MEMORANDUM

TO: **Transportation Planning and Programming Committee** **April 1, 2009**

FROM: **Seth Asante, Mark Abbott, Efi Pagitsas, and Alicia Wilson**

RE: **Traffic Operations and Bus Access and Egress at the Route 2/Route 16 Intersection and the Alewife MBTA Garage: Existing Conditions and Recommended Improvements**

INTRODUCTION

The purpose of this memorandum is to fulfill the requirements of Tasks 3 and 4 of the work program "Alewife Station: Improvements to Feeder Bus Routes, Bus Access and Egress, and Route 2/Route 16 Intersection," November 1, 2007. In addition, this memorandum incorporates many of the issues and potential solutions discussed as part of the Alewife Working Group that was convened by Massachusetts State Senator Stephen Tolman. In May 2008, Senator Tolman's office organized a working group to examine traffic operations in the Alewife MBTA station area, including the intersections of Route 16 with Cambridgepark Drive and Rindge Avenue. The group included representatives from the Department of Conservation and Recreation (DCR), MassHighway, Massachusetts State Police, Cambridge Traffic and Parking, Cambridge Police, the Boston Region MPO, Wyeth Corporation, the MBTA, Cambridge Chamber of Commerce, Senator Tolman's office, and Jones Lang LaSalle; Representative William Brownsberger,. The Alewife Working Group met four times in 2008.

This memorandum describes geometric and operational issues at the Route 2/Route 16 intersection, presents analysis results for existing conditions and several alternatives, and makes recommendations for improvements. It also deals with issues related to bus access and egress at the Alewife MBTA station; improvements to the Route 2/Route 16 intersection are critical to reducing bus access and egress delays. The text that follows contains observations of the traffic operations at various roadway segments and intersections in the vicinity of the Route 2/Route 16 intersection and Alewife Station that cause delays to traffic, including delays to buses to and from the MBTA garage at the station. The memorandum also explores various options to reduce these delays and recommendations for improvements at locations that presently have problems related to access and egress of buses at the station.

Operations at the Route 2/Route 16 intersection are crucial. They impact schedule adherence for MBTA feeder buses to/from Alewife Station and slow down motorists and passengers driving through it. The intersection is typically severely congested during both peak hours, with queues extending in all four directions far enough to impede other traffic flow. Travel speeds of the roadway segments feeding into the intersection consistently range from less than 10 mph to

about 30 mph, compared to posted speed limits of between 55 and 25 mph on Route 2 and 30 mph on Route 16 in the vicinity.

A side impact of the delays through this intersection is the diversion of traffic to other roadways in the area. For example, eastbound Route 2 traffic bypasses this intersection and uses the Route 2 eastbound off-ramp, the Alewife Station Access Road, and Cambridgepark Drive to reach Alewife Brook Parkway southbound and northbound. Diversion of traffic through this internal network of streets clogs access to the station and egress from local commercial developments.

INTERSECTION DESCRIPTION

The Route 2/Route 16 signalized intersection is at the eastern terminus of the limited-access portion of Route 2 (Concord Turnpike). At this intersection, Route 2 merges with Route 16 (Alewife Brook Parkway). The intersection is commonly referred to as Alewife Circle, because up to the mid-1980s this location operated as a traffic circle. The two roadways are under different jurisdictional control. Up to a point just east of the bridge over the Minuteman Bike Path, MassHighway operates Route 2. Route 16 is a Department of Conservation and Recreation (DCR) roadway. The intersection is controlled by a DCR-operated and -maintained traffic signal, which is coordinated with those at Route 16/Cambridgepark Drive and Route 16/Rindge Avenue.

Figure 1 shows the roadway network in the general area surrounding the Alewife garage, where the intersection is located. As may be seen, the Route 2/Route 16 intersection actually consists of four intersections, with the conflicting traffic movements spread out among these smaller intersections. All approaches to the intersections are under signalized control. Essentially, the signals work as a coordinated signal system controlled by one traffic controller.

The Route 2 eastbound approach has two primary lanes, which split at the intersection into one left-turn lane (used by drivers as two lanes during peak hours) and two through lanes. However, during congested periods, the inner of the two through lanes is blocked by left-turning traffic, essentially resulting in only one eastbound lane's being available to serve the eastbound through traffic. The Route 16 northbound approach has two lanes which split into four lanes at the intersection: two lanes leading to Route 2 westbound and two lanes going to Route 16 northbound. Route 16 on the southbound approach, from Massachusetts Avenue, is also two lanes wide. These lanes split at the intersection, with two lanes continuing south to Route 16 and one lane turning right to Route 2 westbound. The fourth approach to the intersection is the Alewife Station Access Road. This approach provides direct egress from the MBTA station and Cambridgepark Drive to Route 2 westbound and Route 16 northbound. It is a single-lane approach, which splits into one through lane to Route 2 westbound and a right-turn lane to Route 16 northbound, with a small island separating these lanes. During the PM peak period, drivers use it as two travel lanes from the Route 16 underpass up to the intersection.

Bus access to Alewife Station from Route 2 is provided along a ramp/service road, which exits directly from Route 2 eastbound approximately 1,400 feet prior to the intersection. This service road also provides access to Acorn Park and Cambridgepark Drive.

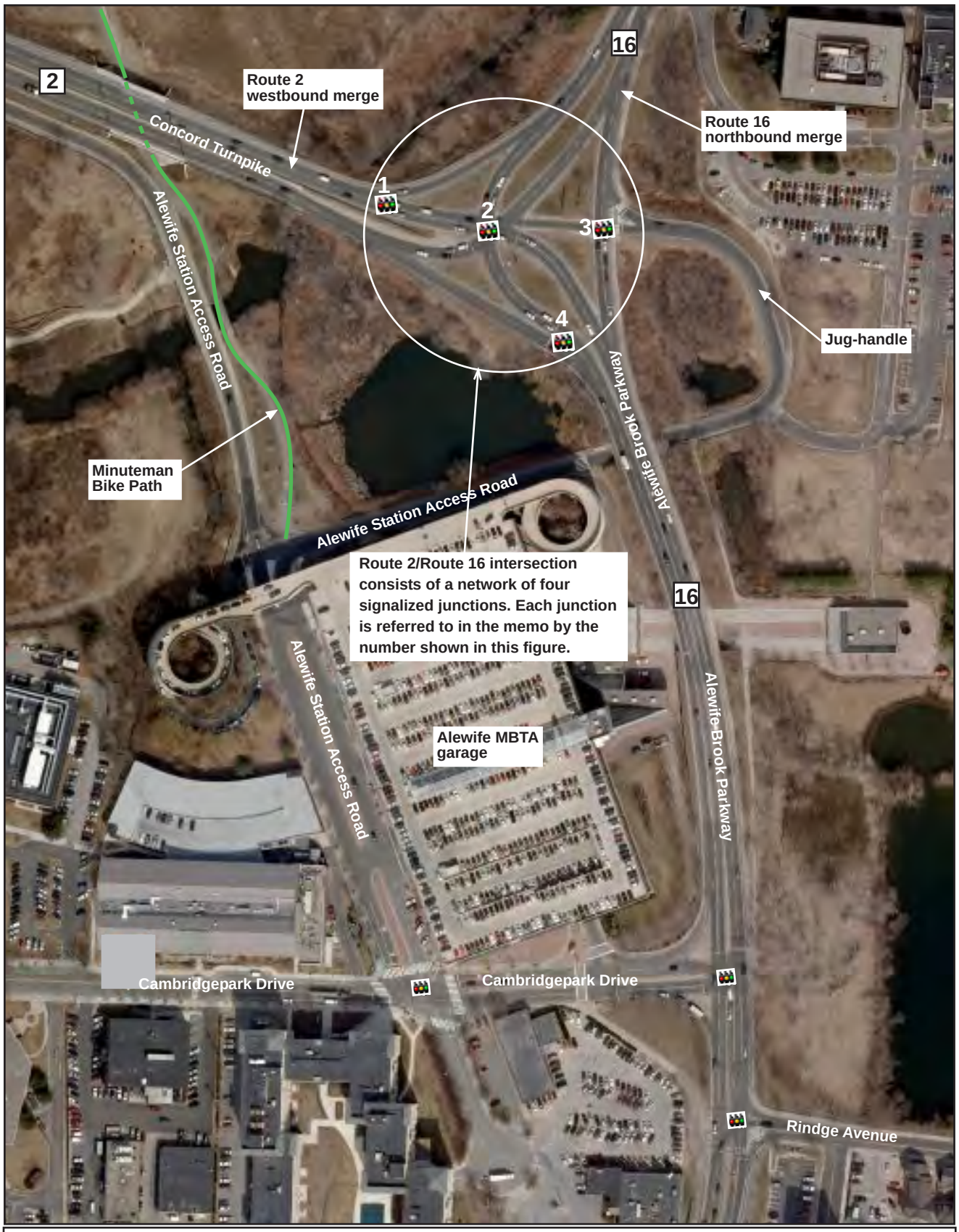

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FIGURE 1
Roadway Network

Route 2/Alewife
Brook Parkway
Traffic Study

BUS ROUTE NETWORK IN THE ALEWIFE AREA

There are six routes to/from Alewife Station that use Route 2 and Route 16 in the study area. Figure 2 shows the layout of the bus routes to/from the station. Buses 79 and 350 arrive at and leave the station via Route 16 (blue line in the figure) and the Alewife Station Service Road (jug-handle), respectively. Buses 62, 67, 76, and 84 access the station via Route 2 eastbound (yellow line) and the Alewife Station Service Road; they leave the station via the Alewife Station Service Road (jug-handle), the Route 2/Route 16 intersection, and Route 2 westbound. The Alewife Station Service Road south of Route 2 connects with Route 2 eastbound via the Route 2 eastbound off-ramp, approximately 1,400 feet west of the Route 2/Route 16 intersection, and also provides access to Acorn Park (not shown in Figure 2). At the other end, the Alewife Station Service Road passes under Route 16 and connects with the Route 2/Route 16 intersection via a jug-handle configuration (see Figure 2).

