

**TRAFFIC OPERATIONS ASSESSMENT
MALDEN CENTRAL BUSINESS DISTRICT
MALDEN, MASSACHUSETTS**



315 Norwood Park South, Norwood, MA 02062
Lincoln, RI & Rocky Hill, CT
email: BETA@BETA-inc.com

July 11, 2011

TRAFFIC OPERATIONS ASSESSMENT
MALDEN CENTRAL BUSINESS DISTRICT

FINAL REPORT

Prepared by: BETA Group, Inc.

Prepared for: The City of Malden

July 11, 2011

TABLE OF CONTENTS

1.0	Introduction.....	1
1.1	Project Purpose	1
1.2	Study Area.....	1
2.0	Existing Conditions.....	3
2.1	Study Area Intersections.....	3
2.2	Existing Traffic Volumes	7
2.3	Existing Traffic Operations	7
2.3.1	<i>Analysis Methodology</i>	<i>7</i>
2.3.2	<i>Existing Conditions Analysis Results</i>	<i>10</i>
3.0	Observed Deficiencies/Proposed Improvements	16
3.1	General	16
3.2	Intersection Specific	16
3.3	Traffic Signal Coordination.....	21
3.3.1	<i>Traffic Signal Coordination Methods.....</i>	<i>22</i>
3.3.2	<i>Level of Service Analysis Results with Traffic Signal Coordination</i>	<i>22</i>
3.4	Pedestrian Improvements	22
3.4.1	<i>Streetscape/Urban Design Elements</i>	<i>23</i>
3.4.2	<i>Pedestrian Phasing Changes at Existing Traffic Signals</i>	<i>25</i>
4.0	Conclusions.....	26
5.0	Recommendations.....	26
	Appendix A - Traffic Signal Glossary	29
	Appendix B - Photos of Existing Traffic Signal Controllers	30
	<u>Volume 2</u>	
	Appendix C - Traffic Volume Data	31
	Appendix D - Traffic Analysis.....	32

LIST OF FIGURES

Figure 1 - Study Area 2

Figure 2 - 2011 Existing Traffic Volumes – Weekday Morning Peak Hour..... 8

Figure 3 - 2011 Existing Traffic Volumes - Weekday Evening Peak Hour 9

Figure 4 - Level of Service Results 11

Figure 5 - Traffic Signal Phasing - Main St at Route 60 & Exchange St..... 20

Figure 6 - Potential Streetscape/Urban Design Improvements 24

LIST OF TABLES

Table 1 - Level of Service Criteria 7

Table 2 - Level of Service Analysis Results - Signalized Intersections 12

Table 3 - Level of Service Analysis Results - Unsignalized Intersections 15

Table 4 - Summary of Recommended Improvements 27

1.0 INTRODUCTION

1.1 Project Purpose

BETA Group, Inc. has been contracted by the City of Malden, through its Planning Board, to conduct an assessment of existing traffic conditions within the Downtown Central Business District. This analysis is part of the Planning Board's on-going master planning activities and will serve as a baseline to be used in the assessment of future proposed developments, and/or future transportation improvements within the District.

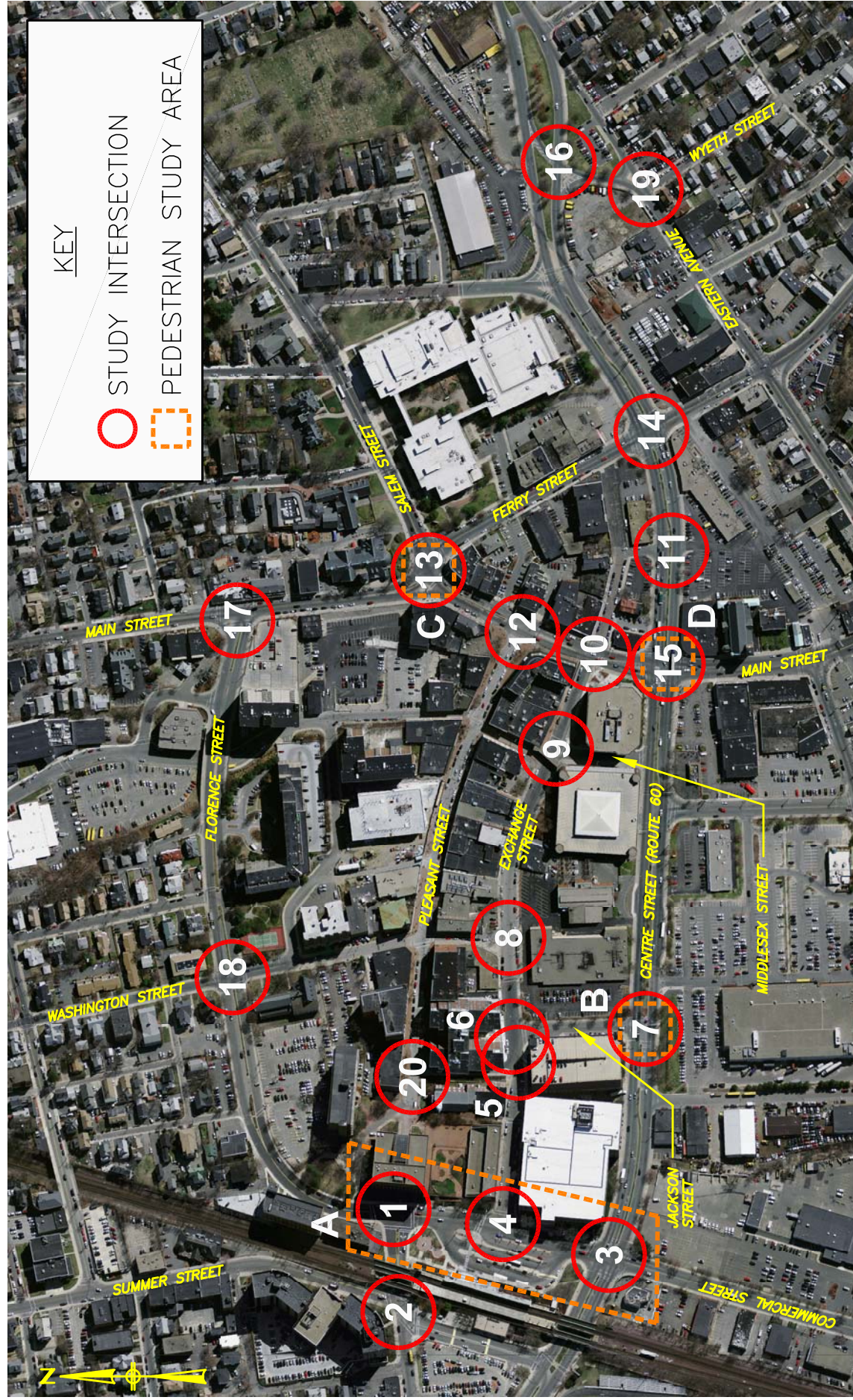
1.2 Study Area

The study area is presented in Figure 1 and is generally bounded by Route 60 to the south, Florence Street to the north, Commercial Street to the west, and Ferry Street-Main Street to the east. Traffic operations were evaluated at the following locations:

1. Pleasant Street at Florence Street and Commercial Street (Signalized)
2. Pleasant Street at Summer Street and MBTA driveway (Unsignalized)
3. Commercial Street at Centre Street (Route 60) (Signalized)
4. Exchange Street at Commercial Street (Signalized)
5. Exchange Street at Abbot Street (Unsignalized)
6. Exchange Street at Jackson Street (Unsignalized)
7. Centre Street (Route 60) at Jackson Street (Signalized)
8. Exchange Street at Washington Street (Unsignalized)
9. Exchange Street at Middlesex Street (Unsignalized)
10. Exchange Street at Main Street (Signalized)
11. Centre Street (Route 60) at Irving Street (Unsignalized)
12. Pleasant Street at Main Street (Signalized)
13. Main Street at Salem Street and Ferry Street (Signalized)
14. Centre Street (Route 60) at Ferry Street (Signalized)
15. Centre Street (Route 60) at Main Street (Signalized)
16. Centre Street (Route 60) at Eastern Avenue (Signalized)
17. Florence Street and Main Street (Signalized)
18. Florence Street and Washington Street (Signalized)
19. Eastern Avenue at Wyeth Street (Unsignalized)
20. Pleasant Street at Abbot Street (Unsignalized)

In addition, improvements to pedestrian safety were evaluated at the following locations:

- A. Commercial Street between Pleasant Street and Centre Street
- B. Jackson Street at Route 60
- C. Main Street at Salem Street and Ferry Street
- D. Centre Street (Route 60) at Main Street



B E T A

Traffic Operations Assessment
Malden, Massachusetts

Figure 1
Study Area

2.0 EXISTING CONDITIONS

The following section will provide descriptions of the intersections included in the study area. The results of the Level of Service analysis for existing conditions will also be presented.

2.1 Study Area Intersections

1. Pleasant Street at Florence Street and Commercial Street – This intersection is a three-way signalized intersection with Commercial Street/Florence Street running in the north-south direction and Pleasant Street intersecting from the west. The northbound Commercial Street approach consists of one shared left-turn/through lane and a through lane. Field observations indicate that this through lane is frequently blocked by parked vehicles. The southbound Florence Street approach consists of one through lane and a shared through/right-turn lane. The Pleasant Street approach consists of an exclusive left-turn lane and an exclusive right-turn lane. Signal operation at this intersection is four-phase semi-actuated, with the northbound Commercial Street approach given a leading phase; there is also an exclusive pedestrian phase. Pedestrian crosswalks are provided on all three legs of the intersection.

2. Pleasant Street at Summer Street and MBTA driveway – This intersection is an off-set four-way intersection with Pleasant Street running in the east-west direction with the MBTA driveway intersecting from the south and Summer Street intersecting from the north. The eastbound Pleasant Street approach is one general purpose lane, while the westbound Pleasant Street approach consists of a shared left-turn/through lane and an exclusive right-turn lane. The northbound MBTA Driveway consists of an exclusive left-turn lane and a shared through/right-turn lane. The southbound Summer Street leg consists of an exclusive left-turn lane and an exclusive right-turn lane. The signal is currently under flashing control with the MBTA Driveway and Summer Street getting a red flashing light (stop controlled) and the Pleasant Street approaches get a flashing yellow light (yield controlled). There are pedestrian crosswalks on all four approaches at the intersection, and although the intersection is equipped with pedestrian signals they are not currently in use.

