on-ramp, which both serve high speed traffic. Therefore, a mountable curb is needed to establish a park boundary to the north and west while still allowing emergency and maintenance vehicles to enter the area. To the south, there is a sidewalk that currently serves pedestrians walking on the north side of Beacon Street, which establishes a park boundary. The east boundary of the park is created by Massachusetts Avenue. The area of the park bordered by Massachusetts Avenue and Storrow Drive will be discussed in more detail in the following section.

Expending further on safety, lighting conditions must be taken into account. The existing lighting conditions are inadequate for serving people using the path at night. Proper lighting is needed in order to prevent the possibility of criminal activity and to give the user a sense of security.

7.0 PARK/ RAMP/ BRIDGE

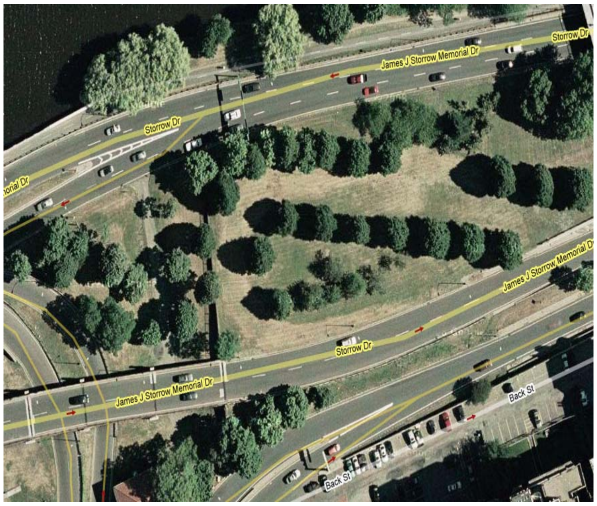


Figure 7A: Park Layout
The park is located between Storrow Drive Eastbound and Westbound along the Massachusetts Avenue Bridge.

The last and final connection for this path is through "The Lost Park". At first, the idea of a park near such a busy roadway may seem reckless, but a similar park can be seen farther west at Boston University, locally known as "BU Beach", and farther east at the Hatch Shell. The need to open up this 2.5 acre park is not just for a connection, but for a place that the community can come to relax and enjoy the beauty of the Charles River Esplanade.

The park will create a place to lie out in the sun; a place to have a nice Sunday picnic with your family or significant other; a place to escape the busy city life and relax after a hard day in the office. These are just some of the activities this park can bring to the community. The following section breakdowns the inner workings of how to make this vision a reality.

Figure 7B: Upper Level of the Park
The current grade of the upper level is suitable for park users.

7.1 Existing Conditions

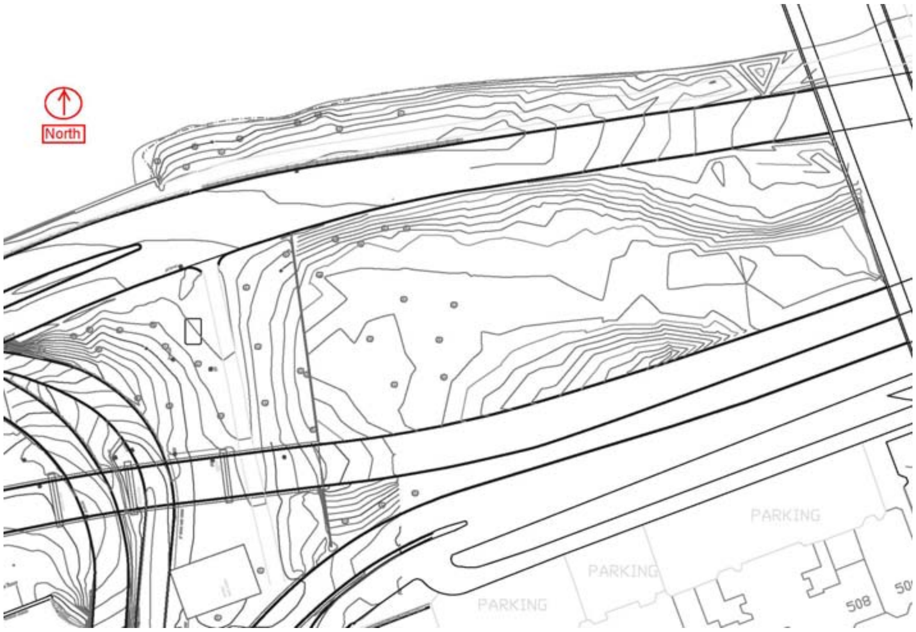


Figure 7.1A: Existing Grades
The lower level of the park is located on the left
along with the existing retaining wall that will later be removed.