This description of bus access and egress shows that all westbound, southbound, and northbound buses must pass through the Route 2/Route 16 intersection, which experiences lengthy delays and queues during peak periods. In addition, all Route 2 eastbound buses arrive at the station via the Route 2 eastbound off-ramp, which is often blocked by Route 2 eastbound traffic backed up from the Route 2/Route 16 intersection.

FIELD OBSERVATIONS

As mentioned previously, the area is heavily congested during the peak traffic periods. Field visits to the area, augmented by insights from the Cambridge Traffic Department,[1] provided the following observations of the traffic operations in the area of Alewife Station, including operations at the Route 2/Route 16 intersection. Note that the observations described below make up a comprehensive list of known problems on the roadways surrounding the MBTA garage and that many of these were discussed in the Alewife Working Group in 2008. Figure 3 is a map showing the operations issues observed in the field, including the traffic diversion routes (shown in yellow lines) from the Route 2 eastbound off-ramp.

Although the operations problems include other intersections in the vicinity besides the Route 2/Route 16 intersection, the scope of this study is mainly to address operational issues at the Route 2/Route 16 intersection and access/egress issues of MBTA buses to/from the garage.

Route 2/Route 16 Intersection (see Figure 3)

Route 2 Eastbound:
In both lanes, queues extend back to the off-ramp to the Alewife Station Service Road. Queuing sometimes extends back past the off-ramp to the Lake Street interchange and prohibits buses and other ramp-destined vehicles from reaching the off-ramp. Due to congestion at the intersection, the left-most of the two through lanes is used by vehicles destined for Route 16 northbound, and vehicles headed to Route 16 southbound use the right lane. Thus, this approach limits the effectiveness and capacity of the four lanes at the intersection.

[1] City of Cambridge and CTPS staff presentation to the Alewife Working Group, May 2008.

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FIGURE 2
Bus Routes to/from Alewife MBTA Station

Route 2/Alewife Brook Parkway Traffic Study

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FIGURE 3
Traffic Operations Issues at the Alewife MBTA Station

Route 2/Alewife Brook Parkway Traffic Study

Alewife Station Access Road (Jug-handle):
During the evening peak hour, the queue on the single-lane roadway prevents vehicles turning right from reaching the intersection. Also the heavy queuing delays MBTA bus service.

Route 16 Southbound:
This approach has a heavy right-turn movement to Route 2 westbound during both peak periods. Queuing is significant in this single right-turn lane and limits the effectiveness of the two southbound through lanes, which southbound Route 16 buses use to reach the station.

Route 16 Northbound (including the merge area):
At the merge point north of the intersection, Route 2 eastbound and Route 16 northbound traffic merge from four lanes total into two lanes. Queues from the Route 16-to-Route 2 movement spill back past the diverge point and block vehicles destined for Route 16 northbound. This operational difficulty affects the overall level of service of the intersection; impacts on buses are included in the effects.

Route 2 Westbound Merge:
The merging area of the Route 16-to-Route 2 westbound traffic and the Alewife Station Access Road westbound traffic is very short and limits the capacity of these two movements at the intersection.

Route 2 Eastbound Off-Ramp to Alewife Station Access Road (see Figure 3)

Route 2 Off-Ramp:

- The queues from the Route 2/Route 16 intersection extend back past the ramp and block access to it.
- As a result of the queuing, MBTA buses are blocked from the station.
- Review of the AM and PM peak period traffic volumes reveals that traffic uses the Route 2 eastbound off-ramp to bypass the congested Route 2/Route 16 intersection as follows:

    1. Drivers divert from Route 2 using Acorn Park Road from the Lake Street interchange to access the Alewife Station Access Road (see yellow lines in Figure 3). They connect to Route 16 northbound and southbound using the Access Road (jug-handle) or Cambridgepark Drive. This diversion occurs when the Route 2 eastbound traffic queue builds up beyond the off-ramp to Alewife Station.

    2. Drivers also divert from the off-ramp to Alewife Station to avoid congestion at the Route 2/Route 16 intersection (see yellow lines in Figure 3). They usually do this when the Route 2 eastbound traffic queue is close to the off-ramp but not beyond it. They connect to Route 16 northbound or southbound using the same roads described earlier.

    In both situations drivers travel for a longer distance, but the total delay is perceived by drivers to be less than the delay of passing through the Route 2/Route 16 intersection from Route 2 eastbound.

Alewife Station Access Road/Cambridgepark Drive Intersection (see Figure 3)

Cambridgepark Drive Eastbound:

- During the evening peak period, this approach experiences long queues. These queues then block access to the bicycle lane.
- Eastbound vehicles frequently travel down the wrong side of the center yellow line into oncoming traffic due to congestion and long waiting times during the PM peak period.

Cambridgepark Drive Westbound:

- Frequent drop-offs are made at MBTA/Bertucci's on this approach; afterwards vehicles proceed to make U-turns at the intersection.

Alewife Station Access Road Southbound:

- The previously mentioned bypass vehicles make left turns at the intersection, thus delaying vehicles exiting from Cambridgepark Drive.
- Double left turns are permitted concurrently with the northbound movement.
- Left-turning vehicles do not yield to pedestrians in the crosswalk during the concurrent pedestrian phase.

Route 16/Cambridgepark Drive Intersection (see Figure 3)

Route 16 Northbound:

- Limited capacity on Route 16 limits access for vehicles turning left from Cambridgepark Drive.
- Left-turning vehicles are frequently using the yellow and red clearances to complete turns.
- The protected left-turn movement is constrained by southbound vehicles continuing during yellow and red phases.
- In the morning, there is a long queue on Route 16 at Cambridgepark Drive and at Rindge Avenue, while there is room for vehicles north of Cambridgepark Drive.

Route 16 Southbound:

- Due to extended delays, southbound vehicles continue during yellow and red phases.
- Right turns from Cambridgepark Drive fill the single right lane to Route 16 southbound. Additional vehicles turning right use the right-most of the two left-turn lanes to go around the channelization island in order to turn onto Route 16 southbound.

Cambridgepark Drive Eastbound:

- MBTA buses exit the garage across four lanes of traffic. (Note that this might no longer occur because of routing changes.)
- Queuing from the Route 2/Route 16 intersection spills back, limiting left turns from Cambridgepark Drive.
- Due to queuing from the Rindge Avenue intersection, right turns are being made from the left-turn lane, around the channelization island, to the second southbound lane.

INTERSECTION LEVEL OF SERVICE

As explained in the *Highway Capacity Manual (HCM 2000),* the concept of levels of service uses qualitative measures that characterize operational conditions within a traffic stream and how motorists and passengers perceive them. The criterion defining the levels of service for a signalized intersection is based on six ranges of control delay that is estimated from intersection geometry, operational parameters, and approaching traffic volumes. Figure 4 shows the levels of service for signalized intersections from HCM 2000. Level of service (LOS) A represents the most favorable condition, with minimal traffic delay. LOS F represents the worst condition, with significant traffic delay. LOS D is generally considered acceptable in an urban environment.

Using the peak hour traffic volumes and intersection geometry data collected in field reconnaissance, staff analyzed the existing traffic operations through the application of Synchro/ SimTraffic,[2] a traffic analysis and simulation software package that contains methodologies based on HCM 2000. Although the operations problems include other intersections in the vicinity besides the Route 2/Route 16 intersection, the scope of this study is to address mainly operational issues at the Route 2/Route 16 intersection and access/egress issues of MBTA buses to/from the garage. Therefore, analysis of existing conditions was focused only on this particular intersection. The results of the existing condition analysis are described below.

EXISTING CONDITIONS: ROUTE 2/ROUTE 16

Figure 5 shows existing traffic volumes. Tables 1 and 2 summarize existing conditions analysis results for the AM and PM peak hours, respectively. As previously stated, this intersection was analyzed as four smaller intersections, all coordinated with each other. (Refer to Figure 2, which shows how the intersections are numbered for the purposes of the analysis.)

As the tables show, many movements at the intersection are operating over capacity (volume-to-capacity ratio, V/C, is greater than 1.0) and with LOS E or F, causing significant delays and queuing (in the tables, see 95% queue,[3] Q, in feet). These delays and queuing also significantly impact the operations of the MBTA buses.

The next sections describe possible options for improving traffic operations at the Route 2/Route 16 intersection and for improving access to/from Alewife Station.

POTENTIAL ROUTE 2/ROUTE 16 INTERSECTION IMPROVEMENT OPTIONS

Eight options were developed for improving the operations and traffic flow at the Route 2/Route 16 intersection; many of them were developed and analyzed by staff as part of the work performed for the Alewife Working Group. The list of options below is a comprehensive list of those developed within the context of this study and from the work of the Alewife Working Group. Some options were analyzed quantitatively using the microsimulation software VISSIM[4] or the software SYNCHRO, and others were analyzed qualitatively.