3. Commercial Street at Centre Street (Route 60) – This intersection is a four-way signalized intersection with Centre Street running in the east-west direction and Commercial Street running in the north-south direction. Both the eastbound and westbound Centre Street approaches consist of an exclusive left-turn pocket, a through lane, and a shared through/right-turn lane. The northbound and southbound Commercial Street approaches each contain a shared left-turn/through lane and a shared through/right-turn lane. The intersection operates as a four-phase pre-timed signal, with both the eastbound Centre Street and southbound Commercial Street approaches given a leading phase. There are pedestrian crossings on all four approaches to the intersection, and pedestrian crossings run concurrent with the vehicular movements.

4. Exchange Street at Commercial Street – This intersection is a three-way signalized intersection with Commercial Street running in the north-south direction and Exchange Street running one-way eastbound away from the intersection with Commercial Street. The northbound Commercial Street approach consists of one through lane and one shared through/right-turn lane. The southbound Commercial Street approach consists of one shared left-turn/through lane and one through lane. The Exchange Street consists of one receiving lane, as it is a one-way street away from the intersection. The intersection

operates as a two-phase pre-timed signal, with an exclusive pedestrian phase included. There are pedestrian crosswalks on the southbound Commercial Street approach and the Exchange Street leg. In addition to the three legs of the intersection, the MBTA drop-off driveway is located adjacent to the intersection with the entrance located to the north of the intersection and the exit located to the south of the intersection. The MBTA entrance and exit operate independent of the intersection and are not included in the operation of the signal.

5. Exchange Street at Abbot Street – This intersection is a three-legged unsignalized intersection with Exchange Street running one-way in the eastbound direction and Abbott Street running one-way in the southbound direction. The Exchange Street approach consists of one through lane and the Abbott Street approach consists of an exclusive left-turn lane. There are no pedestrian crosswalks at this intersection.

6. Exchange Street at Jackson Street – This intersection is a three-legged unsignalized intersection with Exchange Street running one-way in the eastbound direction and Jackson Street intersecting Exchange Street from the south. The eastbound Exchange Street approach consist of one shared through/right-turn lane, while the northbound Jackson Street approach consist of an exclusive right-turn lane. The Jackson Street approach is under stop control, and the Exchange Street approach is uncontrolled. There is a pedestrian crosswalk across the Jackson Street approach.

7. Centre Street (Route 60) at Jackson Street – This intersection is a three-way signalized intersection which operates as a four-phase semi-actuated signal. The eastbound Centre Street approach consists of a 120-foot exclusive left-turn pocket and two through lanes. The westbound Centre Street approach consists of a through lane and a shared through/right-turn lane. The southbound Jackson Street approach consists of one general purpose lane. The eastbound Centre Street approach receives a leading phase, and there is also an exclusive pedestrian phase under the current signal phasing. There are pedestrian crosswalks on all three approaches.

8. Exchange Street at Washington Street – This intersection is a three-legged unsignalized intersection with Exchange Street running one-way in the eastbound direction and Washington Street running one-way in the southbound direction. The eastbound Exchange Street approach consists of one though lane, while the southbound Washington Street approach consists of one left-turn lane. There are pedestrian crosswalks on each of the eastbound and southbound approaches.

9. Exchange Street at Middlesex Street – This intersection is a four-legged unsignalized intersection with Exchange Street running one-way in the eastbound direction and Middlesex Street running in the north-south direction south of the intersection and one-way northbound north of the intersection. The eastbound Exchange Street approach consists of one shared left-turn/through-right-turn lane. The northbound Middlesex Street approach consists of one shared through/right-turn lane. The northbound Middlesex Street approach should be under stop control, but the Stop sign is missing. The eastbound Exchange Street approach is uncontrolled. There are pedestrian crosswalks on all four legs of the intersection.

10. Exchange Street at Main Street – This intersection is a four-legged signalized intersection with Main Street running in the north-south direction. Exchange Street is one-way in the eastbound direction and intersects Main Street from the west, while Irving Street is also one-way eastbound and leaves the intersection to the east. The northbound Main Street approach consists of a through lane and a shared through/right-turn lane.

The southbound Main Street approach consists of a shared left-turn/through lane and a through lane. The Exchange Street eastbound approach consists of an exclusive left-turn lane and a shared through/right-turn lane. There are pedestrian crosswalks on all four legs of this intersection. Operations at this intersection are controlled by the same traffic signal controller which controls operations at the Centre Street at Main Street intersection. When the Exchange Street approach is given the green indication all movements at the Centre Street at Main Street intersection are stopped, and the north/south pedestrian crossing at this intersection runs concurrently with the Centre Street at Main Street intersection's leading eastbound movement.

11. Centre Street (Route 60) at Irving Street – This intersection is a two-way unsignalized intersection with Centre Street carrying vehicles in the westbound direction and Irving Street intersecting Centre Street from the north. The westbound Centre Street approach consists of one through lane, and then opens up to two through lanes just past the intersection. Irving Street is one-way in the southbound direction and consists of one right-turn lane.

12. Pleasant Street at Main Street - This intersection is a three-way signalized intersection with Main Street carrying vehicles in the north-south direction and Pleasant Street intersecting Main Street from the west. Pleasant Street is one-way in the westbound direction, with just one travel lane away from the intersection. The northbound Main Street approach has a 100-foot exclusive left-turn pocket and a through lane. The southbound Main Street approach has one shared through/right-turn lane. There are pedestrian crosswalks on all three approaches to the intersection. The signal operates as a two-phase pre-timed signal, and includes an exclusive pedestrian phase.

13. Main Street at Salem Street and Ferry Street - This intersection is a four-way signalized intersection which operates as a three-phase pre-timed signal. The northbound Main Street approach has an exclusive left-turn lane and a shared through/right-turn lane. The southbound approach has a shared left-turn/through lane and an exclusive right-turn lane. The southbound exclusive right-turn lane runs on an overlap phase with the northbound left-turn and through/right-turn phase. The westbound Salem Street approach includes one wide lane that is used as a left-turn lane and a shared through/right-turn lane. The northbound Ferry Street approach is one shared, general purpose lane. Pedestrian crossings at this intersection run concurrent with the parallel vehicular movements.

14. Centre Street (Route 60) at Ferry Street - This is a four-way signalized intersection with Ferry Street carrying vehicles in the north-south direction and Centre Street carrying vehicles in the east-west direction. Each Centre Street approach consists of an exclusive left-turn lane, a through lane, and a shared through/right-turn lane. Each approach on Ferry Street consists of a single lane that is wide enough to allow vehicles to make a right turn on red. The signal operates with three signal phases, with Ferry Street northbound having a leading phase.

15. Centre Street (Route 60) at Main Street- This is a four-way signalized intersection with Main Street running in the north-south direction and Centre Street (Route 60) running in the east-west direction. The Main Street northbound approach consists of an exclusive left-turn lane, a through lane, and a shared through/right-turn lane. The Main Street southbound approach consists of an exclusive left-turn lane, a through lane, and an exclusive right-turn lane. Each Centre Street approach consists of an exclusive left-turn lane, a through lane, and a shared through/right-turn lane. The Centre Street eastbound approach is given a leading phase. Pedestrians cross concurrently with the vehicular

movements at this intersection. Operations are controlled by the same traffic signal controller which controls operations at the Exchange Street at Main Street intersection. When Exchange Street is given the green indication all movements at this intersection are stopped.

16. Centre Street (Route 60) at Eastern Avenue – This is a two-way signalized intersection that is part of the Centre Street at Eastern Avenue interchange. At this intersection Centre Street is one-way traveling eastbound, while Eastern Ave Connector is one way traveling southbound. The eastbound Centre Street approach consists of one through lane and a shared through/right-turn lane with a splitter island, while the southbound Eastern Ave Connector approach consists of one through lane. Operations at this intersection are controlled by a two-phase pre-timed signal. There is a pedestrian crosswalk along the south side of the intersection and the pedestrian phase runs concurrently with the eastbound vehicular movement.

17. Florence and Main Streets – This is a three-way signalized intersection with Main Street running in the north-south direction and Florence Street intersecting Main Street from the West. The northbound Main Street approach consists of one shared left-turn/through lane and the southbound Main Street approach consists of a shared through/right-turn lane with a small splitter island. The Florence Street eastbound approach consists of one exclusive left-turn lane and one right-turn lane. Operations at this intersection include a four-phase semi-actuated signal, with the northbound Main Street approach getting a leading phase. There are pedestrian crosswalks on all three approaches, and pedestrian crossings run as an exclusive phase.

18. Florence and Washington Streets – This intersection is a four-way signalized intersection with Florence Street running in the east-west direction and Washington Street running in the north-south direction. The eastbound Florence Street approach consists of two general purpose lanes, while the westbound Florence Street approach has a 100-foot left-turn pock, a through lane, and a shared through/right-turn lane. The northbound Washington Street approach consists of a shared left-turn/through lane and an exclusive right-turn lane, while the southbound Washington Street approach consists of just one general purpose lane. Operations at this intersection include a four-phase semi-actuated signal. The northbound and southbound Washington Street approaches run under split phasing. There are crosswalks on all four approaches and there is an exclusive pedestrian phase.

19. Eastern Avenue at Wyeth Street – This intersection is a three-way unsignalized intersection with Eastern Ave running in the east-west direction and Wyeth Street intersecting Eastern Ave from the south and Eastern Avenue Connector intersecting Eastern Ave from the north. The eastbound Eastern Ave approach consists of one general purpose lane; since Eastern Ave becomes one-way in the eastbound direction and there is no westbound approach, only a receiving lane. The northbound Wyeth Street approach consists of a shared left-turn/right-turn lane. The southbound Eastern Avenue Connector approach is one-way in the southbound direction, and splits into a channelized left-turn lane and a channelized right-turn lane. The northbound Wyeth Street approach should be under stop control, but the Stop sign is currently missing.

20. Pleasant Street at Abbot Street – This intersection is a three-way unsignalized intersection with Pleasant Street running in the east-west direction and Abbott Street intersecting Pleasant Street from the south. Both the eastbound and westbound Pleasant Street approaches consist of one general purpose lane. Abbott Street is one-way in the

southbound direction and consists of one receiving lane. The Pleasant Street approaches are uncontrolled.

2.2 Existing Traffic Volumes

Traffic volumes were collected at all of the project area intersections on April 27, 2011. Counts were conducted between 7:00 and 9:00 during the morning peak period and 4:00 and 6:00 during the afternoon peak period. The peak hour for all intersections included in the study area occurred between 7:30 and 8:30 during the morning and between 5:00 and 6:00 during the afternoon. The peak hour traffic volumes were plotted and volumes between intersections were balanced to ensure that traffic leaving one intersection matched the traffic entering the next intersection where necessary and appropriate. The balanced traffic volume networks are presented in Figure 2 for the morning peak hour and Figure 3 for the afternoon peak hour.

2.3 Existing Traffic Operations

The following section will present the analysis methodology and results for the study area intersections.