As seen in *figure 7.1A*, the current layout of the park is unsuitable for a potential park user and therefore needs improvement to be fully functional. With traffic on both sides and no barriers or railings, the separation between vehicles and pedestrians is non-existent. Also an existing wall, leftover from the demolition of an on-ramp to Storrow Drive Eastbound, still remains separating the lower and upper levels of the park.

The borders of the park consist of Storrow Drive Westbound to the north, which is approximately 8 ft below grade of the upper level; and to the south, Storrow Drive Eastbound, which is at park grade. The park is landscaped with small trees that were placed when this area functioned as an on-ramp, but this landscape configuration may be reconsidered when the function shifts to a park.

The lower level of the park is at the same grade of Storrow Drive Westbound and is encompassed by the Newton on-ramp and the overpass to Storrow Drive Eastbound. There is also an existing service road that connects the gate house with Storrow Drive through the lower level of the park. As far as existing grades, the lower level of the park drains towards Storrow Drive Westbound, and the upper level of the park drains towards both sides of Storrow Drive. The grades will be discussed further in section 7.2.

7.2 Proposed Park Layout

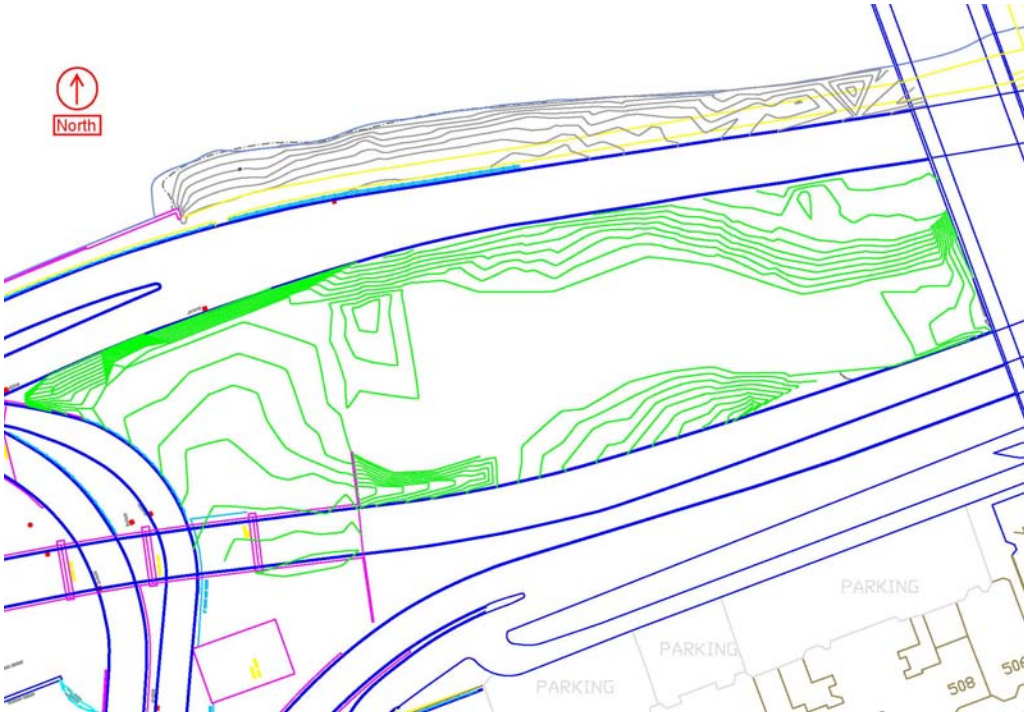


Figure 7.2A: Proposed Grades
The lower level of the park is located on the left
along with the existing retaining wall that will later be removed.