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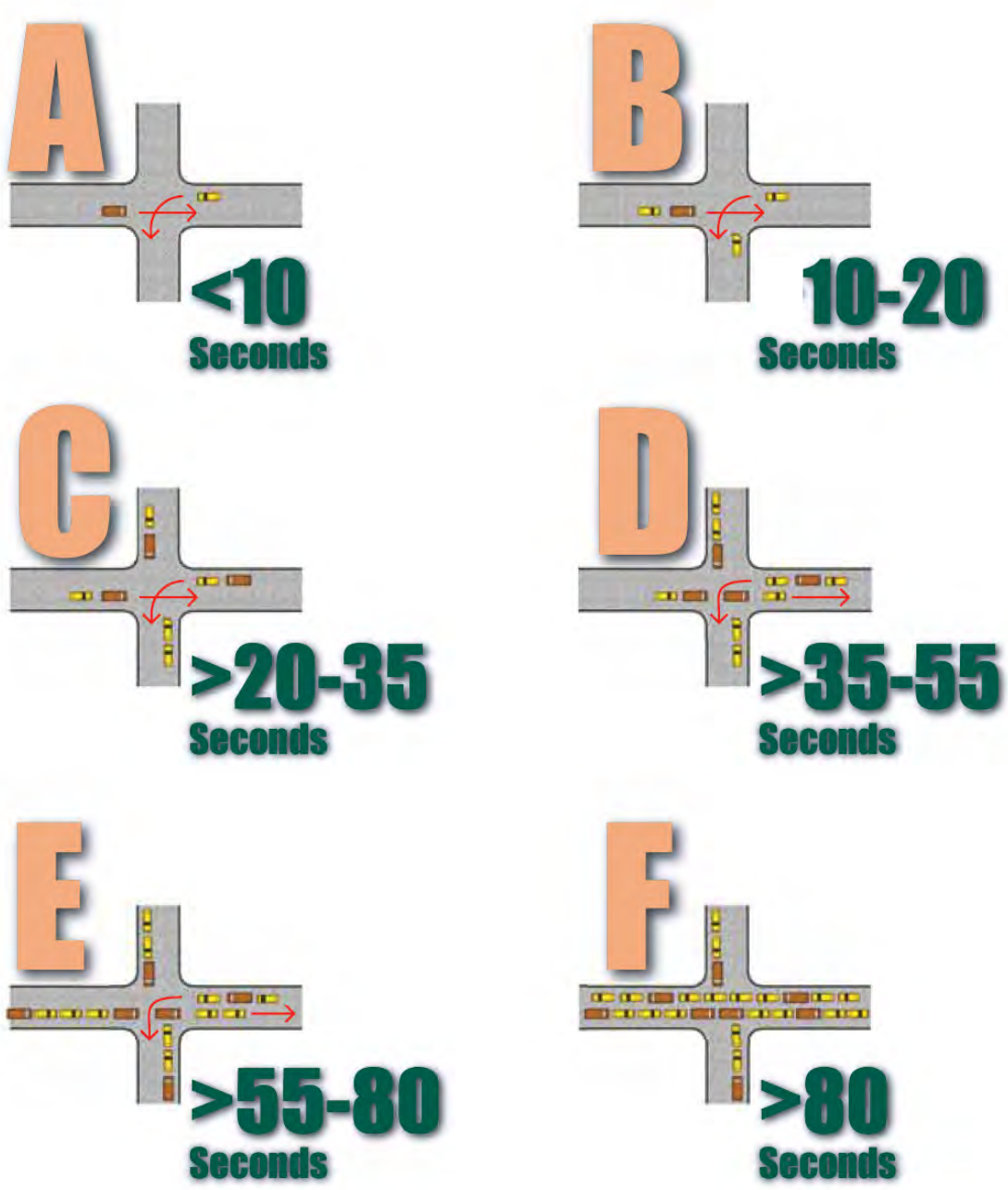
[2] *Synchro/SimTraffic Version 6*, Trafficware Corporation, 2003.
[3] A 95% approach queue is one which is expected to be longer than indicated 5% of the time.
[4] *VISSIM Version 5.0*, PTV America, 2007.



The average control delay per vehicle is estimated for each lane group and aggregated for each approach and for the intersection as a whole. The level of service is directly related to the control delay value.

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FIGURE 4
Concept of Level of Service for Signalized Intersection
Average Control Delay

Route 2/Alewife Brook Parkway Traffic Study

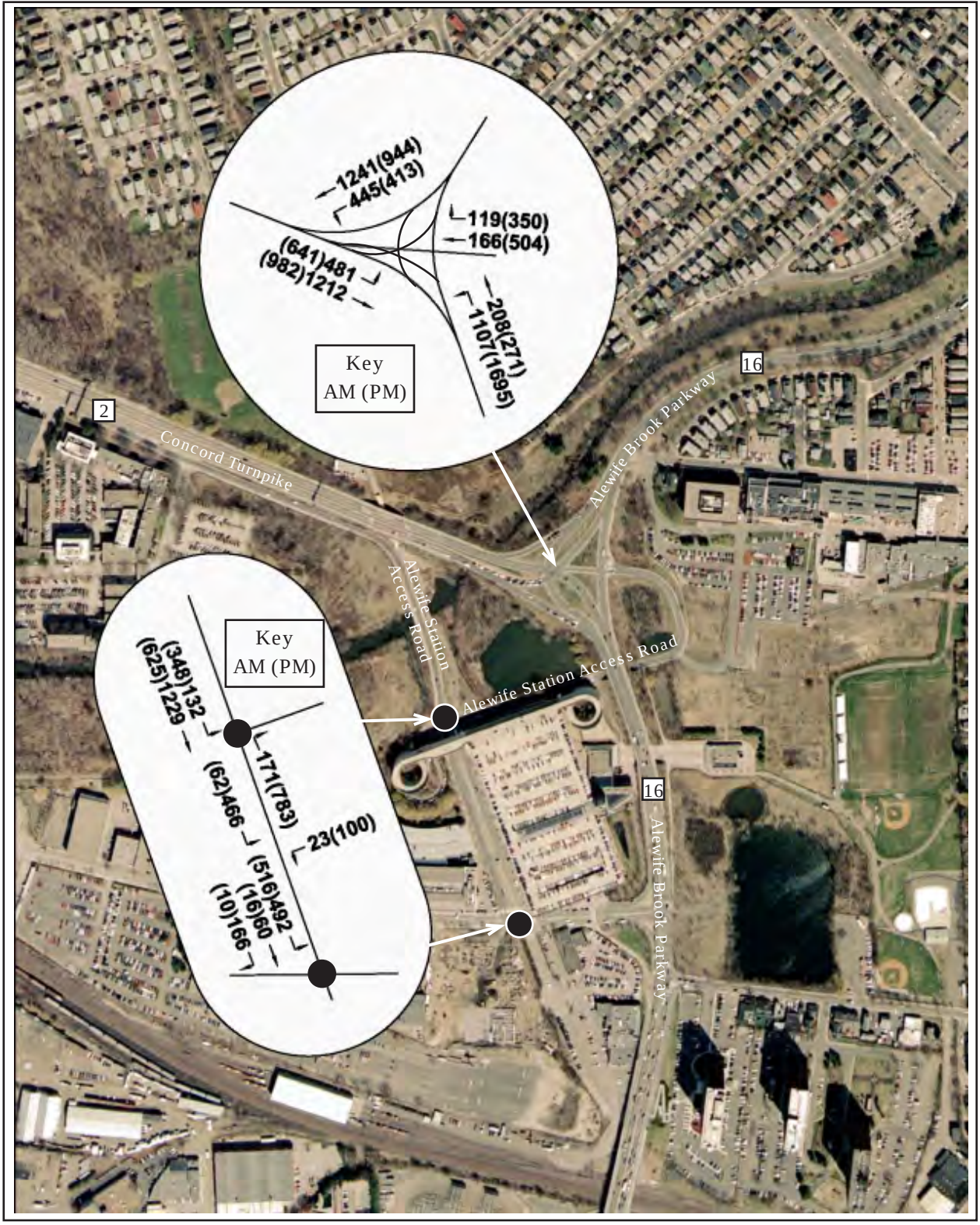

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FIGURE 5
Existing Traffic Volumes

Route 2/Alewife Brook Parkway Traffic Study

TABLE 1
Existing Conditions - AM Peak Hour

Intersection #	Movement	LOS	Delay (Sec)	V/C Ratio	95% Queue (ft)
1	Route 2 WB	C	34.9	1.02	m127
	Alewife to Route 2 WB	F	290.3	1.57	#1745
	Overall	F	160.7	1.34	n/a
2	Alewife Station Exit - Through	A	1.9	0.25	3
	Alewife SB to Alewife	C	33.7	0.43	206
	Alewife NB to Route 2 WB	F	136.5	1.14	#680
	Route 2 EB to Alewife NB	E	57.3	0.81	#274
	Overall	F	88.0	0.75	n/a
3	Alewife NB to Alewife	A	2.6	0.12	m17
	Alewife Station Exit - Through	C	26.2	0.26	154
	Alewife Station Exit - Right	C	23.9	0.08	40
	Overall	C	15.9	0.18	n/a
	Route 2 EB to Alewife SB	C	21.6	0.72	415
	Alewife SB to Alewife	A	5.6	0.44	14
	Overall	B	17.3	-	n/a

Note: # - 95% volume exceeds capacity, queue may be longer.
m - Volume for 95% queue is metered by upstream signal.