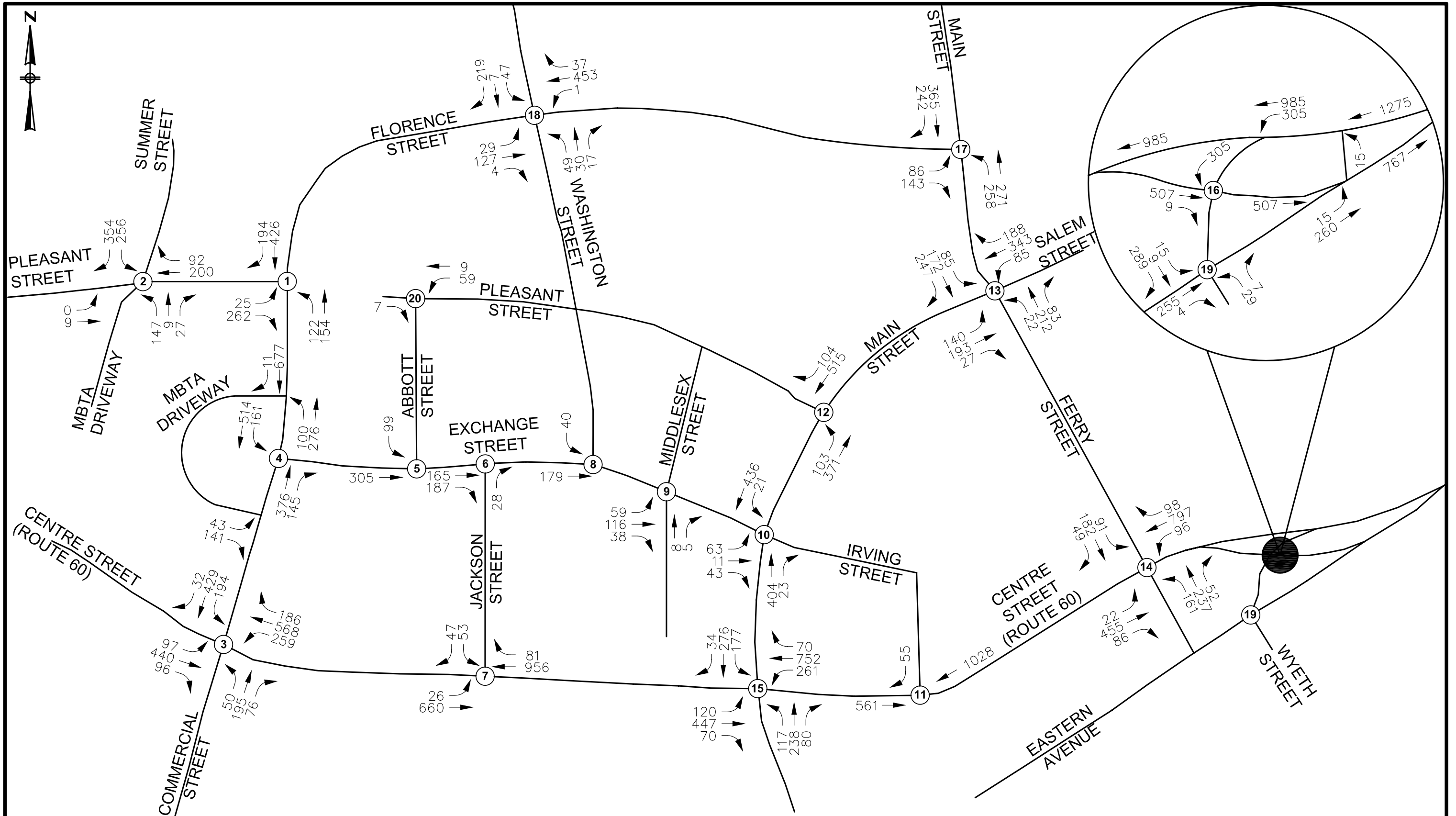
2.3.1 Analysis Methodology

Intersection operations at the project intersections were evaluated using the SYNCHRO software package (Version 6, Build 614). This software package is based on methodologies contained in the 2000 Highway Capacity Manual. Traffic operations are defined by Level of Service (LOS), which is a qualitative measure that associates LOS with vehicle delays. The criteria for unsignalized intersections are different than for signalized intersections because drivers expect different performance levels from each type of intersection. The relationship between LOS and delay is summarized below in Table 1.

Table 1 - Level of Service Criteria

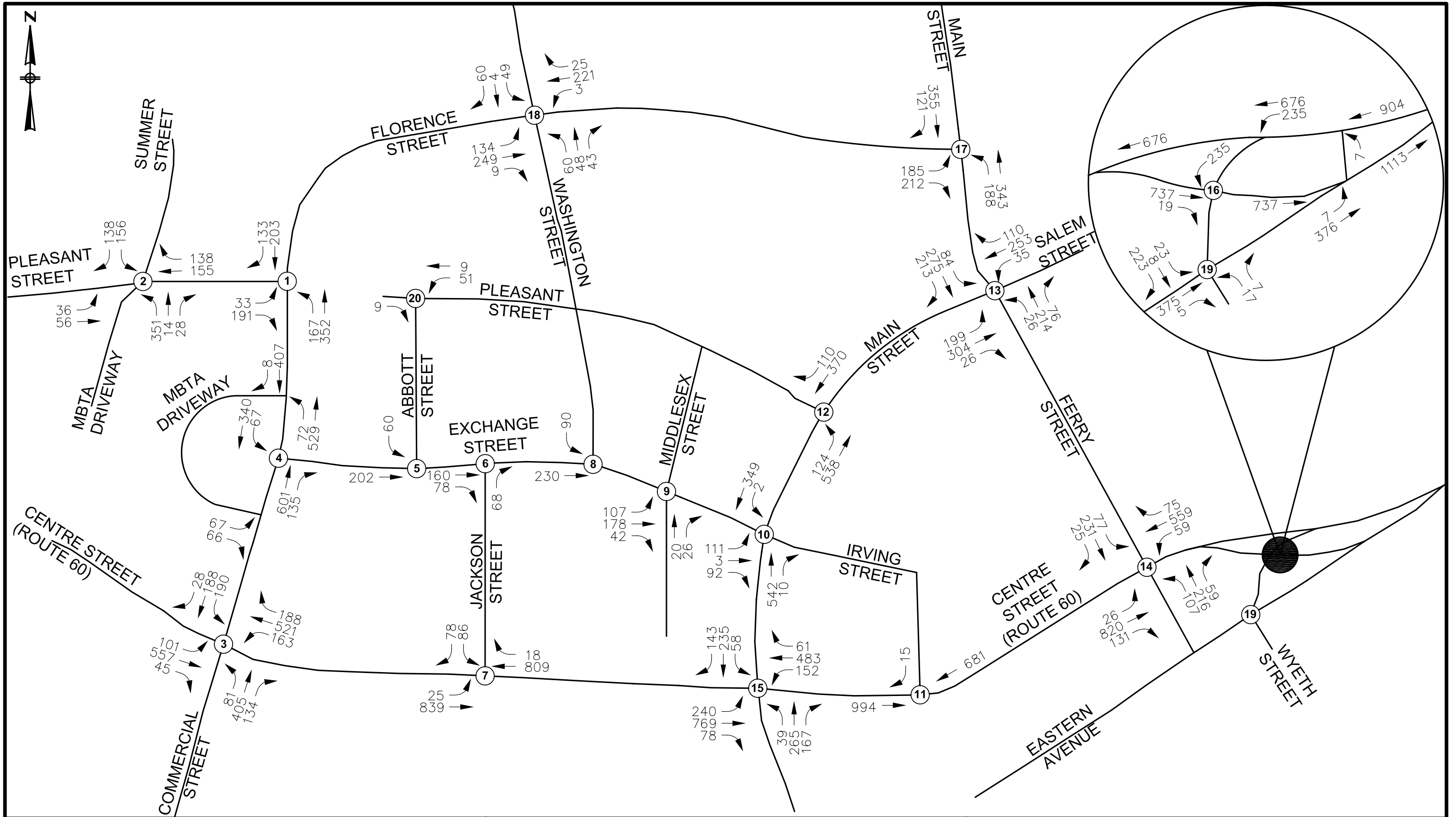
LOS	Unsignalized Intersection Criteria Average Total Delay (Seconds per Vehicle)	Signalized Intersection Criteria Average Total Delay (Seconds per Vehicle)	General Description of Traffic Flow
A	< 10.0	< 10.0	Free Flow
B	10.1 to 15.0	10.1 to 20.0	Stable Flow (Slight Delays)
C	15.1 to 25.0	20.1 to 35.0	Stable Flow (Acceptable Delays)
D	25.1 to 35.0	35.1 to 55.0	Nearing Unstable Flow (Tolerable Delays)
E	35.1 to 50.0	55.1 to 80.0	Unstable flow (Intolerable Delays)
F	> 50.0	> 80.0	Forced Flow (Jammed)

Source: Highway Capacity Manual, Transportation Research Board; Washington, DC; 2000