With the threat of Storrow drive on both sides and a lack of accessibility, this area remains unused. This threat can be removed through the use of berms. By building up earth along the eastbound side of Storrow drive in the upper level of the park, as well as the westbound side of Storrow Drive in the lower level of the park, a sound barrier is created as well as a physical barrier. This will increase the comfort level of the park and prevent vehicle/park user interaction.

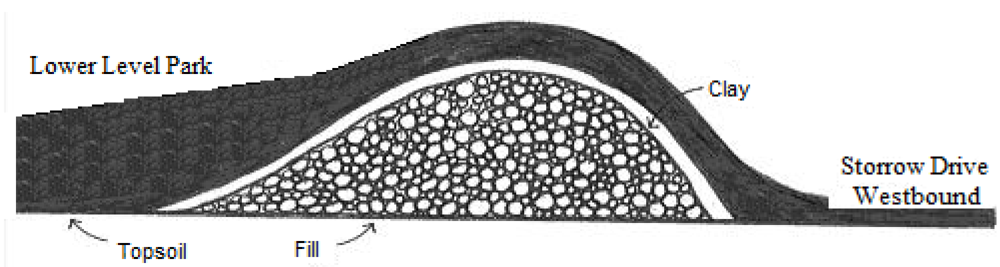


Figure 7.2B: Proposed Berm
This will protect the user in the lower level of the park and
provide a sound barrier from Storrow Drive Westbound.

The creation of the berm on the lower level of the park will be achieved by first grading to a height of 16ft; 3 ft above existing grade after passing under Storrow Drive Eastbound. The park will then continue to slope towards the upper level of the park at a 5% slope or smaller to provide gentle slopes that can support grass and trees. The proposed lower level of the park will have a maximum elevation of 20ft; 8ft above existing grade at the peak of the berm. In order to protect the user and enclose the park, these grades are necessary. One of the major governing factors of the lower level park grade is achieving the elevation needed to cross Storrow drive with the proposed path.

An additional berm will be created along the eastbound side of Storrow Drive bordering the upper level of the park. This will have a maximum elevation of 28ft; 3ft above existing grade. With the addition of this extra earth the retaining wall height may need to be increased, but this is yet to be determined. Once the park is enclosed, the park itself must be regraded.

By removing the existing wall, the grades on the upper level can be pulled out and built up in a way that doesn't ruin the landscape.

Figure 7.2C: Existing Retaining Wall

The existing wall will be removed up to the point where the upper level berm comes in contact with the wall. This is necessary in order to keep the earth holding Storrow drive up in place and to provide support for the proposed horizontal force that will be exerted outward from the berm.

The existing trees on the lower level and upper level will be relocated, or replaced as necessary once the new grades are in place. The grades from the Newton on-ramp will be diverted in order to drain along with the new proposed grades. One of the major changes to this area will be the removal of the access road to Storrow drive from the gate house. The current layout of this road is unsafe as there is a blind corner onto Storrow drive that makes it very dangerous to pull in/out. With the new proposed path in place, service vehicles, as well as emergency vehicles will have access through the park and to the Harvard Bridge.