TABLE 2
Existing Conditions - PM Peak Hour

Intersection #	Movement	LOS	Delay (Sec)	V/C Ratio	95% Queue (ft)
1	Route 2 WB	F	113.6	1.22	m1145
	Alewife to Route 2 WB	F	435.9	1.87	#1465
	Overall	F	207.9	1.46	n/a
2	Alewife Station Exit - Through	A	2.6	0.59	10
	Alewife SB to Alewife	F	82.5	0.95	#288
	Alewife NB to Route 2 WB	E	68.2	1.07	m#907
	Route 2 EB to Alewife NB	F	125.6	1.13	#451
	Overall	E	69.5	1.03	n/a
3	Alewife NB to Alewife	C	28.1	0.24	m110
	Alewife Station Exit - Through	B	18.9	0.59	417
	Alewife Station Exit - Right	B	14.2	0.32	80
	Overall	B	19.4	0.46	n/a
	Route 2 EB to Alewife SB	A	6.6	0.48	161
	Alewife SB to Alewife	E	63.4	1.02	m#98
	Overall	C	23.4	0.55	n/a

Note: # - 95% volume exceeds capacity, queue may be longer.
m - Volume for 95% queue is metered by upstream signal.

Of the eight options, the first four are low- to medium-capital-investment options; the last four are high-capital-investment options. Each option is discussed in detail in the subsections below.

1. Optimize signal timings
2. Replace existing left-turn lane from Route 2 eastbound to Route 16 northbound with a double left-turn lane
3. Eliminate Route 2 eastbound left turns and divert traffic to the Alewife Station Access Road
4. Add a third lane along Route 2 westbound from the Alewife Station Access Road approach to just past the Minuteman Bike Path overpass
5. Construct a fly-over from Route 16 northbound to Route 2 westbound
6. Replace intersection with a conventional roundabout
7. Replace intersection with a roundabout, including right-turn slip ramps
8. Replace intersection with a roundabout, including a fly-over for traffic from Route 16 northbound to Route 2 westbound

Option 1: Optimize signal timings
Optimizing signal timings is the easiest and least expensive way to improve operations at an intersection. Optimization aims at improving the efficiency of the intersection's operations by examining the allocation of green time in the signal and, if necessary, reallocating it among the various signal phases/approaches to reduce overall intersection delays and queues. However, as Table 3 shows, this option is not effective for this intersection, as it cannot, as a stand-alone strategy (without geometric changes), reduce sufficiently the significant delays and queues at this location.

Option 2: Replace existing left-turn lane from Route 2 eastbound to Route 16 northbound with a double left-turn lane
At present, traffic for the single left-turn lane from Route 2 eastbound to Route 16 northbound spills onto the Route 2 eastbound through lanes, reducing the processing capacity of that movement. Although for a short distance within the intersection left-turning vehicles line up in two lanes, this lane use is not sufficient to store enough vehicles and prevent the spillover. The recommended improvement would be to construct a longer double left-turn lane that would allow for full use/storage and increased capacity for left turns without impacting through movements. However, analysis (Table 4) showed that this minor lane adjustment is not sufficient by itself to improve traffic operations at the intersection and needs to be combined with another option.

Option 3: Eliminate Route 2 eastbound left turns and divert traffic to the Alewife Station Access Road
This proposed improvement would place the left-turning vehicles onto the Alewife Station Access Road. The left turns would exit Route 2 at the Alewife Station Access Road off-ramp, continue onto the access road past the garage, and eventually reach the Route 2/Route 16 intersection from the east (via the jug-handle) to make the right turn to Route 16 northbound. This improvement allows for the elimination of one phase from the design of the traffic signal, giving additional time to the other critical movements. Table 5 shows the results of this improvement.

TABLE 3
Option 1: Optimize Signal Timings

Intersection	Movement	LOS		Delay		Volume-to-Capacity Ratio		95% Queue Length	
		Existing	Option 1	Existing	Option 1	Existing	Option 1	Existing	Option 1
AM Peak Hour									
1	Route 2 WB	C	B	39.4	18.3	1.02	0.91	m127	m135
	Route 16 SB to Route 2 WB	F	F	290.3	365.6	1.57	1.73	#1745	#1810
	Overall	F	F	160.7	189.4	1.34	1.34	n/a	n/a
2	Alewife Station Exit to Route 2 WB	A	A	1.9	1.6	0.25	0.23	3	3
	Route 16 SB - Through	C	D	33.7	39.4	0.43	0.51	206	222
	Route 16 NB to Route 2 WB	F	E	136.5	57.7	1.14	0.91	#680	#569
	Route 2 EB to Route 16 NB	E	E	57.3	57.3	0.81	0.81	#274	274
	Overall	F	D	88	49.6	0.75	0.74	n/a	n/a
3	Route 16 NB - Through	A	A	2.6	5.7	0.12	0.13	m17	m42
	Alewife Station Exit - Through	C	C	26.2	22.1	0.26	0.23	154	141
	Alewife Station Exit - Right	C	C	23.9	20.2	0.08	0.08	40	36
	Overall	B	B	15.9	14.9	0.18	0.18	n/a	n/a
4	Route 2 EB to Route 16 SB	C	B	21.6	17.4	0.72	0.68	415	381
	Route 16 SB - Through	A	A	5.6	6.6	0.44	0.53	14	14
	Overall	B	B	17.3	14.5	N/A	0.64	n/a	n/a
PM Peak Hour									
1	Route 2 WB	F	F	113.6	239.7	1.22	1.48	m#1145	m#1174
	Route 16 SB to Route 2 WB	F	F	435.9	221.9	1.87	1.38	#1465	#1593
	Overall	F	F	207.9	234.5	1.46	1.43	n/a	n/a
2	Alewife Station Exit to Route 2 WB	A	A	2.6	4.2	0.59	0.71	10	9
	Route 16 SB - Through	F	E	82.5	663.0	0.95	0.73	#288	285
	Route 16 NB to Route 2 WB	E	F	68.2	236.3	1.07	1.41	m#907	#1376
	Route 2 EB to Route 16 NB	F	E	125.6	57.0	1.13	0.76	#451	408
	Overall	E	F	69.5	140.0	1.03	1.02	n/a	n/a
3	Route 16 NB - Through	C	C	28.1	24.1	0.24	0.18	m110	120
	Alewife Station Exit - Through	B	D	18.9	36.7	0.59	0.72	417	644
	Alewife Station Exit - Right	B	C	14.2	26.1	0.32	0.35	80	135
	Overall	B	C	19.4	30.6	0.46	0.46	n/a	n/a
4	Route 2 EB to Route 16 SB	A	B	6.6	11.8	0.48	0.51	161	260
	Route 16 SB - Through	E	A	63.4	3.0	1.02	0.61	m#98	1
	Overall	C	A	23.4	9.2	0.55	0.53	n/a	n/a

Note: # - 95% volume exceeds capacity; queue may be longer.
m - Volume for 95% queue is metered by upstream signal.

TABLE 4
Option 2: Install a Double Left-Turn Lane for Route 2 Eastbound Traffic

Intersection	Movement	LOS		Delay		Volume-to-Capacity Ratio		95% Queue Length	
		Existing	Option 2	Existing	Option 2	Existing	Option 2	Existing	Option 2
AM Peak Hour									
1	Route 2 WB	C	B	39.4	18.3	1.02	0.91	m127	m135
	Route 16 SB to Route 2 WB	F	F	290.3	365.6	1.57	1.73	#1745	#1810
	Overall	F	F	160.7	189.4	1.34	1.34	n/a	n/a
2	Alewife Station Exit to Route 2 WB	A	A	1.9	1.6	0.25	0.23	3	3
	Route 16 SB - Through	C	D	33.7	39.4	0.43	0.51	206	222
	Route 16 NB to Route 2 WB	F	E	136.5	57.7	1.14	0.91	#680	#569
	Route 2 EB to Route 16 NB	E	E	57.3	61.3	0.81	0.83	#274	300
	Overall	F	D	88	49.6	0.75	0.74	n/a	n/a
3	Route 16 NB - Through	A	A	2.6	5.7	0.12	0.13	m17	m42
	Alewife Station Exit - Through	C	C	26.2	22.1	0.26	0.23	154	141
	Alewife Station Exit - Right	C	C	23.9	20.2	0.08	0.08	40	36
	Overall	B	B	15.9	14.9	0.18	0.18	n/a	n/a
4	Route 2 EB to Route 16 SB	C	B	21.6	17.4	0.72	0.68	415	381
	Route 16 SB - Through	A	A	5.6	6.6	0.44	0.53	14	14
	Overall	B	B	17.3	14.5	N/A	0.64	n/a	n/a
PM Peak Hour									
1	Route 2 WB	F	F	113.6	239.7	1.22	1.48	m#1145	m#1174
	Route 16 SB to Route 2 WB	F	F	435.9	221.9	1.87	1.38	#1465	#1593
	Overall	F	F	207.9	234.5	1.46	1.43	n/a	n/a
2	Alewife Station Exit to Route 2 WB	A	A	2.6	4.2	0.59	0.71	10	9
	Route 16 SB – Through	F	E	82.5	663.0	0.95	0.73	#288	285
	Route 16 NB to Route 2 WB	E	F	68.2	236.3	1.07	1.41	m#907	#1376
	Route 2 EB to Route 16 NB	F	E	125.6	57.0	1.13	0.76	#451	408
	Overall	E	F	69.5	140.0	1.03	1.02	n/a	n/a
3	Route 16 NB - Through	C	C	28.1	24.1	0.24	0.18	m110	120
	Alewife Station Exit - Through	B	D	18.9	36.7	0.59	0.72	417	644
	Alewife Station Exit - Right	B	C	14.2	26.1	0.32	0.35	80	135
	Overall	B	C	19.4	30.6	0.46	0.46	n/a	n/a
4	Route 2 EB to Route 16 SB	A	B	6.6	11.8	0.48	0.51	161	260
	Route 16 SB - Through	E	A	63.4	3.0	1.02	0.61	m#98	1
	Overall	C	A	23.4	9.2	0.55	0.53	n/a	n/a

Note: # - 95% volume exceeds capacity; queue may be longer.
m - Volume for 95% queue is metered by upstream signal.
Currently drivers line up in two lanes to turn left; this option helps in storage of left-turn vehicles. The results for Option 2 are similar to those of Option 1.