Traffic Operations Assessment
Malden, Massachusetts

Figure 2
2011 Existing
Traffic Volumes
Weekday Morning
Peak Hour



Traffic Operations Assessment
Malden, Massachusetts

Figure 3
2011 Existing
Traffic Volumes
Weekday Evening
Peak Hour

2.3.2 Existing Conditions Analysis Results

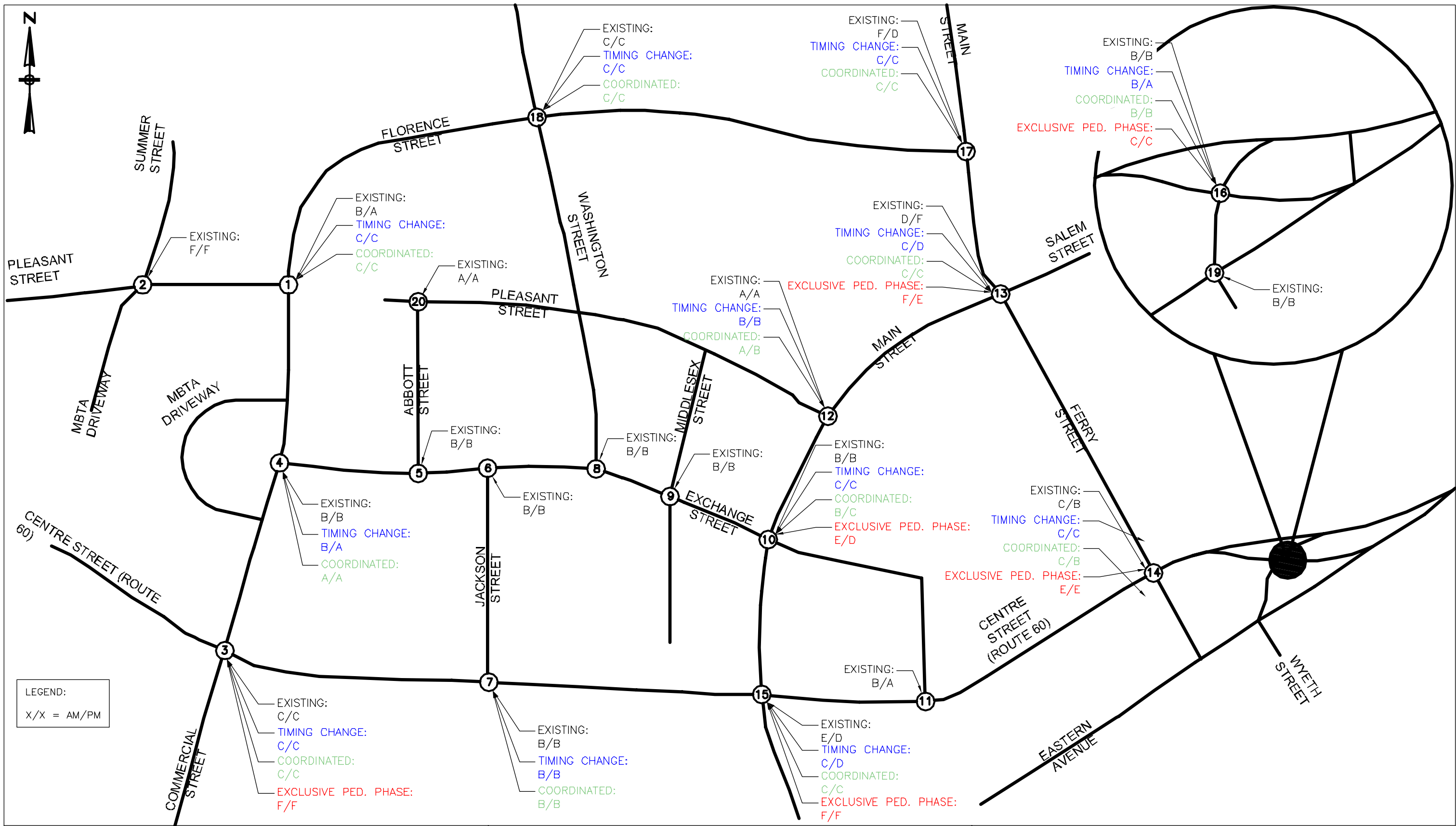
The results of the level of service analysis are summarized in Figure 4 and in Table 2 for signalized intersections and Table 3 for the unsignalized intersections.

Signalized Intersections

Most intersections within the study area operate at an overall LOS C or better during the morning and afternoon peak hours. Intersections that operate at LOS D or better are typically acceptable within an urban downtown area such as the Malden Central Business District. The few intersections within the study area that operate at LOS D or worse are:

- **3. Centre Street (Route 60) and Commercial Street** This intersection operates overall at LOS C during the peak hours, but the westbound left-turn movement operates at LOS F (105 seconds of delay) during the morning peak hour and LOS E (55 seconds of delay during the afternoon peak hour. The queues on this approach also exceed the capacity of the turning lane during each peak hour.
- **13. Main Street at Salem Street and Ferry Street** - This intersection operates overall at LOS D during the morning peak hour and LOS F during the afternoon peak hour. The level of service during the morning peak hour is primarily attributed to the poor operations of the southbound left turn movement from Main Street. Poor operations during the afternoon peak hour are attributed to the following movements:
 - Main Street eastbound left-turn (LOS F - 164 seconds of delay)
 - Ferry Street northbound approach (LOS F - greater than 200 seconds of delay)
 - Main Street southbound left-turn (LOS F - greater than 200 seconds of delay)
- **15. Centre Street (Route 60) at Main Street** - This intersection operates overall at LOS E during the morning peak hour and LOS D during the afternoon peak hour. The intersection level of service is attributed to the Main Street northbound left turn movement (LOS F - 342 seconds of delay) and the westbound left-turn movement (LOS F 186.6 seconds of delay) during the morning peak hour. The following movements contribute to the poor operations during the afternoon peak hour:
 - Centre Street westbound left-turn (LOS E - 76 second of delay)
 - Main Street northbound through/right-turn (LOS E - 60 seconds of delay)
 - Main Street southbound left-turn (LOS F - 110 seconds of delay)
 - Main Street southbound right-turn (LOS E - 57 seconds of delay)

A large portion of the delay at this intersection is due to the traffic signal phasing. When Exchange Street receives the green indication, all traffic at this intersection is stopped.
- **17. Florence Street at Main Street** - This intersection operates overall at LOS F during the morning peak hour and LOS D during the afternoon peak hour. The Main Street northbound approach operates at LOS F with 249 seconds of delay during the morning peak hour. The approach also has significant queuing which extends back to the Main Street at Salem Street and Ferry Street intersection. During the afternoon peak hour the northbound approach operates with an improved level of service (LOS E – 64 seconds of delay), but, the queues still extend back to the Salem Street intersection.



Traffic Operations Assessment
Malden, Massachusetts

Figure 4
Level Of Service Results

Table 2 - Level of Service Analysis Results - Signalized Intersections

	2011 Existing Conditions						2011 Future Conditions (Optimized Phasing/Timing)						2011 Future Conditions (Traffic Signal Coordination)						2011 Future Conditions (Add Exclusive Pedestrian Phasing)					
	AM PEAK HOUR			PM PEAK HOUR			AM PEAK HOUR			PM PEAK HOUR			AM PEAK HOUR			PM PEAK HOUR			AM PEAK HOUR			PM PEAK HOUR		
Location & Approach	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)
1. Pleasant Street at Florence Street and Commercial Street																								
Pleasant St EB L	D	39.9	38	C	31.2	37	C	32.7	36	C	33.4	45	D	50.9	46	D	48.1	55	Exclusive Pedestrian Phasing is Currently Implemented at This Intersection					
Pleasant St EB R	D	41.1	#110	C	28.4	50	C	34.0	72	C	33.2	56	D	52.4	86	D	47.2	64						
Commercial St NB LT	A	6.6	52	A	1.6	40	B	16.5	88	B	18.0	152	B	11.2	62	A	7.5	150						
Florence St SB TR	B	14.1	147	A	5.1	36	C	28.1	223	C	21.4	81	B	19.5	226	C	28.9	97						
OVERALL	B	18.6	-	A	8.5	-	C	26.7	-	C	22.3	-	C	25.1	-	C	22.5	-						
3. Commercial Street at Centre Street (Route 60)																								
Centre St EB L	B	18.7	58	B	17.4	59	B	18.3	61	B	19.0	61	D	38.6	105	C	20.3	69	E	73.5	#134	E	73.4	#134
Centre St EB TR	B	13.6	126	B	13.9	145	C	26.6	196	C	21.7	193	C	34.1	241	C	30.8	244	C	26.8	213	F	87.1	#396
Centre St WB L	F	105.6	#334	E	55.3	#230	C	25.6	156	C	25.6	109	C	33.6	133	C	28.6	104	F	188.1	#457	F	108.9	#275
Centre St WB TR	C	26.6	256	C	25.4	224	C	31.3	296	C	23.7	224	C	29.4	165	B	17.7	189	D	38.3	358	F	94.6	#440
Commercial St NB LTR	C	31.7	121	D	54.7	#296	C	34.5	135	D	41.3	#282	D	36.8	152	D	39.0	281	F	192.3	#265	F	88.3	#407
Commercial St SB LTR	B	18.0	152	B	16.0	96	C	30.3	235	C	23.0	127	C	30.2	241	B	17.6	104	F	232.6	#512	D	37.3	180
OVERALL	C	30.0	-	C	30.2	-	C	29.4	-	C	27.3	-	C	32.2	-	C	26.6	-	F	118.8	-	F	83.1	-
4. Exchange Street at Commercial Street																								
Commercial St NB TR	A	8.1	45	B	11.6	m126	A	8.2	61	A	9.1	101	A	4.3	47	A	9.3	136	Exclusive Pedestrian Phasing is Currently Implemented at This Intersection					
Commercial St SB LT	A	12.4	116	A	8.4	57	B	11.6	128	A	8.4	63	A	8.2	150	A	6.3	35						
OVERALL	B	10.5	-	B	10.5	-	B	10.1	-	A	8.8	-	A	6.5	-	A	8.2	-						
7. Centre Street (Route 60) at Jackson Street																								
Centre St EB L	B	12.9	20	B	11.7	19	B	11.9	20	B	10.9	20	A	7.4	m11	B	13.7	m18	Exclusive Pedestrian Phasing is Currently Implemented at This Intersection					
Centre St EB T	B	11.3	164	B	12.4	203	B	11.2	165	B	12.3	214	A	5.7	124	B	14.2	283						
Centre St WB TR	C	22.6	#436	C	20.9	286	B	19.0	#438	B	18.2	#338	B	12.4	m240	B	10.8	212						
Jackson St SB L	C	31.5	53	C	26.9	77	D	43.4	62	D	46.2	83	E	66.1	80	D	53.3	110						
Jackson St SB R	C	22.4	18	B	18.3	20	C	33.4	23	C	28.4	23	D	54.6	m28	D	46.1	31						
OVERALL	B	18.4	-	B	17.4	-	B	17.1	-	B	17.6	-	B	12.7	-	B	16.3	-						
10. Exchange Street at Main Street																								
Exchange St EB L	D	35.3	71	D	37.3	120	E	62.1	86	E	59.5	#141	D	53.8	86	E	64.4	#153	E	60.7	94	E	63.6	156
Exchange St EB TR	C	33.0	29	C	33.0	42	D	47.0	34	D	43.1	47	D	45.2	31	E	56.7	52	D	50.8	36	D	48.2	49
Main St NB TR	A	3.7	43	A	5.6	m79	A	4.5	m54	A	5.5	m77	A	7.9	52	A	9.3	m79	A	3.5	m18	A	3.4	m18
Main St SB LT	B	10.9	108	B	10.2	77	C	28.0	184	C	26.1	132	C	21.8	190	B	15.8	94	F	156.6	#358	E	70.3	#229
OVERALL	B	10.8	-	B	12.8	-	C	20.9	-	C	20.9	-	B	19.3	-	C	21.4	-	E	73.3	-	C		-
12. Pleasant Street at Main Street																								
Main St NB L	A	9.3	42	A	6.7	46	B	16.7	63	B	15.9	84	A	6.8	34	B	18.0	m76	Exclusive Pedestrian Phasing is Currently Implemented at This Intersection					
Main St NB T	A	6.5	96	A	7.0	155	A	9.7	132	B	14.5	257	A	5.0	98	B	14.6	315						
Main St SB TR	A	9.0	204	A	6.9	124	B	13.6	282	B	14.4	214	A	2.8	m35	B	15.4	266						
OVERALL	A	8.0	-	A	6.9	-	B	12.4	-	B	14.6	-	A	4.1	-	B	15.3	-						

= 95th percentile volume exceeds capacity. Queue may be longer. Queue reported is the maximum queue after two cycles.
m = Volume for the 95th percentile queue is metered by upstream signals.