7.3 Proposed Path Layout

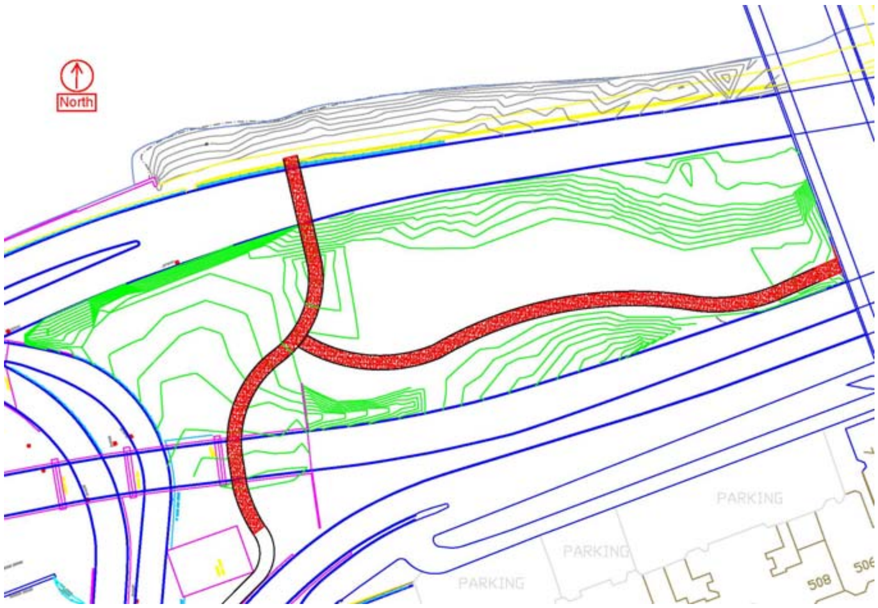


Figure 7.3A: Proposed Path Layout
The path will be set back as far as possible
to allow for park recreational activities.

Picking up the path from the gate house, the path will continue along the existing service road under the overpass. At the start of the overpass, the path will begin grading upwards. One concern in this area is the overhead clearance. The minimum overhead clearance as stated by AASHTO is 8 ft, but the clearance in this area will be well above this.

The existing grades slope downward toward Storrow drive. In order to create a divider between Storrow Drive and the park, the grades will be reversed to drain towards the gate house. A further analysis may be needed as far as relocation of existing sewer manholes and catch basins, and utilities.

The existing elevation of Storrow Drive is 13ft at the proposed crossing. In order to obtain a 12 ft clearance above Storrow Drive, assuming a 1ft bridge deck, the pedestrian bridge must be at a height of 26 ft. The current elevation of the park is at 21 ft; therefore 2ft of grade must be built up to accomplish a height of 23ft. From this elevation the pedestrian bridge will rise to the desired height of 26ft at an 8% grade.

Once in the upper level of the park, the path will be set back from the westbound side of Storrow drive to provide a wide open space for park users. The path will follow the outer tree line until it connects up to the Harvard Bridge. The elevation difference between the Harvard Bridge and the park is 5ft; therefore an embankment graded at 5% slope will be created.

7.4 Storrow Drive Westbound Crossing

The final link in the Charlesgate Path is a connection between the Lost Park and the Charles River. The impedance is Storrow Drive Westbound. Currently at this location, there is no way to cross this busy arterial. The extremely high traffic volume of this roadway makes a signalized crosswalk completely infeasible. Instead four alternatives for crossing Storrow Drive via a newly constructed pedestrian and bicycle bridge have been developed. All bridges were designed meeting the following requirements.

- A clearance of 12’ from Storrow Drive to the bottom of the bridge deck
- A 1’ thick bridge deck
- A single span crossing Storrow Drive supported on both sides with piers
- An overall width of 12’
- The ramp is compliant with ADA requirements
    - 1/12 slope
    - Landings provided every 2.5’ of elevation change

Figure 7.4A: Aerial View of Park Land

7.4.1 Alternatives A & B

The first two Alternatives are basic pedestrian bridge designs. They consist of a straight ramp parallel to Storrow Drive down to the existing pathway. The support system for the ramp and the bridge are piers. In both cases the existing path will need to be bumped out towards the river to accommodate the width taken up by the ramp. The major difference in the two designs is the orientation of the ramp. Alternative A crosses Storrow Drive to the east and down slopes upstream, while alternative B crosses to the west and down slopes down stream. The specific elevations and resulting ramp lengths are presented below in *table 7.4.A.*

Alternative A chases the grade resulting in a 43' longer ramp. This results in a 28.7% larger visual impact than alternative B. The extra ramp length will also moderately increase the cost of the ramp. However, alternative A is more efficient in terms of travel time for the users. Users going up stream see no difference in travel time between alternative A & B; however pedestrians going downstream experience an increase of nearly 1.5 minutes in travel time with alternative B.