While this improvement addresses some of the problems associated with some movements within the intersection, it does not adequately improve the overall operations of the entire intersection. For example, it does not improve the Route 2 westbound/Route 16 southbound merge. Delays and queuing on the Alewife Station Access Road approach, the jug-handle, would necessitate widening the roadway to two lanes along its entirety, including widening the Route 16 bridge over the Alewife Station Access Road. In addition, as this option would add 500 to 600 vehicles to the off-ramp and the Alewife Station Access Road, MBTA bus routes would suffer additional delays, and drivers and passengers would incur additional vehicle-miles and vehicle-time traveled (VMT and VHT). This option was dropped because of its impacts on MBTA bus operations to/from the Alewife Station.

Option 4: Add a third lane along Route 2 westbound from the Alewife Station Access Road approach (jug-handle) to just past the Minuteman Bike path overpass or to Lake Street

Adding a third lane westbound on the north side of Route 2 is an effective measure, as it frees up green time at the intersection for reallocation to other approaches, including the Alewife Station Access Road. This option, shown in Figure 6, also includes a double right-turn lane from Route 16 southbound to Route 2 westbound and a double left-turn lane from Route 2 eastbound to Route 16 northbound. Analysis showed that adding the third lane westbound, along with the other two features, would result in lower delays and shorter queues on all approaches of the intersection. This option has overarching benefits that include reductions in travel times and delays for vehicles and buses. Option 4 also reduces the eastbound queue that blocks the off-ramp, thus improving bus access from the west.

For the portion of the third lane within the intersection, there is right-of-way available for its construction. For the portion of the third lane west of this area, specifically between the intersection and the Minuteman Bike Path overpass, right-of-way appears to be available. The additional roadway width would have to be secured from an existing and potentially abandoned, sidewalk that begins just north of the intersection on the western side of Route 16 and ends at the Minuteman Bike Path overpass. (MAPC's draft report, *Alewife Access Study*, March 2009 states that there is a need to maintain a pedestrian corridor on the north side of Route 2.) In addition, analysis showed that extension of the third lane to Lake Street is not required in the short term but should be reconsidered in the longer term (Table 6). This option has the potential of improving traffic operations at the Route 2/Route 16 intersection with minimal cost and minimal adverse construction impacts.

Option 5: Construct a Route 2 westbound fly-over

This option is the most beneficial of the improvements presented, but also has the greatest cost. The fly-over removes the most traffic overall from the intersection and allows the other, accompanying improvements to operate better. Figure 7 shows this option. As the figure shows, a single-lane fly-over ramp would be constructed to remove the Route 16 northbound-to-Route 2 westbound traffic from the intersection. Also, a third departing lane would be constructed for a short distance on Route 2 westbound so that the fly-over ramp would have its own lane westbound while Route 16 southbound and Alewife Station Access Road traffic would use the remaining two lanes.

This option eliminates the need for a signal at intersection #1 (see Figure 1). The widening also allows for improved traffic flow through the Lake Street interchange, where Route 2 widens to four lanes. As Table 7 shows, the operations of the remaining intersections improve greatly, with V/C ratios for all movements well below one.

TABLE 5
Option 3: Eliminate Route 2 Eastbound Left Turns

Intersection	Movement	LOS		Delay		Volume to Capacity Ratio		95% Queue Length	
AM Peak Hour									
		Existing	**Option 3**	**Existing**	**Option 3**	**Existing**	**Option 3**	**Existing**	**Option 3**
1	Route 2 WB	C	F	39.4	425.6	1.02	1.86	m127	m122
	Route 16 SB to Route 2 WB	F	B	290.3	15.4	1.57	0.84	#1745	#1853
	Overall	F	F	160.7	217.5	1.34	1.34	n/a	n/a
2	Alewife Station Exit to Route 2 WB	A	A	1.9	4.1	0.25	0.21	3	17
	Route 16 SB - Through	C	C	33.7	21.5	0.43	0.30	206	163
	Route 16 NB to Route 2 WB	F	E	136.5	61.9	1.14	0.93	#680	#581
	Route 2 EB to Route 16 NB	E	-	57.3	-	0.81	-	#274	-
	Overall	F	D	88	45.7	0.75	0.56	n/a	n/a
3	Route 16 NB - Through	A	A	2.6	5.6	0.12	0.14	m17	m40
	Alewife Station Exit - Through	C	C	26.2	25.2	0.26	0.52	154	310
	Alewife Station Exit - Right	C	C	23.9	20.5	0.08	0.27	40	56
	Overall	B	B	15.9	19.2	0.18	0.34	n/a	n/a
4	Route 2 EB to Route 16 SB	C	C	21.6	33.4	0.72	0.82	415	467
	Route 16 SB - Through	A	A	5.6	3.4	0.44	0.30	14	12
	Overall	B	D	17.3	25.4	N/A	0.57	n/a	n/a
PM Peak Hour									
1	Route 2 WB	F	F	113.6	106.4	1.22	1.20	m#1145	m#1101
	Route 16 SB to Route 2 WB	F	F	435.9	456.7	1.87	1.91	#1465	#1476
	Overall	F	F	207.9	209	1.46	1.46	n/a	n/a
2	Alewife Station Exit to Route 2 WB	A	A	2.6	2.1	0.59	0.58	10	m21
	Route 16 SB - Through	F	D	82.5	31.5	0.95	0.38	#288	185
	Route 16 NB to Route 2 WB	E	E	68.2	76.7	1.07	1.09	m#907	m#919
	Route 2 EB to Route 16 NB	F	-	125.6	-	1.13	-	#451	-
	Overall	E	D	69.5	53.6	1.03	0.78	n/a	n/a
3	Route 16 NB - Through	C	C	28.1	27.5	0.24	0.25	m110	m108
	Alewife Station Exit - Through	B	D	18.9	39.5	0.59	0.93	417	#987
	Alewife Station Exit - Right	B	C	14.2	26.9	0.32	0.80	80	571
	Overall	B	C	19.4	32.6	0.46	0.69	n/a	n/a
4	Route 2 EB to Route 16 SB	A	B	6.6	17.1	0.48	0.57	161	263
	Route 16 SB - Through	E	A	63.4	4.5	1.02	0.38	m#98	11
	Overall	C	B	23.4	13.4	0.55	0.50	n/a	n/a

Note: # - 95% volume exceeds capacity, queue may be longer.
m - Volume for 95% queue is metered by upstream signal.

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FIGURE 6
Option 4: Add a Third Lane Along Route 2 Westbound

Route 2/Alewife Brook Parkway Traffic Study

TABLE 6
Option 4: Add a Third Lane Along Route 2 Westbound from Alewife Station Access Road to Minuteman Bike Path Overpass*

Approach	Movement	LOS		Delay	
		Existing	Option 4	Existing	Option 4
AM Peak Hour					
Route 16 SB	Route 2 WB	D	B	42.1	14.3
	Route 16 SB	F	C	103.0	24.8
	Overall	E	B	57.8	17.1
Route 16 NB	Route 16 NB	F	B	117.0	13.2
	Route 2 EB	F	C	256.1	33.2
	Overall	F	C	234.0	30.0
Jug-Handle	Route 16 NB	C	C	29.2	22.4
	Route 2 WB	C	C	32.0	22.9
	Overall	C	C	30.8	22.7
Route 2 EB	Route 16 SB	F	B	133.5	17.9
	Route 16 NB	F	D	85.2	41.7
	Overall	F	C	119.8	24.7
PM Peak Hour					
Route 16 SB	Route 2 WB	D	B	41.8	20.0
	Route 16 SB	E	D	64.7	46.7
	Overall	D	C	48.8	28.1
Route 16 NB	Route 16 NB	F	B	81.0	18.9
	Route 2 EB	F	C	131.6	34.9
	Overall	F	C	124.6	32.7
Jug-Handle	Route 16 NB	D	C	36.2	30.9
	Route 2 WB	F	D	134.5	45.7
	Overall	F	D	94.2	39.6
Route 2 EB	Route 16 SB	F	B	33.5	18.7
	Route 16 NB	B	D	123.5	46.8
	Overall	E	B	69.0	19.1

Results are from VISSIM software
* This option includes a double right-turn lane from Route 16 southbound and a double left-turn lane from Route 2 eastbound to Route 16 northbound.

Based upon MassHighway layout plans, the widening could occur within the existing 100-foot right-of-way. However, it would require the reconstruction of Route 2 in both directions from Route 2/Route 16 to the Lake Street interchange to ease impacts to the properties located along the north side of Route 2. This option was dropped owing to the high costs of construction and of construction impacts.

Option 6: Replace intersection with conventional roundabout

Analysis of a two-lane conventional roundabout revealed a long traffic queue on Route 16 southbound (Figure 8). This phenomenon usually occurs at a roundabout when traffic is not balanced at the intersection, as indicated by the high directional traffic flow between Route 2 and Route 16 and the lack of sufficient left and right turns from the approaches. The net effect of this condition is a constant flow of traffic (from Route 16 northbound to Route 2 westbound) across the entrance of Route 16 southbound, resulting in excessive delays and queuing on that approach (Table 8). Based on the results of the analysis, this option was dropped.