Table 2 (Continued) - Level of Service Analysis Results - Signalized Intersections

	2011 Existing Conditions						2011 Future Conditions (Optimized Phasing/Timing)						2011 Future Conditions (Traffic Signal Coordination)						2011 Future Conditions (Exclusive Pedestrian Phasing)					
	AM PEAK HOUR			PM PEAK HOUR			AM PEAK HOUR			PM PEAK HOUR			AM PEAK HOUR			PM PEAK HOUR			AM PEAK HOUR			PM PEAK HOUR		
Location & Approach	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)
<i>13. Main Street at Salem Street and Ferry Street</i>																								
Main St EB L	E	64.5	#153	F	164.1	#229	E	59.4	#159	E	66.1	#231	D	54.5	195	D	38.3	#242	F	241.0	#277	F	137.6	#272
Main St EB TR	A	6.2	67	A	7.2	104	A	8.7	88	B	11.5	156	C	23.2	211	A	8.7	168	C	23.3	180	C	33.3	310
Salem St WB L	B	13.0	52	B	11.8	26	B	17.2	63	C	20.2	37	C	24.5	86	C	30.0	48	C	32.3	99	D	35.6	54
Salem St WB TR	C	24.3	#366	B	16.7	193	D	36.4	#446	C	30.1	286	D	46.7	#603	D	45.1	#388	F	97.9	#708	E	63.9	#468
Ferry St NB LTR	D	50.5	m#216	F	*	#323	C	34.8	220	D	43.9	267	C	36.2	303	C	32.7	273	F	196.3	m#341	E	73.8	#391
Main St SB LT	F	135.2	#286	F	*	#389	D	44.4	#263	E	57.9	#393	D	41.6	#347	C	30.1	#278	F	407.9	#500	F	93.3	#523
Main St SB R	B	14.9	133	B	14.2	113	B	13.4	132	B	11.3	109	A	8.9	131	A	8.8	83	D	38.5	155	C	26.4	101
OVERALL	D	44.1	-	F	109.5		C	31.6	-	D	36.3	-	C	35.1	-	C		-	F	151.8	-	E	69.3	-
<i>14. Centre Street (Route 60) at Ferry Street</i>																								
Centre St EB L	B	15.0	22	B	12.6	22	C	24.1	30	B	19.9	29	B	19.6	m11	B	14.2	m11	E	60.6	m21	C	30.2	40
Centre St EB TR	B	14.2	119	B	17.4	231	B	19.7	153	C	28.2	308	B	16.7	100	B	14.4	m187	D	53.4	m240	D	42.7	#442
Centre St WB L	B	17.4	70	C	29.1	#73	C	26.2	91	E	72.0	#100	C	31.6	116	D	36.9	#87	F	111.4	#195	F	167.4	#140
Centre St WB TR	B	17.3	223	B	14.6	143	C	24.6	284	C	22.3	192	C	30.9	389	C	21.2	214	E	74.3	#552	C	32.9	272
Ferry St NB LTR	D	46.0	#273	B	17.7	181	C	24.9	224	B	12.8	164	C	31.0	318	C	22.3	252	F	137.0	#574	F	98.2	#498
Ferry St SB LTR	D	40.1	m185	D	37.6	m139	B	18.0	m129	C	20.4	213	C	29.2	216	C	27.2	m349	C	26.2	m136	F	104.9	#470
OVERALL	C	26.0	-	B	19.8	-	C		-	C	24.1	-	C	27.3	-	B	19.9	-	E	77.0	-	E	60.4	-
<i>15. Centre Street (Route 60) at Main Street</i>																								
Centre St EB L	D	37.0	94	D	37.7	#192	C	33.1	95	D	46.8	#216	D	54.0	115	D	46.1	#198	E	67.6	120	F	184.4	#357
Centre St EB TR	B	19.1	161	C	21.2	270	D	37.1	230	E	57.7	#444	B	19.8	106	D	39.4	#409	E	71.7	#306	F	153.3	#568
Centre St WB L	F	186.6	#393	E	76.3	#225	D	53.6	#261	D	35.2	123	D	54.4	m#242	D	54.3	145	F	139.3	m#222	F	81.6	#186
Centre St WB TR	D	39.1	358	C	29.4	210	D	51.0	#431	D	36.2	238	D	37.7	#393	C	21.4	105	F	166.2	m#481	D	51.3	289
Main St NB L	F	342.3	#225	D	49.2	55	C	30.6	118	C	25.7	44	D	38.5	139	C	26.6	45	F	137.6	#221	D	48.7	61
Main St NB TR	D	37.1	133	E	59.7	160	C	26.1	112	C	31.0	129	C	32.5	135	C	32.2	137	E	60.8	176	F	113.9	#218
Main St SB L	C	29.4	52	F	110.4	#120	A	3.9	m4	A	6.0	8	A	4.8	m5	A	8.6	14	C	24.7	m8	D	50.8	m35
Main St SB T	D	42.4	#312	D	35.8	227	A	4.4	20	A	4.9	24	A	4.9	28	A	6.8	41	C	28.2	m59	C	21.9	m75
Main St SB R	E	72.0	104	E	56.9	71	A	0.4	0	A	0.4	0	A	0.7	0	A	2.9	0	C	34.5	m0	B	16.3	m0
OVERALL	E	65.0	-	D	40.3	-	C	35.0	-	D	37.1	-	C	29.7	-	C	30.5	-	F	100.8	-	F	102.7	-
<i>16. Centre Street (Route 60) at Eastern Avenue</i>																								
Centre St EB TR	A	8.9	85	A	9.9	127	B	12.3	103	A	8.6	101	B	10.4	119	B	12.4	247	C	29.5	184	C	33.5	#280
Centre St WB L	B	19.6	167	B	16.8	123	B	14.0	142	B	14.0	98	B	13.4	137	B	14.2	108	B	12.4	192	B	11.0	133
OVERALL	B	12.9	-	B	11.6	-	B	13.0	-	A	9.9	-	B	11.6	-	B	12.8	-	C	23.0	-	C	28.1	-

= 95th percentile volume exceeds capacity. Queue may be longer. Queue reported is the maximum queue after two cycles.
m = Volume for the 95th percentile queue is metered by upstream signals.

Table 2 (Continued) - Level of Service Analysis Results - Signalized Intersections

	2011 Existing Conditions						2011 Future Conditions (Optimized Phasing/Timing)						2011 Future Conditions (Traffic Signal Coordination)						2011 Future Conditions (Exclusive Pedestrian Phasing)					
	AM PEAK HOUR			PM PEAK HOUR			AM PEAK HOUR			PM PEAK HOUR			AM PEAK HOUR			PM PEAK HOUR			AM PEAK HOUR			PM PEAK HOUR		
Location & Approach	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)	LOS	Delay (sec)	Queue (ft)
17. Florence Street at Main Street																								
Florence St EB L	C	28.9	87	C	34.0	172	E	57.5	#136	E	60.2	#265	E	68.6	#156	E	65.7	#269	Exclusive Pedestrian Phasing is Currently Used at This Intersection					
Florence St EB R	C	27.0	42	C	26.4	55	D	46.5	53	C	34.6	65	D	50.4	54	D	40.7	65						
Main St NB LT	F	249.3	#666	E	64.2	#639	D	36.8	#458	C	27.8	#489	C	31.7	#485	B	14.9	#455						
Main St SB TR	C	23.9	#484	C	21.2	344	C	20.2	463	C	20.3	353	C	20.1	387	C	28.3	374						
OVERALL	F	117.6	-	D	39.8	-	C	32.5	-	C	30.7	-	C	31.5	-	C	30.3	-						
18. Florence Street at Washington Street																								
Florence St EB LTR	B	16.2	63	B	16.8	153	C	20.5	68	C	21.9	153	C	20.5	61	C	21.9	153	Exclusive Pedestrian Phasing is Currently Used at This Intersection					
Florence St WB L	B	14.8	4	B	13.4	8	B	18.6	4	B	17.2	8	B	18.8	4	B	17.2	8						
Florence St WB TR	B	19.5	175	B	14.8	90	C	25.6	190	B	19.0	90	C	25.5	167	B	19.0	90						
Washington St NB LT	C	32.5	85	D	37.8	107	D	35.9	89	D	53.0	107	C	28.4	80	D	53.0	107						
Washington St NB R	C	29.3	18	C	31.7	25	C	30.7	19	D	35.7	26	C	24.5	17	D	35.7	26						
Washington St SB LTR	C	29.9	131	D	35.9	83	C	30.3	131	D	41.1	82	C	29.4	#150	D	41.1	82						
OVERALL	C	22.8	-	C	22.4	-	C	26.9	-	C	28.4	-	C	25.9	-	C	28.4	-						

= 95th percentile volume exceeds capacity. Queue may be longer. Queue reported is the maximum queue after two cycles.
m = Volume for the 95th percentile queue is metered by upstream signals.

Table 3 - Level of Service Analysis Results - Unsignalized Intersections

Location & Approach	AM PEAK HOUR			PM PEAK HOUR		
	Level of Service	Delay (seconds)	Queue (ft)	Level of Service	Delay (seconds)	Queue (ft)
2. Pleasant Street at Summer Street and MBTA Driveway						
Pleasant Street EB LTR	A	0.0	0	A	3.4	3
Pleasant Street WB LT	A	0.0	0	A	0.0	0
Pleasant Street WB R	A	0.0	0	A	0.0	0
MBTA Driveway NB L	F	*	**	F	*	**
MBTA Driveway NB TR	B	12.3	6	B	12.8	9
Summer St SB L	F	66.3	201	D	31.1	85
Summer St SB R	C	18.6	94	B	13.0	26
5. Exchange Street at Abbott Street						
Exchange St EB T	A	0.0	0	A	0.0	0
Abbott St WB L	B	11.1	9	B	11.0	8
6. Exchange Street at Jackson Street						
Exchange St EB TR	A	0.0	0	A	0.0	0
Jackson St NB R	B	10.5	5	B	10.9	14
8. Exchange Street at Washington Street						
Exchange St EB T	A	0.0	0	A	0.0	0
Washington St SB L	B	11.1	8	B	12.0	14
9. Exchange Street at Middlesex Street						
Exchange St EB LTR	A	2.3	3	A	2.9	7
Middlesex St NB TR	B	10.7	3	B	12.1	8
11. Centre Street (Route 60) at Irving Street						
Centre St EB T	A	0.0	0	A	0.0	0
Centre St WB T	A	0.0	0	A	0.0	0
Irving St SB R	B	11.1	8	A	9.8	2
19. Eastern Ave at Wyeth Street						
Eastern Ave EB TR	A	0.0	0	A	0.0	0
Wyeth St NB LR	B	14.6	11	B	13.8	7
Wyeth St SB LTR	B	11.0	47	B	10.4	32
20. Pleasant Street at Abbott Street						
Pleasant St EB TR	A	0.0	0	A	0.0	0
Pleasant St WB LT	A	6.6	4	A	6.4	3

* Delay is greater than 200 seconds.