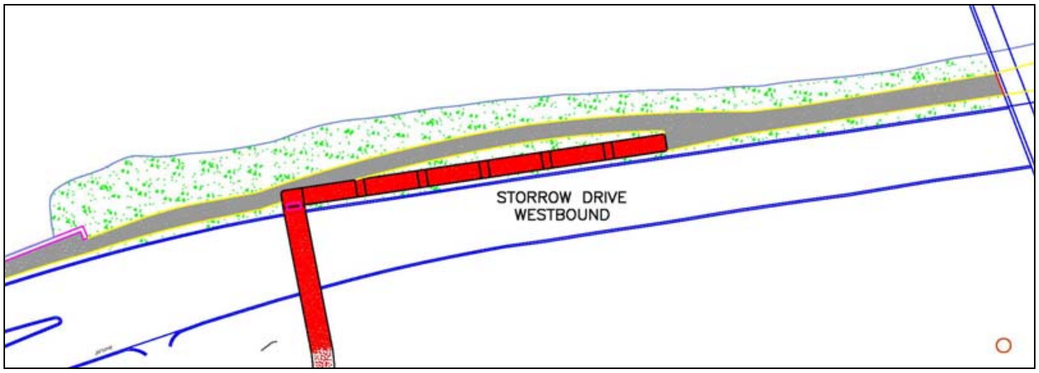


Figure 7.4B: Bridge Alternative A
Bridge crossing to the west and the resulting 193' ramp down the east.

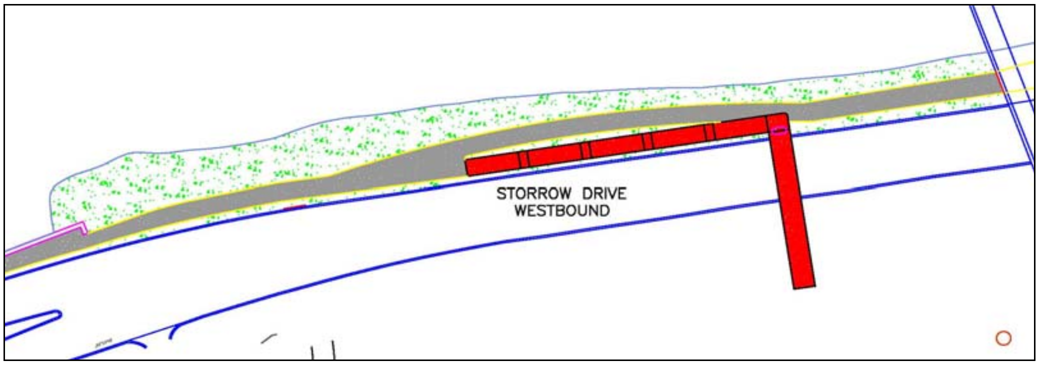


Figure 7.4C: Bridge Alternative B
Bridge crossing to the east and the resulting 150' ramp down the west.

7.4.2 Alternatives C & D

Alternative C and D vary from the standard pedestrian bridge design. Unlike the previous two alternatives the ramps for alternatives C & D swing out over the Charles River instead of coming down adjunct to Storrow Drive. Both C and D utilize the same pier supported single span bridge over Storrow drive. From this point on they are very different. Their specific differences are laid out in *table 7.4.A.*

Alternative C

This design calls for a pier supported structure extending out 62' into the river. The design calls for 3 piers to be located in the river. The process of constructing these piers will increase the cost the bridge when compared to alternatives B and A. A major benefit to the bridge is its relatively low horizontal visual impact. The standard has been set for a bridge of this style. Down river to the east the Harvard Bridge connects to the Charles River path through a pier supported ramp extended over the river.