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FIGURE 7
Option 5: Route 2 Westbound Fly-Over

Route 2/Alewife
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TABLE 7
Option 5: Eliminate Route 2 Westbound Flyover

Intersection	Movement	LOS		Delay		Volume to Capacity Ratio		95% Queue Length	
AM Peak Hour									
		Existing	**Option 5**	**Existing**	**Option 5**	**Existing**	**Option 5**	**Existing**	**Option 5**
1	Route 2 WB	C	n/a	39.4	n/a	1.02	n/a	m127	n/a
	Route 16 SB to Route 2 WB	F	n/a	290.3	n/a	1.57	n/a	#1745	n/a
	Overall	F	n/a	160.7	n/a	1.34	n/a	n/a	n/a
2	Alewife Station Exit to Route 2 WB	A	A	1.9	3.1	0.25	0.25	3	7
	Route 16 SB - Through	C	C	33.7	33.7	0.43	0.43	206	206
	Route 16 NB to Route 2 WB	F	E	136.5	57.3	1.14	0.81	#680	#274
	Route 2 EB to Route 16 NB	E	-	57.3	-	0.81	-	#274	-
	Overall	F	D	88	39.2	0.75	0.43	n/a	n/a
3	Route 16 NB - Through	A	A	2.6	2.6	0.12	0.12	m17	m17
	Alewife Station Exit - Through	C	C	26.2	26.2	0.26	0.26	154	154
	Alewife Station Exit - Right	C	C	23.9	23.9	0.08	0.08	40	40
	Overall	B	B	15.9	15.9	0.18	0.18	n/a	n/a
4	Route 2 EB to Route 16 SB	C	C	21.6	21.6	0.72	0.72	415	415
	Route 16 SB - Through	A	A	5.6	5.6	0.44	0.44	14	14
	Overall	B	C	17.3	17.3	N/A	0.62	n/a	n/a
PM Peak Hour									
1	Route 2 WB	F	n/a	113.6	n/a	1.22	n/a	m#1145	n/a
	Route 16 SB to Route 2 WB	F	n/a	435.9	n/a	1.87	n/a	#1465	n/a
	Overall	F	n/a	207.9	n/a	1.46	n/a	n/a	n/a
2	Alewife Station Exit to Route 2 WB	A	B	2.6	10.8	0.59	0.87	10	m49
	Route 16 SB - Through	F	C	82.5	34.9	0.95	0.42	#288	196
	Route 16 NB to Route 2 WB	E	E	68.2	78.1	1.07	0.98	m#907	#414
	Route 2 EB to Route 16 NB	F	-	125.6	-	1.13	-	#451	-
	Overall	E	D	69.5	43.2	1.03	0.75	n/a	n/a
3	Route 16 NB - Through	C	A	28.1	2.6	0.24	0.16	m110	39
	Alewife Station Exit - Through	B	D	18.9	26.2	0.59	0.89	417	#677
	Alewife Station Exit - Right	B	C	14.2	23.9	0.32	0.35	80	120
	Overall	B	C	19.4	15.9	0.46	0.46	n/a	n/a
4	Route 2 EB to Route 16 SB	A	B	6.6	21.6	0.48	0.55	161	256
	Route 16 SB - Through	E	A	63.4	5.6	1.02	0.44	m#98	13
	Overall	C	B	23.4	17.3	0.55	0.51	n/a	n/a

Note: # - 95% volume exceeds capacity, queue may be longer.
m - Volume for 95% queue is metered by upstream signal.

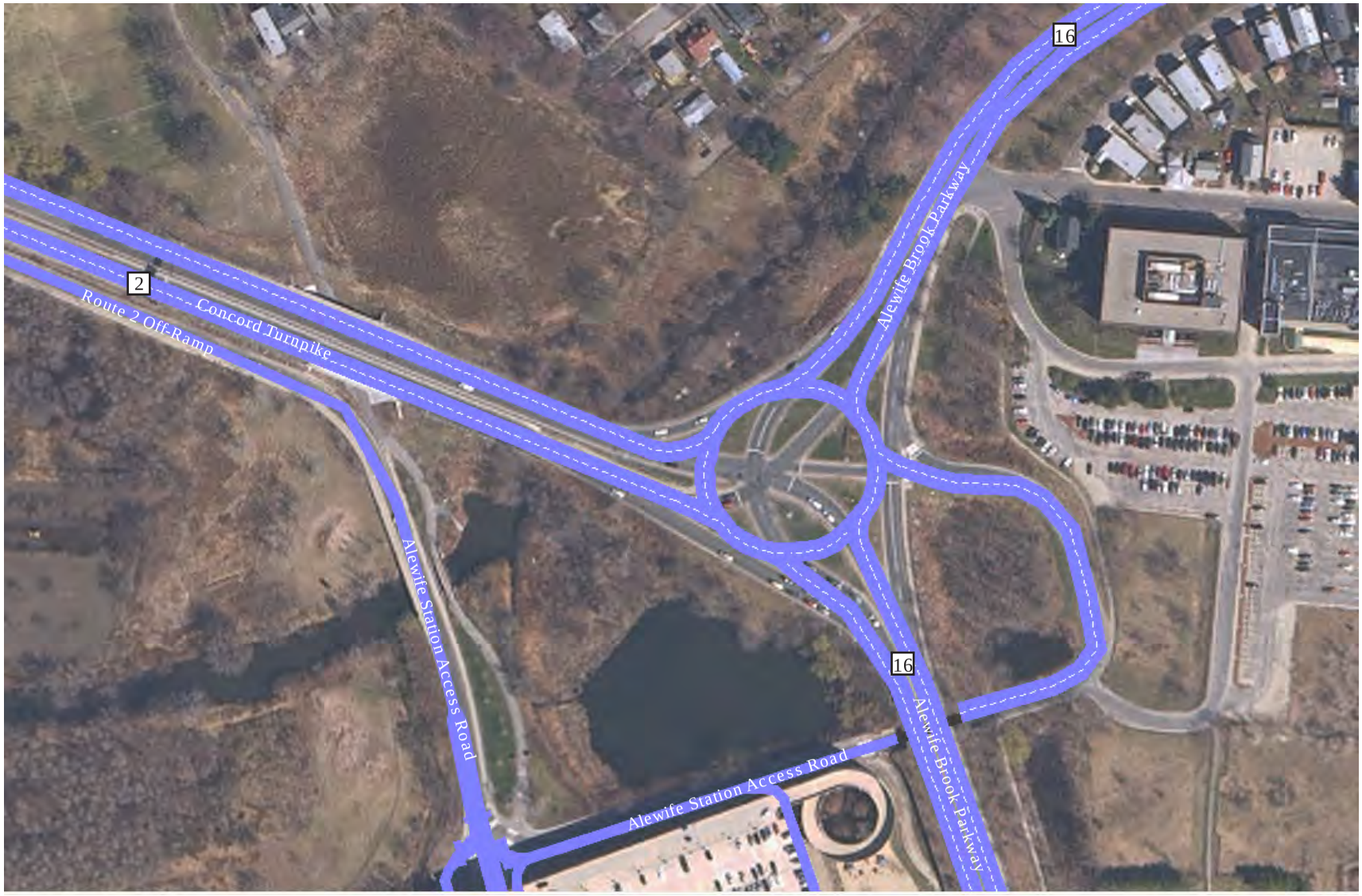

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FIGURE 8
Option 6: Conventional Roundabout

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TABLE 8
Option 6: Conventional Roundabout

Approach	Movement	LOS		Delay	
		Existing	Option 6	Existing	Option 6
AM Peak Hour					
Route 16 SB	Route 2 WB	D	F	42.1	151.2
	Route 16 SB	F	F	103.0	151.2
	Overall	E	F	57.8	151.2
Route 16 NB	Route 16 NB	F	A	117.0	8.6
	Route 2 EB	F	A	256.1	8.6
	Overall	F	A	234.0	8.6
Jug-Handle	Route 16 NB	C	E	29.2	50
	Route 2 WB	C	E	32.0	50
	Overall	C	E	30.8	50
Route 2 EB	Route 16 SB	F	A	133.5	4.4
	Route 16 NB	F	A	85.2	4.4
	Overall	F	A	119.8	4.4

Results are from VISSIM software

Option 7: Replace intersection with roundabout, including right-turn slip ramps

To reduce the effect of a long traffic queue and excessive delay on Route 16 southbound, staff analyzed a two-lane roundabout with right-turn slip ramps on all approaches (Figure 9). The purpose of the right-turn slip ramps was to allow these streams of traffic to change direction without conflicting with traffic within the roundabout, thus proceeding directly to Route 2 or Route 16. The slip ramps increase the capacity of the roundabout, but they also send more traffic quickly downstream to the intersection of Route 16 and Cambridgepark Drive; that intersection is unable to handle the increase in traffic during the AM peak period. The end result of this operation is excessive traffic delay and a queue that backs up into the roundabout, causing long traffic queues on Route 2 eastbound (Table 9). During the PM peak period, the high volumes of left turns from Route 2 eastbound cause excessive delays on Route 16 northbound and the off-ramp to Alewife Station. Based on the results of the analysis, this option was dropped.

Option 8: Replace intersection with roundabout, including a fly-over for traffic from Route 16 northbound to Route 2 westbound

A roundabout with slip ramps and a fly-over from Route 16 northbound to Route 2 westbound works well in the PM peak period (Figure 10). However, it does not work well during the AM peak period, because it sends more traffic quickly downstream to the intersection of Route 16 and Cambridgepark Drive, and that intersection is unable to handle this. The end result of this operation is excessive traffic delay and a queue that backs up into the roundabout, causing long traffic queues on Route 2 eastbound (Table 10). Based on the results of the analysis, this option was dropped.