** Queue exceeds capacity.

Unsignalized Intersections

The approaches to most unsignalized intersections within the study area operate at LOS B or better during the morning and afternoon peak hours. The only unsignalized intersection where this is not the case is the intersection of Pleasant Street, Summer Street, and the MBTA driveway which has two approaches that operate poorly during the morning and afternoon peak hours. The analysis shows that MBTA Driveway northbound left-turn operates at LOS F during both peak hours. Observations indicated that buses tend to pull into the intersection and wait for an on-coming vehicle to stop and let them into traffic. A similar situation occurs on the Summer Street southbound left turn, which also operates at a poor level of service during the morning peak hour.

3.0 OBSERVED DEFICIENCIES/PROPOSED IMPROVEMENTS

The following section will discuss the deficiencies observed at the study area intersections during the field inspection of traffic signal equipment performed on April 26, 2011. This section will also provide proposed improvements to mitigate the observed deficiencies.

3.1 General

A few general improvements that should be implemented at all intersections:

1. Tactile Warning Panels should be installed at all curb ramps. These warning panels provide a notification to sight impaired pedestrians that they are about to enter the roadway. Tactile warning panels are required on all curb ramps by the regulations of the Americans with Disabilities Act (ADA).
2. New pedestrian signal heads with countdown pedestrian timers should be added at all signalized intersections. The countdown feature provides additional information to the pedestrian to assist them in making their decisions on crossing the street. The countdown pedestrian signal heads would replace the existing pedestrian signal heads in use at the intersections. The countdown pedestrian display is required by latest MUTCD standards (2009) on all crossings with a pedestrian clearance interval greater than or equal to seven seconds.
3. The use of Accessible Pedestrian Signals (APS) should be evaluated at all signalized intersections within the study area. APS communicate information about pedestrian timing in non-visual formats such as audible tones, verbal messages, and/or vibrating surfaces. Accessible Pedestrian Signals are required by the regulations of the ADA.
4. Air filters in all traffic signal controller cabinets should be replaced. Exhausting the heat generated by the traffic signal equipment while also maintaining a clean environment within the cabinet is very important to the longevity of the equipment. Proper air circulation within the cabinet is an important key to cooling. The current air filters suppress air flow because they are filled with dust and dirt. Dust and dirt are also beginning to build up and collect on the equipment within the cabinet.

3.2 Intersection Specific

The following section presents specific deficiencies encountered at each intersection and improvements recommended to correct these deficiencies. A Level of Service analysis was conducted at each of the study area intersections assuming that the recommended

improvements were implemented and that signal timings were optimized. Results of this analysis are located in Table 2. Improvements to pedestrian accommodation at the intersections were limited to modifying the pedestrian times for existing pedestrian phases. Further improvements to pedestrian phasing will be discussed later in this report in Section 3.4.2.

1. Pleasant Street at Florence Street and Commercial Street

The existing exclusive pedestrian phase at this intersection consists of an eight second Walk interval and a seven second Flashing Don't Walk interval. The timing of the Flashing Don't Walk interval is insufficient to serve the 78-foot long crossing of the Pleasant Street approach. The Walk interval is typically set to seven seconds, and it is recommended that the Flashing Don't Walk interval be extended to 20 seconds to be compliant with current standards set forth in the Manual on Uniform Traffic Control Devices (MUTCD). It is also recommended that with the pedestrian interval modifications the cycle length of the intersection be increased from the current 85 second cycle length to 90 seconds.

2. Pleasant Street at Summer Street and MBTA driveway

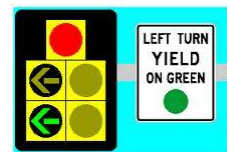
This intersection currently has traffic signals installed, but they are set to operate in flash mode. The two-way stop controlled analysis presented in Section 2.3 shows that there are long delays on the MBTA driveway and Summer Street approaches, but field observations indicate these approaches operate with much less delay than the analysis shows. It is recommended that this traffic signal continue to operate in flash mode.

3. Commercial Street at Centre Street (Route 60)

This intersection operates as a pre-timed signal. The concurrent pedestrian phase for east-west traveling pedestrians is intended to be served automatically during every cycle. This pedestrian phase is never served, however, due to a hardware problem in the controller cabinet that should be resolved to allow the pedestrian signal indications to function properly.

Westbound left-turning vehicles from Centre Street (Route 60) to Commercial Street are allowed to move on a permissive phase. This means they can make the left-turn move when there is a sufficient gap in on-coming traffic. The eastbound left-turn move is served first by a protected phase and then by a permissive phase. It is suggested that the westbound left-turn move be allowed to move at the same time as the eastbound left-turn move during the protected phase, and then continue to operate in the permitted state. This signal phasing change would require the following:

- A new 5-section traffic signal cluster arranged in a “dog-house” configuration (identical to the 5-section cluster currently provided for the eastbound left turn move, see the included image),
- R10-12 signs mounted over the eastbound and westbound lanes indicating that left turning vehicles must yield to oncoming traffic on a solid green indication.
- Minor reprogramming of the traffic signal controller,
- Wiring changes between the traffic signal cabinet and some traffic signal heads.



This signal should also be reprogrammed to provide a seven second Walk interval for all pedestrian phases, an 18 second Flashing Don't Walk interval for the east-west pedestrian phase, and a 22 second Flashing Don't Walk interval for the north-south pedestrian phase.

It is also recommended that the cycle length for the intersection be increased from the current 88 second cycle length to 100 seconds during the morning peak period and 95 seconds during the afternoon peak period. Individual signal timing plans should be developed and implemented during each of the morning, mid-day, and afternoon peak periods, as well as a plan to cover the off-peak hours.

4. Exchange Street at Commercial Street

This signalized intersection serves as a pedestrian crossing signal. The existing pedestrian phase is programmed with a ten second Walk interval and a ten second Flashing Don't Walk interval. The pedestrian intervals at this intersection should be reprogrammed to bring them into conformance with the MUTCD. The pedestrian Walk interval should be maintained at 10 seconds (because of the proximity of the train station), but the Flashing Don't Walk interval should be increased to 15 seconds. The signal cycle length should also be increased from the current 44 second cycle length to 55 seconds to accommodate the increased pedestrian intervals and improve the efficiency of the traffic signal.

5. Exchange Street at Abbot Street

This unsignalized intersection currently has no major deficiencies.

6. Exchange Street at Jackson Street

This unsignalized intersection currently has no major deficiencies.

7. Centre Street (Route 60) at Jackson Street

This signalized intersection features an exclusive pedestrian signal phase with a seven second Walk interval and an eight second Flashing Don't Walk interval. The eight second Flashing Don't Walk interval is insufficient to serve the 80-foot crossing of Centre Street in conformance with the MUTCD standards. The Flashing Don't Walk interval should be reprogrammed to provide 19 seconds of pedestrian clearance time.

All vehicle phases at this intersection are provided with a four second yellow change interval but no all-red clearance interval. It is suggested that the all-red clearance interval be added to all vehicular phases to meet MUTCD standards.

It is recommended that the current 84 second signal cycle length be reduced to 80 seconds in the morning peak period and 75 seconds during the afternoon peak period. These changes will help improve the efficiency of the traffic signal.

This signal cabinet has been hit at some point causing the front door to be misaligned. The misalignment allows water to infiltrate into the cabinet. A plastic tarp has been draped inside the cabinet to protect the electrical equipment. The cabinet should be repaired or replaced. Replacement of the cabinet may also require full replacement of all the existing equipment within the current cabinet because of the age of the existing equipment.

8. Exchange Street at Washington Street

This unsignalized intersection currently has no major deficiencies.

9. Exchange Street at Middlesex Street

This unsignalized intersection currently has no major deficiencies.

10. Exchange Street at Main Street

Traffic signal operations at this intersection are controlled by the traffic controller for the Centre Street (Route 60) at Main Street intersection. The traffic signal currently stops all vehicles at the Centre Street (Route 60) at Main Street intersection when the Exchange Street approach receives the green indication. Right-turning vehicles from Exchange Street then queue on the short roadway link between the two intersections. It is recommended that the existing signal phasing be changed to improve the coordination between the two intersections. The current and proposed traffic signal phasing for the intersections is presented in Figure 5. A signal phasing change would require reprogramming of the traffic signal controller, and possible wiring changes between the controller cabinet and the traffic signal heads.

11. Centre Street (Route 60) at Irving Street

This unsignalized intersection currently has no major deficiencies.

12. Pleasant Street at Main Street

This signalized intersection serves as a pedestrian crossing signal. The existing Pedestrian phase is programmed with a six second Walk interval and a twelve second Flashing Don't Walk interval. The Flashing Don't Walk interval is insufficient to accommodate the 68-foot crossing of Main Street. Therefore, the pedestrian intervals at this intersection should be reprogrammed to bring it into conformance with the MUTCD. The pedestrian Walk interval should be increased to seven seconds, and the Flashing Don't Walk interval should be increased to 17 seconds. The signal cycle length should also be increased from 63 seconds to 70 seconds to accommodate the extra pedestrian time while maintaining efficiency for vehicular traffic.

13. Main Street at Salem Street and Ferry Street

This intersection features a leading protected left-turn phase for the eastbound approach. The signal head which controls this left-turn phase is located on the far left side of the intersection. Drivers often will not see the left-turn signal head because it is located so far to the left. It is recommended that this signal head be move to a location closer to the center of the left-turn lane.

This traffic signal currently operates on a 70 second cycle length at all times. It is recommended that specific timing plans be developed for each of the morning, mid-day, and afternoon peak periods, as well as a plan to cover the off-peak overnight hours. Cycle lengths of 80 and 90 seconds are recommended for the morning and afternoon peak periods respectively.