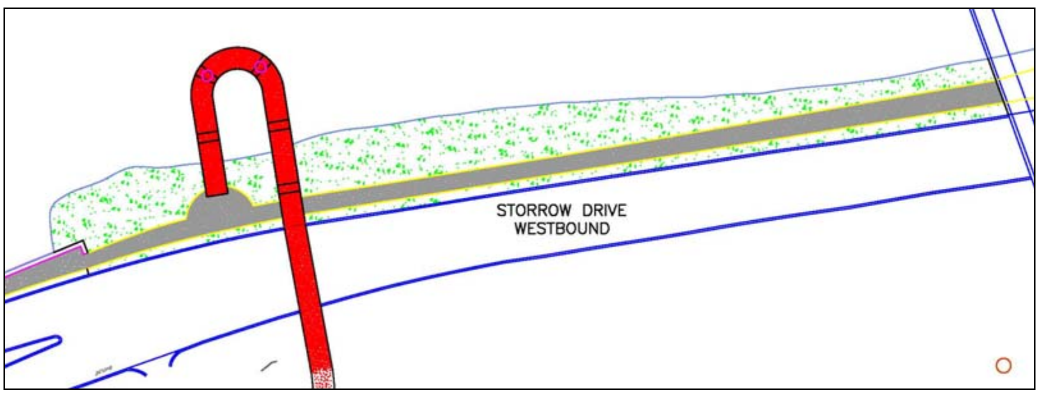


Figure 7.4D: Bridge Alternative C
Bridge crossing to the east. The design calls for piers to be placed in the Charles River.
The major Benefit is the relatively low horizontal visual impact.

Alternative D

This is the grandest design. It calls for a cable-stayed ramp to extend 32' over the Charles River. The ramp has a lookout point with two 8' benches for gazing out over the river. The benefit to the cable-stayed approach is two fold. First it eliminates the need for piers in the river. Secondly the design is visually appealing. It will be the focal point along the Charles River.

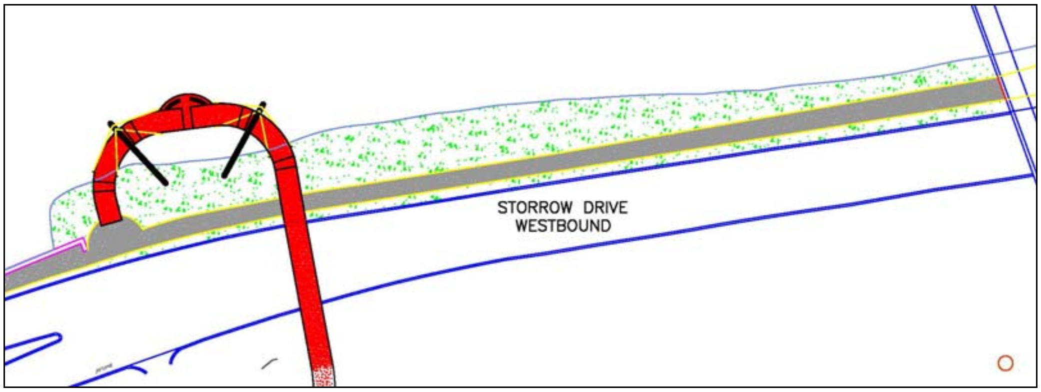


Figure 7.4E: Bridge Alternative D
The grandiose design calls for a cable-stayed ramp extending over the river.