In summary, of the eight options considered in this analysis, the first three offer minor operational improvements that are insufficient to significantly benefit the intersection of Route 2/Route 16. The last four options entail capital-intensive reconstruction solutions that either are not effective, have construction impacts, or cause bottlenecks elsewhere. Option 4, however, appears to offer an effective solution with opportunities for immediate implementation by transportation agencies, the City of Cambridge, or a development proponent, or by various combinations/partnerships of the above entities.

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FIGURE 9
Option 7: Roundabout with Right-Turn Slip Lanes

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TABLE 9
Option 7: Conventional Roundabout with Slip Lanes

Approach	Movement	LOS		Delay	
		Existing	Option 7	Existing	Option 7
AM Peak Hour					
Route 16 SB	Route 2 WB	D	A	42.1	1.4
	Route 16 SB	F	B	103.0	14.9
	Overall	E	A	57.8	5.0
Route 16 NB	Route 16 NB	F	C	117.0	20.4
	Route 2 EB	F	C	256.1	20.4
	Overall	F	C	234.0	20.4
Jug-Handle	Route 16 NB	C	B	29.2	11.5
	Route 2 WB	C	B	32.0	11.5
	Overall	C	B	30.8	11.5
Route 2 EB	Route 16 SB	F	F	133.5	138.6
	Route 16 NB	F	F	85.2	145.3
	Overall	F	F	119.8	143.2
PM Peak Hour					
Route 16 SB	Route 2 WB	D	A	41.8	2.4
	Route 16 SB	E	B	64.7	16.2
	Overall	D	A	48.8	6.6
Route 16 NB	Route 16 NB	F	C	81.0	20.4
	Route 2 EB	F	C	131.6	20.4
	Overall	F	C	124.6	20.4
Jug-Handle	Route 16 NB	D	F	36.2	218
	Route 2 WB	F	F	134.5	218
	Overall	F	F	94.2	218
Route 2 EB	Route 16 SB	F	B	33.5	10.4
	Route 16 NB	B	A	123.5	9.2
	Overall	E	A	69.0	9.9

Results are from VISSIM software

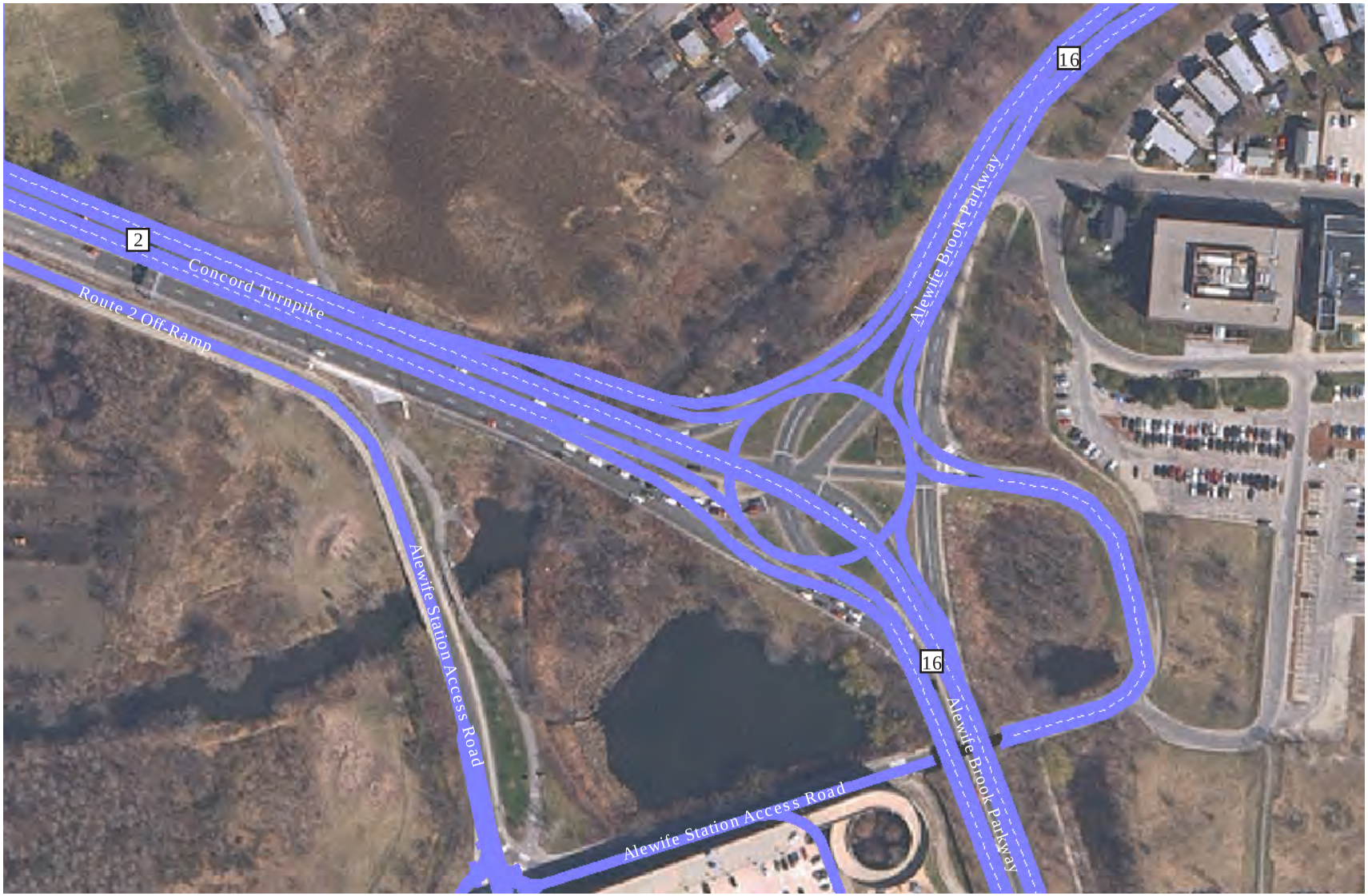

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FIGURE 10
Option 8: Roundabout with Right-Turn Slip Lanes
and a Route 2 Westbound Fly-Over

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TABLE 10
Option 8: Conventional Roundabout with a Fly-Over

Approach	Movement	LOS		Delay	
		Existing	Option 8	Existing	Option 8
AM Peak Hour					
Route 16 SB	Route 2 WB	D	A	42.1	0.7
	Route 16 SB	F	A	103.0	3.8
	Overall	E	A	57.8	1.5
Route 16 NB	Route 16 NB	F	A	117.0	0.6
	Route 2 EB	F	A	256.1	5.5
	Overall	F	A	234.0	1.4
Jug-Handle	Route 16 NB	C	A	29.2	10.0
	Route 2 WB	C	A	32.0	10.0
	Overall	C	A	30.8	10.0
Route 2 EB	Route 16 SB	F	F	133.5	139.9
	Route 16 NB	F	F	85.2	116.5
	Overall	F	F	119.8	133.1
PM Peak Hour					
Route 16 SB	Route 2 WB	D	A	41.8	3.0
	Route 16 SB	E	B	64.7	9.2
	Overall	D	A	48.8	4.9
Route 16 NB	Route 16 NB	F	C	81.0	20.4
	Route 2 EB	F	C	131.6	20.4
	Overall	F	C	124.6	20.4
Jug-Handle	Route 16 NB	D	E	36.2	42
	Route 2 WB	F	E	134.5	42
	Overall	F	E	94.2	42
Route 2 EB	Route 16 SB	F	A	33.5	6.3
	Route 16 NB	B	A	123.5	4.0
	Overall	E	A	69.0	5.4

Results are from VISSIM software

The section that follows examines treatments to improve bus access/egress to/from the station.

IMPROVING BUS ACCESS/EGRESS TO/FROM ALEWIFE STATION

Improving Access from the West (Route 2 Eastbound)

Improvements to this access point would reduce delays to buses 62, 67, 76, and 84. These buses approach the garage via the Route 2 eastbound off-ramp, which is often blocked by the eastbound queue seeking to be processed through the Route 2/Route 16 intersection. Three options were evaluated for improving bus access from the west at the Route 2 eastbound off ramp:

- Improve the Route 2/Route 16 intersection so that the queue from the eastbound traffic does not block the entrance to the ramp.
- Provide priority entrance to the off-ramp for MBTA buses only.
- Allow buses to use Acorn Park Road.

Improve the Route 2/Route 16 Intersection

Improving the operations at this intersection has overarching benefits that include reductions in travel times and delays for vehicles and buses. Of the eight options that were examined, Option 4 offers an effective, relatively immediate operational solution for the intersection (merits of this option are discussed earlier in this memo and again later under Summary and Recommendations) and also reduces the eastbound queue that blocks the off-ramp, thus improving bus access from the west (Route 2 eastbound).

Provide Auxiliary Lane on Route 2 Eastbound for Bus Use Only

This treatment, which was analyzed qualitatively, would extend the deceleration lane leading to the Route 2 eastbound off-ramp to a point just east of the Lake Street bridge and would allow only buses to use this extension, or auxiliary lane. Other vehicles would continue exiting Route 2 at the present location; however, they would have to weave/merge with bus traffic that would have entered at the start of the auxiliary lane. The entrance to the auxiliary lane would have to be heavily enforced to keep vehicles other than buses from entering. The auxiliary lane would work better with a service road beginning west of the Lake Street bridge, but that would likely necessitate widening the bridge and making design changes to incorporate the eastbound Lake Street on-ramp. In addition, constructing a service road may require land acquisition on the south side of the highway. Based on high construction cost, safety concerns, operations issues, and enforcement requirements, this treatment was dropped from further consideration.