14. Centre Street (Route 60) at Ferry Street

This signalized intersection features a leading northbound green phase. This northbound phase does not display a green arrow to approaching vehicles during the protected advance phase. Adding a left turn arrow would make it clear to northbound left turning vehicles that they have the right of way, and it would also indicate when the protected period was coming to an end. It is recommended that a 5-section dog-house signal cluster be installed, with a three second yellow change interval and a 1 second all red

Figure 5A – Existing Traffic Signal Phasing

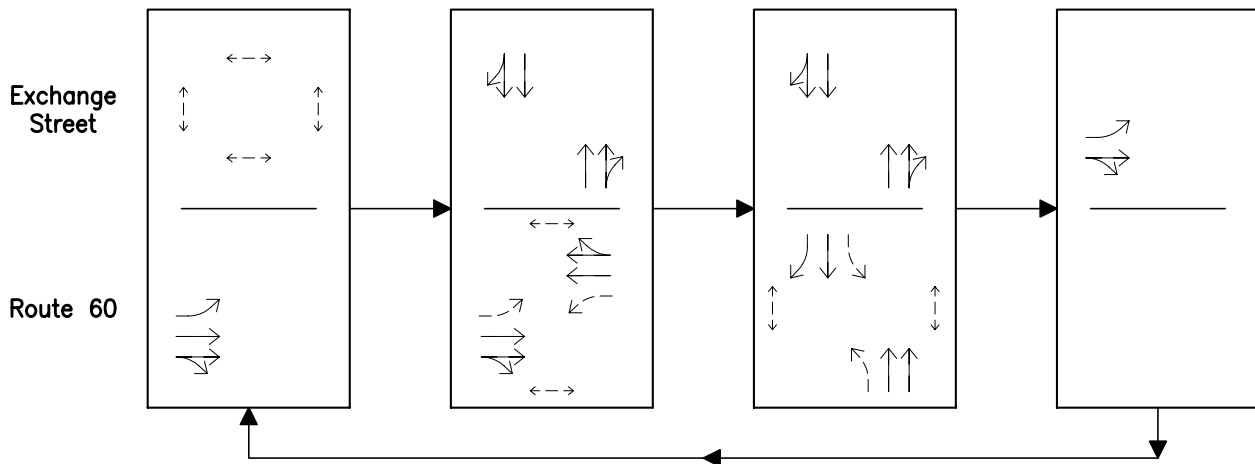
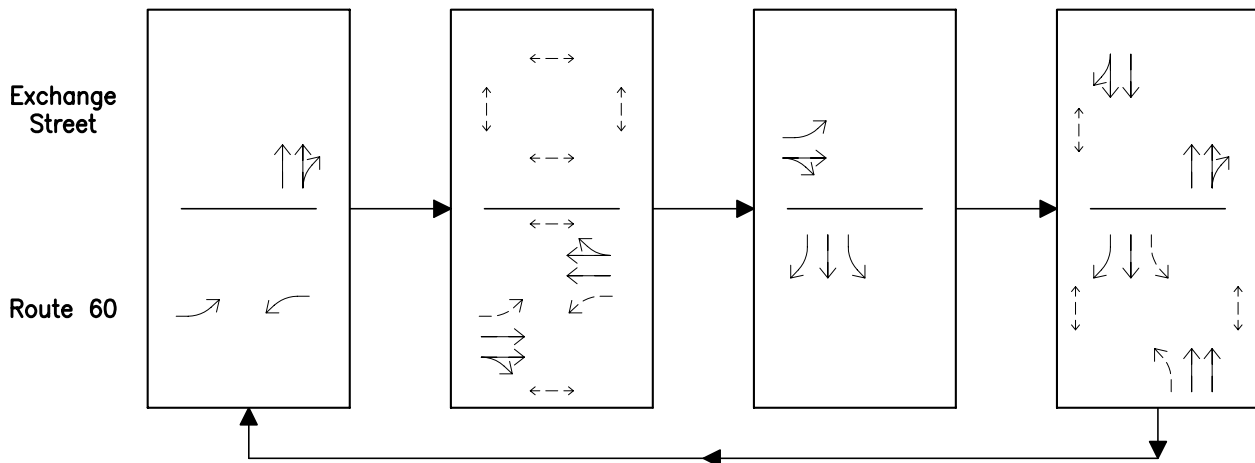


Figure 5B – Proposed Traffic Signal Phasing



clearance interval at the end of the northbound advance phase. This change would require a new 5-head signal cluster, new wiring, and reprogramming of the traffic signal controller.

15. Centre Street (Route 60) at Main Street

The traffic signal controller at this intersection also controls operations at the Exchange Street at Main Street intersection. See the Exchange Street at Main Street intersection for recommended improvements at this intersection.

16. Centre Street (Route 60) at Eastern Avenue

This signalized intersection operates well in its current configuration.

17. Florence Street at Main Street

This signalized intersection features an exclusive pedestrian signal phase with a seven second Walk interval and a ten second Flashing Don't Walk interval. The ten seconds of Flashing Don't Walk time is insufficient to serve the 62-foot crossing of Florence Street in conformance with the MUTCD standards. The Flashing Don't Walk interval should be reprogrammed to provide 16 seconds of pedestrian clearance time.

The existing 86-second signal cycle length is short for the volume of traffic demand being served. It is recommended that the signal cycle length be increased to 120 seconds during all times of the day to improve traffic operations.

18. Florence Street at Washington Street

This signalized intersection also features an exclusive pedestrian signal phase with a seven second Walk interval, an eight second Flashing Don't Walk interval, and a three second all-red interval. The eight seconds of Flashing Don't Walk time is insufficient to serve the 81-foot crossing of Florence Street in conformance with the MUTCD standards. The Flashing Don't Walk interval should be reprogrammed to provide 20 seconds of Flashing Don't Walk.

It is recommended that the existing 86-second signal cycle length be changed to 85 seconds during the morning peak period and 80 seconds during the afternoon peak period. The new cycle lengths will improve the efficiency of traffic operations at this location.

19. Eastern Avenue at Wyeth Street

This unsignalized intersection currently has no major deficiencies.

20. Pleasant Street at Abbot Street

This unsignalized intersection currently has no major deficiencies.

3.3 Traffic Signal Coordination

Intersections within the study area are closely spaced, but the traffic signal operations are not coordinated. Efficiencies could be gained at each intersection by coordinating signal operations within the Central Business District. This section will provide a brief description of some of the methods that could be used to implement traffic signal coordination within the Downtown area. Level of Service analysis results that could be achieved if traffic signal coordination were implemented will also be presented.

3.3.1 Traffic Signal Coordination Methods

There are many types of traffic signal coordination methods. The most common include: Time Based Coordination (TBC) Systems, Closed-Loop Systems, Urban Traffic Control Systems (UTCS), and traffic adaptive signal control systems. The TBC system operates on a time clock that is used to take actions automatically based upon the time of day and day of week. In contrast, both UTCS and the Closed-Loop systems react to real-world conditions as they are happening, based on actual traffic volume and signal timing data stored in the system.

In UTCS and Closed-Loop systems, traffic signals are interconnected using different types of cables or communication mechanisms. Electrical cables are the most commonly used method of signal system interconnection. Connecting cables are not needed in the TBC system, as adjacent intersections are coordinated by the timing of their individual controlling clocks. It was not evident during field observations of the equipment in the study area if there were electrical conduits connecting any of the traffic signal cabinets to allow the connecting cables to be installed.

For the Downtown Malden area, a Time Based Coordination System is recommended and could be implemented with minimal new hardware and reprogramming of the existing traffic signal controllers. This method would not provide the flexibility of the more advanced systems, but it could improve vehicle operations for a very modest investment.

3.3.2 Level of Service Analysis Results with Traffic Signal Coordination

Level of Service analysis results for the case where Time Based Coordination was implemented at the intersections within the Downtown area are included in Table 2. All signalized intersections within the study area were included as one coordinated system.

Level of Service would remain the same or would improve by one Level of Service at most study area intersections. An insignificant degradation of Level of Service would occur at the intersection of Centre Street (Route 60) and Eastern Avenue (LOS A to LOS B) during the afternoon peak hour. Queues would be reduced on many approaches, and all signalized intersections within the study area would operate at LOS C or better during both peak hours under coordinated signal operation.

3.4 Pedestrian Improvements

The project team was also tasked with evaluating potential pedestrian safety improvements in the following four areas:

- A. Commercial Street between Pleasant Street and Centre Street
- B. Centre Street (Route 60) at Jackson Street
- C. Main Street at Salem Street and Ferry Street
- D. Centre Street (Route 60) at Main Street

Pedestrian safety improvements were looked at in two general categories: streetscape/urban design elements and potential pedestrian phasing changes at existing traffic signals. Pedestrian improvements that were limited to just modifying pedestrian phasing timing were discussed previously in Section 3.2.

3.4.1 Streetscape/Urban Design Elements

A. Commercial Street between Pleasant Street and Centre Street

The area of Commercial Street between Pleasant Street and Centre Street (Pedestrian area A) is a very active pedestrian area. Pedestrians cross Commercial Street moving to/from the Malden Center MBTA Station and the parking garages, businesses and City offices located along the east side of Commercial Street and along the length of Exchange Street. Pedestrians also enter and exit the MBTA Station via Pleasant Street.

A series of potential safety improvements have been developed and are presented in Figure 6. The potential improvements are focused on establishing clear pedestrian pathways and directing pedestrian paths to the existing marked crosswalks.

These changes to pedestrian behavior can be accomplished by making crosswalks more visible and by limiting the areas where pedestrians can leave the curb. Crosswalk visibility can be increased by varying the pavement color and texture within the crosswalk by using brick pavers or stamped concrete/thermoplastic. The pavement color and texture can differentiate the crosswalk from the asphalt roadway and the concrete sidewalks and can attract the attention of pedestrians. Crosswalk visibility could also be increased by placing bollards (usually steel or granite) on each side of the curb ramps.

Limiting the areas where pedestrians can leave the curb can be accomplished through the use of additional bollards which can be connected to each other by decorative chains. These barriers can be set up to channelize pedestrians toward the existing marked crossings. The MBTA has recently implemented similar techniques on the islands located within the bus way and drop-off areas, using decorative fencing instead of bollards and decorative chain.

The use of bollards and crosswalks with increased visibility can be effective when used throughout the entire Central Business District. Consistent application of these elements will eventually train motorists to associate their presence with pedestrian activity.