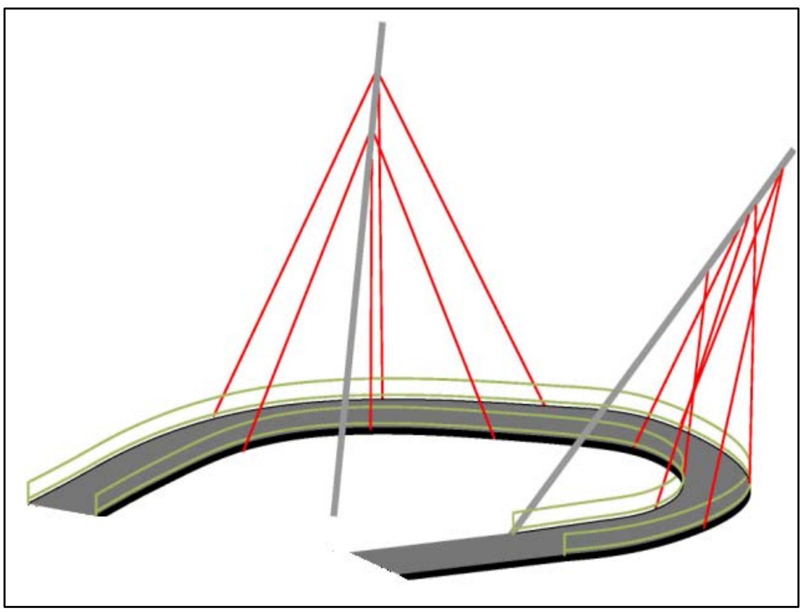


Figure 7.4F: Bridge View

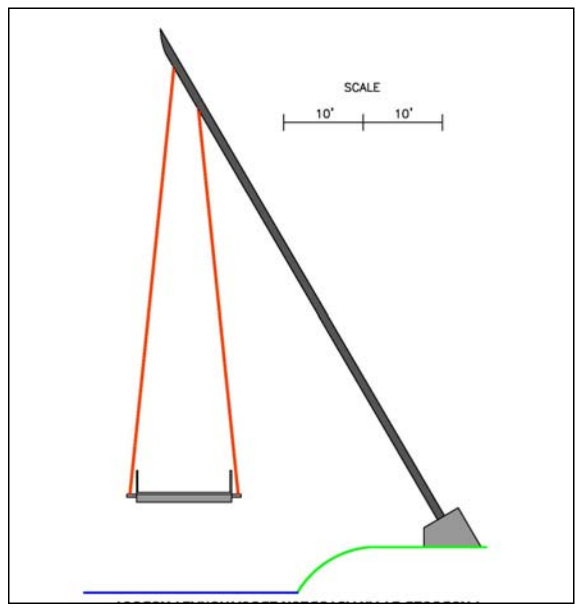


Figure 7.4G: Elevation View.

7.4.3 Overall

Table 7.4A

Alternative	Storrow Drive Elevation	Pedestrian Bridge Deck Elevation	Landing Elevation	Ramp Length	Cost	Support Type	Horiz. Impact	Distance Over the River	Extra Travel Distance*		Extra Travel Time (s)**	
									Upstream	Downstream	Upstream	Downstream
A	11'	24'	13'	150'	Economical	Piers	150'	0'	505	3	112	1
B	13'	26'	12'	193'	Economical	Piers	193'	0'	627	410	139	91
C	13'	26'	11.5'	200'	Mod.	Piers (in river)	52'	62'	228	243	51	54
D	13'	26'	12.5'	193'	High	Cable-stayed	114'	32'	163	294	36	65

* Extra travel distance in relation to the baseline (see figure 7.4.H)