Allow Buses to Use Acorn Park Road

This treatment was analyzed qualitatively. MassHighway counts show that vehicles use the Acorn Park Road to bypass a section of Route 2 and the ramp. One way to solve this problem would be to limit traffic on Acorn Park Road to those drivers who work in Acorn Park by installing a gate and letting them use transponders or gate keycards. Then buses could also be allowed to use the road to bypass part of the queue. However, Acorn Park Road is a public roadway, and access to it cannot be limited. For this reason, it would be difficult to implement this strategy, and it would also place a burden on developers and employers at Acorn Park. Therefore, this option was also dropped from further consideration.

Improving Access from Route 16 Southbound

This access point is actually one of the approaches to the Route 2/Route 16 intersection. Any improvements that would affect the level of service through this intersection would also improve the processing time of buses traveling south on Route 16 to reach Alewife Station. Improvements to the Route 2/Route 16 intersection were described under eight various options above, with Option 4 being more promising than the others (this outcome is also discussed later in this memorandum.). Bus routes 79 and 350 would be affected positively by improvements at this intersection, as the level of service at the Route 16 southbound approach would be in the acceptable range. Furthermore, access of these buses to the station would also be affected by improvements at the intersection of Route 16 and Cambridgepark Drive; this intersection is not included in the analysis in this study.

Improving Egress to Route 2 Westbound and Route 16 Northbound

Presently, MBTA buses heading westbound and northbound use the jug-handle at the eastern end of the Alewife Station Access Road to proceed straight onto Route 2 westbound or turn right onto Route 16 northbound. All these buses would benefit from the Option 4 improvements at the Route 2/Route 16 intersection, as has been described. In addition, the following two treatments were considered:

Install a new Route 2 westbound on-ramp

The main concept under this treatment would be to construct a new Route 2 westbound on-ramp just west of the Minuteman Bike Path for Alewife Station Access Road traffic to join Route 2 westbound directly from under the Path bridge, thus bypassing the Route 2/Route 16 intersection (Figure 11). Buses 62, 67, and 84 would use this egress point to Route 2 westbound as well. The advantages of this ramp include taking vehicles and buses exiting from Alewife Station off of the jug-handle to Route 2 westbound directly, thus reducing Route 2 westbound delay significantly during the evening peak hour. The disadvantages of the ramp include encroachment on environmentally sensitive land (that would have to be acquired) and possible weaving problems with vehicles from Route 16 southbound. The bridge support structure (below deck) would need to be reconstructed for this ramp to share the right-of-way under the bridge with the Minutemen Bike Path. Based on the high construction cost, adverse environmental issues, and potential weaving and merging safety issues, this option was dropped from further consideration.

Widen Alewife Station Access Road (Jug-handle)

Under this strategy, the entire length of the jug-handle would become two lanes as far back as possible to the Alewife transit station. The two lanes could be operated in the following ways:

Bus-Only Lane and General-Purpose Lane: To improve bus operations leaving Alewife Station, one of the two lanes in the jug-handle could be designated as a bus-only lane and the other as a general-purpose lane (Figure 12). A proposed bus priority at the Route 2/Route 16 traffic signal would allow buses to get onto Route 2 westbound with minimal delay.

On the one hand, this treatment would greatly improve bus operations by allowing buses leaving Alewife Station to get onto Route 2 westbound instead of being stuck in a long vehicle queue in

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FIGURE 11
Install a New Route 2 Westbound On-Ramp from the Garage

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FIGURE 12
Widen Alewife Station Access Road (Jug-handle) to Two Lanes and Install Bus Priority

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the jug-handle, and thus reducing bus travel time. On the other hand, because drivers currently line up in two lanes on the jug-handle (one lane for traffic proceeding to Route 2 westbound and the other lane for traffic proceeding to Route 16 northbound), this improvement would cause severe congestion in the general-purpose lane, possibly affecting egress for buses and other traffic from Alewife Station.

During the peak hour, about 22 buses are expected to exit Alewife Station and use the proposed bus priority system on the jug-handle. Based on MBTA bus schedules, the departure times for these 22 buses during the peak hour (5:00 – 6:00 PM) are uniformly distributed. On the average, this results in a bus arriving at the jug-handle every 3 minutes during the peak hour. Such arrival times would affect somewhat about two thirds of the traffic signal cycles at the intersection. A bus-only lane at the Route 2/Route 16 intersection would reduce somewhat total green time for the rest of the traffic at other approaches. In addition, a bus-only lane could lead to empty-lane syndrome or violation by drivers of general-purpose vehicles, as 22 buses are expected to use the lane during peak hour. However, buses carry more persons than single-occupant vehicles; based on number of persons, the bus-only lane may be justified.

Bus Signal Priority System: Under this system, all vehicles would use the two lanes. However, MBTA buses would be equipped with transponders for switching a red light to green on command as they approach the Route 2/Route 16 intersection from the jug-handle. The traffic light at the Route 2/Route 16 intersection would also be equipped with the priority system. The lights would go from red to green or stay green slightly longer on the approach of the jug-handle to allow MBTA buses to pass through the intersection. The result would be faster travel for bus riders and less pollution from idling. Bus preemption systems eliminate empty-lane syndrome and violations while providing the similar benefits as for a bus-only lane. However, a bus-only lane would bring buses faster to the approach of the jug-handle than a preemption system.

This system would affect somewhat about two thirds of the traffic signal cycles at the intersection. A bus preemption system at the Route 2/Route 16 intersection would reduce somewhat total green time for the rest of the traffic at other approaches.

Queue Jumping

Another strategy is to add a third lane at the approach of the jug-handle for buses to jump or bypass the queue, moving to the front (Figure 13). A queue jump is a type of roadway geometry that consists of an additional travel lane on the approach to a signalized intersection. This lane is restricted to transit vehicles only, and the intent of the lane is to allow the high-occupancy vehicles (buses) to cut to the front of the queue, reducing the delay caused by the signal and improving the operational efficiency of buses.

A queue jump lane is generally accompanied by a signal which provides a phase specifically for vehicles within the queue jump lane. Such a signal reduces the need for a designated receiving lane, as vehicles in the queue jump lane get a leading green light “head start” over other queued vehicles and can therefore merge into the regular travel lanes immediately beyond the signal. The main obstacles to a queue jump lane strategy are that constructing the third lane would require land acquisition on the jug-handle and realignment of the existing right-turn lane. Also, buses would encounter some queuing on the jug-handle until they are able to access the queue jump lane.

CTPS

FIGURE 13
Widen Alewife Station Access Road (Jug-handle)
to Two Lanes and Install a Queue Jump Lane for Buses

Route 2/Alewife
Brook Parkway
Traffic Study

SUMMARY AND RECOMMENDATIONS

The intersection of Route 2 and Route 16 in Cambridge currently experiences long delays and queues during the morning and evening peak periods. These delays and queues significantly impact MBTA bus travel times and possibly bus ridership. Bus access to Alewife Station from Route 2 is provided along the Alewife Station Access Road via the Route 2 eastbound off-ramp. The entrance to this access road from Route 2 eastbound is often blocked by eastbound traffic queued at the Route 2/Route 16 intersection.

Based on quantitative and qualitative analyses of various options and strategies described above for improving traffic operations at the Route 2/Route 16 intersection and for improving access to and egress from Alewife Station, staff have the following recommendations, made in conjunction with the Alewife Working Group.

- Add a third westbound lane (Option 4) for a short distance between the Alewife Station Access Road approach (jug-handle) and the Minuteman Bike Path overpass (Figure 6). This would be effective in reducing delays and queues at this intersection. The additional lane capacity frees up traffic signal green time for reallocation to other approaches, including the MBTA Access Road, resulting in shorter queues and delays on all approaches. Right-of-way is available for the portion of the third lane within the intersection. Right-of-way also appears to be available for the lane segment between the intersection and the Minuteman Bike Path overpass; however, the additional roadway width would have to be secured from an existing (possibly unused) sidewalk. The availability of right-of-way between the point where the Route 16 north approach meets Route 2 westbound and the overpass needs to be investigated further, including the need for a pedestrian corridor north of Route 2. Extending the third lane to Lake Street is not required in the short term but should be considered in the longer term.

- Reconstruct the Route 2 eastbound left-turn lane to Route 16 north into a double left-turn lane (Option 2 and also part of Option 4). This would further benefit this intersection, as it would help reduce eastbound queuing on Route 2.

- Reconstruct the Alewife Station Access Road (jug-handle) into two lanes for as far back as possible. This would allow for bus and vehicle storage and for priority bus lane/traffic signal priority for the buses.

- Following all above reconstruction, the traffic signal design would have to be reconsidered, including new equipment for demand-responsive operation and detectors/sensors for bus priority.

Excluding design and right-of-way, the estimated cost of the recommended improvements to the Route 2/Route 16 intersection ranges between $200,00 and $400,000.

IMPLEMENTATION CONSIDERATIONS AND OPPORTUNITIES

Potential implementation issues and opportunities include:

- The usefulness and purpose of the sidewalk along Route 16 southbound needs to be investigated.
- There are multiple stakeholders (DCR, MassHighway, City of Cambridge, Town of Arlington) that need to be consulted, with opportunities for cooperation and partnerships.
- Informing the general community in the area for support and cooperation is very important.
- Opportunities for regional programming or MassHighway and DCR standard maintenance could be sought for implementation of some of these improvements.
- Opportunities for development mitigation for some of these improvements need to be sought by the City of Cambridge.