** Travel time assumes a pedestrain travel speed of 4.5 ft/sec

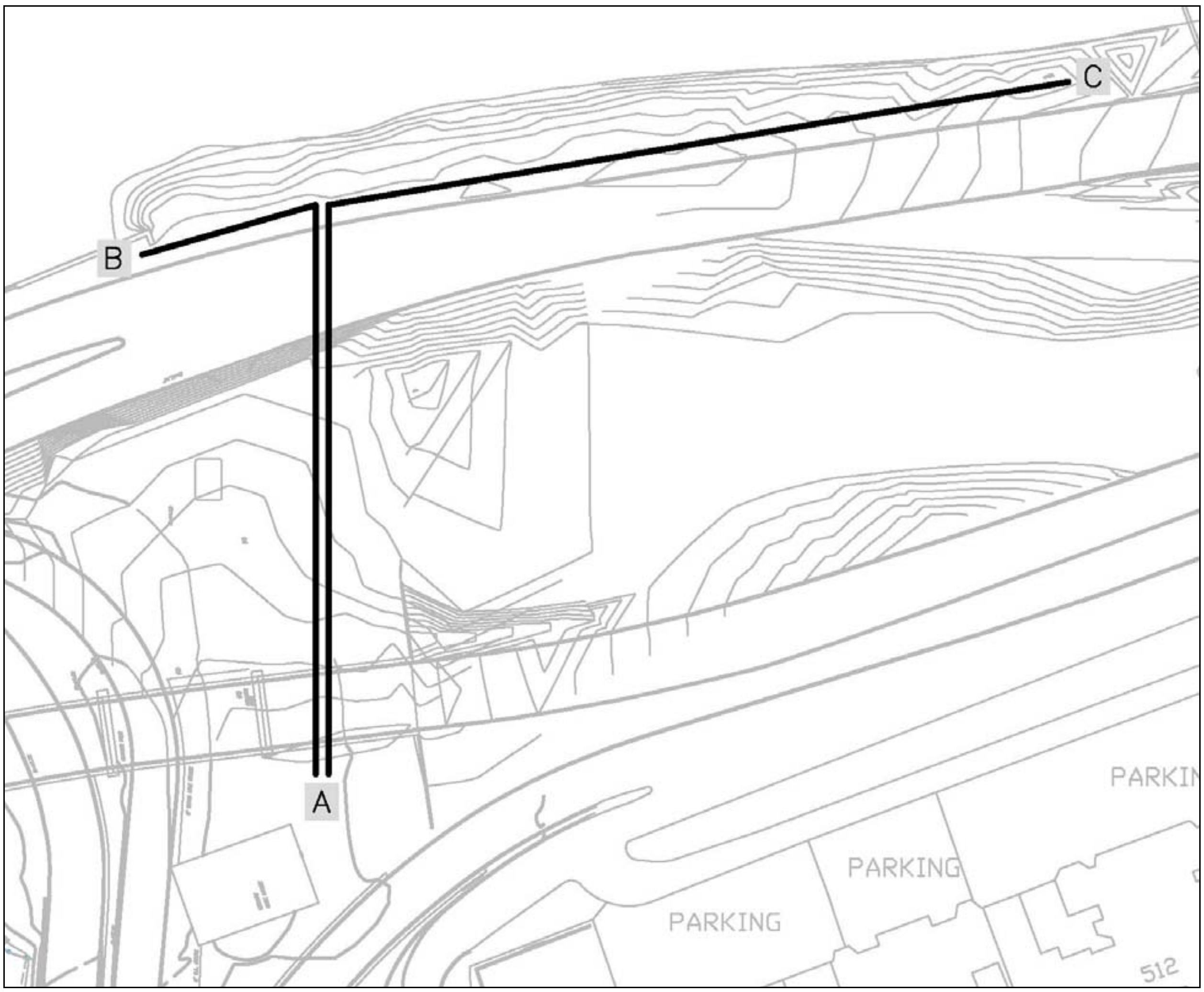


Figure 7.4H: Baseline

Going from the gate house (A) to upstream (B) and downstream (C). The distances where used as a baseline to compare the different bridge design alternatives.

8.0 COST

Table 8A

Item	Amount	Unit	Unit Cost ($)	Boston Metro Area Multiplier	Inflation Multiplier	Total Cost ($)
Asphalt Paving	3,360	Square Yard	15	1.18		59,472.00
Crosswalk	11	Crosswalk (ladder stripping)	300		1.25	4,125.00
Curb Construction	924	Linear Foot	6.75	1.18		7,359.66
Curb Removal	816	Linear Foot	4.85	1.18		4,669.97
Excavation	116	Cubic Yards	1.5	1.18		205.32
Fill	1150	Cubic Yards	3.3	1.18		4,478.10
Handicap Ramp	19	Ramp	800		1.25	19,000.00
Island Modification	2.61	400 Square Feet	20,000		1.25	65,250.00
Lane Marking/Modification	0.53	Mile	3000		1.25	1,987.50
Reconstructing Median	3.86	100 Feet	20,000		1.25	96,500.00
Sidewalk Deconstruction	300	Linear Foot	3.5	1.18		1,239.00
Signal Addition (Ped)	6	Signal	30,000		1.25	225,000.00
Signal Addition (Traffic)	1	Signal	60,000		1.25	75,000.00
Signal Timing Modification	3	Signal System/Intersection	200			600.00
Total						**564,886.55**

Table 8.1 outlines the basic items that need considered for the construction of the Charlesgate Connector. The following assumptions were made:

- The asphalt paving is 3 inches thick without a base
- The cubic yard estimation includes the regarding of the park area of section 7
- New handicap ramps will replace old ones throughout the entire alignment of the shared-use path

Each bridge alternative has varying costs, so they should be considered during project implementation.

Once the Charlesgate Connection is established, this area will effectively accommodate the needs of Boston's cyclists who travel in or through the Back Bay with a reasonable high level of service, without adversely affecting the surrounding street network. The Bowker Overpass will provide shade for new park goers at all hours of the day without blocking sunlight on the east and west sides of the park area. These features allow for the coexistence of modern urban and leisurely transportation in a, what is now, underused park area of the Back Bay.

9.0 ACKNOWLEDGEMENTS

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April 16, 2008

9.1 References

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