B. Centre Street (Route 60) at Jackson Street

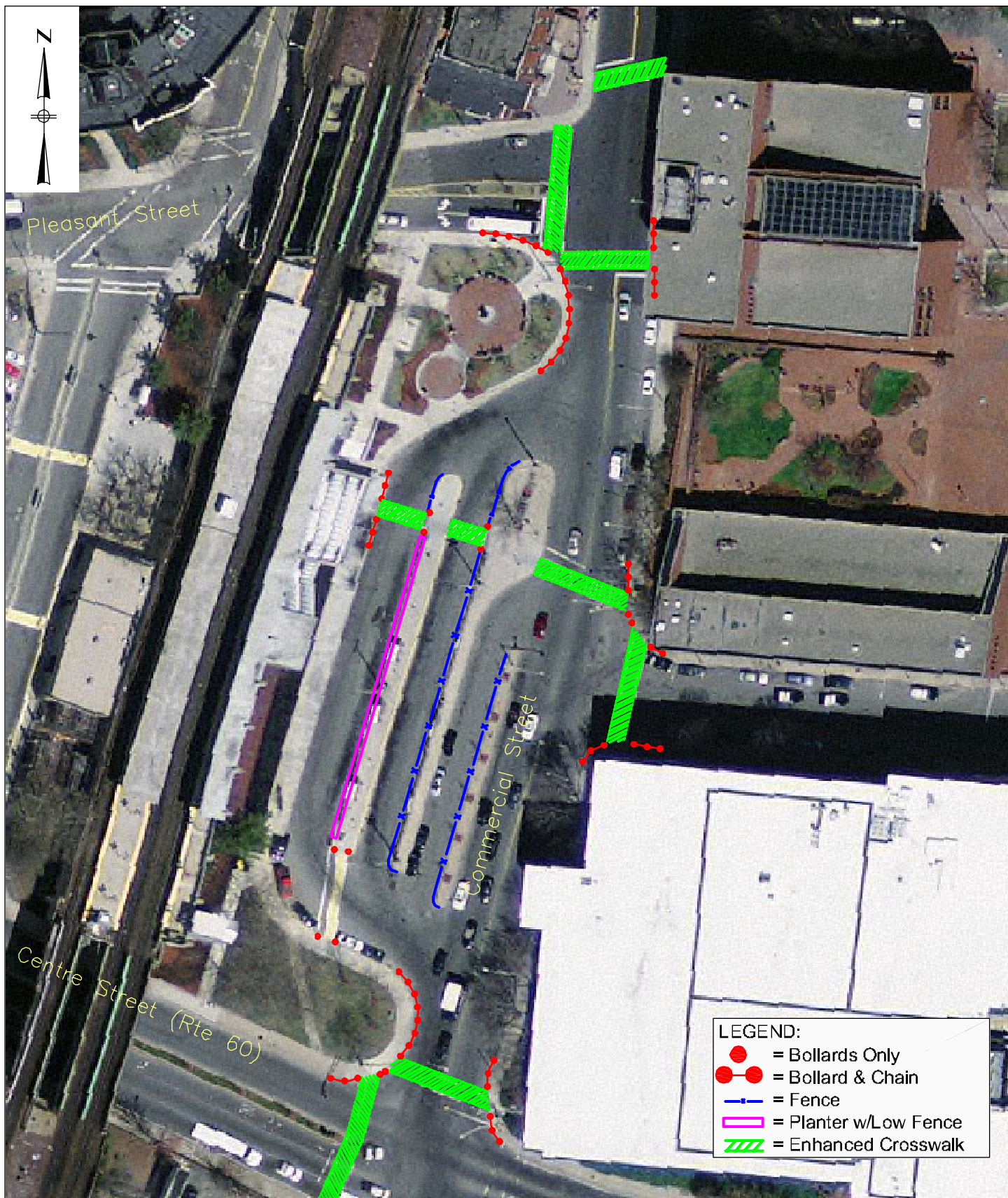
Improvements similar to those proposed for the Commercial Street area (pedestrian Area A) could also be implemented at this intersection. The existing crosswalks on Centre Street and Jackson Street could be replaced with enhanced crosswalks, and bollards could also be installed at the ends of the crosswalks to identify crossing areas.

C. Main Street at Salem Street and Ferry Street

The enhanced crosswalk style and use of bollards as discussed for the Commercial Street area (pedestrian area A) could also be implemented on the crosswalks on all approaches to this intersection.

D. Centre Street (Route 60) at Main Street

Use of enhanced crosswalks and bollards as described for the Commercial Street area (pedestrian area A) could be implemented at this intersection to improve the safety of crossing pedestrians.



Traffic Operations Assessment
Malden, Massachusetts

Figure 6
Potential Streetscape / Urban
Design Improvements

SCALE: 1" = 80'

3.4.2 Pedestrian Phasing Changes at Existing Traffic Signals

In addition to the physical and streetscape concepts described above, the project team also evaluated the potential for including exclusive pedestrian signal phases at intersections within the study area which currently utilize concurrent pedestrian phasing. The results of the Level of Service analysis are presented in Table 2.

Exclusive pedestrian phasing was evaluated at six intersections. Overall level of service would degrade at all six intersections, with most intersections degrading by multiple levels of service. The intersections would operate as follows:

A. Commercial Street between Pleasant Street and Centre Street

1. Pleasant Street at Florence Street and Commercial Street - This intersection currently operates with an exclusive pedestrian signal phase.

3. Commercial Street at Centre Street (Route 60) - This intersection would degrade from LOS C to LOS F during both peak hours. A total of 103 pedestrians cross at this intersection during the morning peak hour and 140 pedestrians cross during the afternoon peak hour.

4. Exchange Street at Commercial Street - This intersection currently operates with an exclusive pedestrian signal phase.

B. Centre Street (Route 60) at Jackson Street

7. Centre Street (Route 60) at Jackson Street - This intersection currently operates with an exclusive pedestrian signal phase.

C. Main Street at Salem Street and Ferry Street

13. Main Street at Salem Street and Ferry Street – This intersection would degrade from LOS C to LOS F (with an average delay of 151.8 seconds per vehicle) during the morning peak hour and LOS D to LOS E during the afternoon peak hour with the addition of an exclusive pedestrian signal phase. A total of 218 pedestrians cross at this intersection during the morning peak hour and 156 pedestrians cross during the afternoon peak hour.

D. Centre Street (Route 60) at Main Street

15. Centre Street (Route 60) at Main Street - This intersection which would degrade from LOS C to LOS F during the morning peak hour and LOS D to LOS F during the afternoon peak hour with the addition of an exclusive pedestrian phase. A total of 53 pedestrians cross at this intersection during the morning peak hour and 112 pedestrians cross during the afternoon peak hour. Operations at this intersection are integral to the operations at the **10. Exchange Street at Main Street** which would degrade from LOS C to LOS E during the morning peak hour and remain at LOS C during the afternoon peak hour with the addition of an exclusive pedestrian phase. A total of 91 pedestrians cross during the morning peak hour and 120 pedestrians cross during the afternoon peak hour.

The following two intersections were not included in the identified pedestrian improvement areas, but exclusive pedestrian signal phasing was evaluated as a potential improvement option.

14. Centre Street (Route 60) at Ferry Street – This intersection would degrade from LOS C to LOS E during both peak hours. A total of 178 pedestrians cross

at this intersection during the morning peak hour and 77 cross during the afternoon peak hour.

16. Centre Street (Route 60) at Eastern Avenue – This intersection would degrade from LOS B LOS C during the morning peak hour and LOS A to LOS C during the afternoon peak hour. A total of 34 pedestrians cross during the morning peak hour and 33 cross during the afternoon peak hour.

4.0 CONCLUSIONS

The following conclusions are made:

- Overall the intersections within the Central Business District operate with acceptable levels of service.
- Existing pedestrian phasing at the intersections generally provide clearance times that are insufficient to cross pedestrians in conformance with the MUTCD.
- Most of the traffic control equipment is dated, but still functions properly and safely.
- Streetscape elements could be incorporated into the Central Business District to enhance pedestrian safety.
- Implementing exclusive pedestrian phasing at intersections that currently utilize concurrent pedestrian phasing would severely degrade vehicular level of service.

5.0 RECOMMENDATIONS

The project team makes the following recommendations to improve traffic operations within the Central Business District. These recommendations are summarized in Table 4.

Short Term Improvements

- Implement a traffic signal retiming program to modify vehicle and pedestrian timings at all signalized intersections within the study area to achieve compliance with the MUTCD standards and to improve the efficiency of the traffic signals.
- **3. Centre Street (Route 60) at Commercial Street:**
 - Install a new 5-section traffic signal cluster for the westbound left turn movement.
 - Modify the traffic signal phasing to allow the eastbound and westbound left-turns to move together at the beginning of the signal cycle.
 - Repair the cabinet to allow the east-west concurrent pedestrian phase to run with east-west vehicles.
- **7. Centre Street (Route 60) at Jackson Street:**
 - Replace the existing cabinet to solve water infiltration issues.
- **15. Centre Street (Route 60) at Main Street/10. Exchange Street at Main Street:**
 - Install a new 5-section traffic signal cluster for the westbound left turn movement.
 - Modify the traffic signal phasing to: better accommodate all traffic moves; allow the Centre Street eastbound and westbound left-turn movements to move together at the beginning of the signal cycle; and eliminate the all stop phase at the Centre Street (Route 60) at Main Street intersection.

Table 4 - Summary of Recommended Improvements

Intersection	Signalized/Unsignalized	Short-Term Improvements								Long-Term Improvements				
		Optimize Traffic Signal Timing	New Signal Head	Extend Pedestrian Clearance Intervals	Add New Signage	Change Existing Signal Cycle Length	Modify Existing Signal Phasing	Replace Traffic Signal Cabinet Air Filters	Replace Existing Controller Cabinet	Implement Traffic Signal Coordination	Streetscaping and Enhanced Crosswalks	Install Tacile Warning Panels	Install Countdown Pedestrian Signal Heads	Evaluate Accessible Pedestrian Signals
1. Pleasant Street at Florence Street and Commercial Street	S	X		X		X		X		X	X	X	X	X
2. Pleasant Street at Summer Street and MBTA driveway	U										X	X		
3. Commercial Street at Centre Street (Route 60)	S	X	X	X	X	X	X	X		X	X	X	X	X
4. Exchange Street at Commercial Street	S	X		X		X		X		X	X	X	X	X
5. Exchange Street at Abbot Street	U										X	X		
6. Exchange Street at Jackson Street	U										X	X		
7. Centre Street (Route 60) at Jackson Street	S	X		X		X		X	X	X	X	X	X	X
8. Exchange Street at Washington Street	U										X	X		
9. Exchange Street at Middlesex Street	U										X	X		
10. Exchange Street at Main Street	S	X					X	X		X	X	X	X	X
11. Centre Street (Route 60) at Irving Street	U										X	X		
12. Pleasant Street at Main Street	S	X		X		X		X		X	X	X	X	X
13. Main Street at Salem Street and Ferry Street	S	X	X			X		X		X	X	X	X	X
14. Centre Street (Route 60) at Ferry Street	S	X	X					X		X	X	X	X	X
15. Centre Street (Route 60) at Main Street	S	X					X	X		X	X	X	X	X
16. Centre Street (Route 60) at Eastern Avenue	S	X						X		X	X	X	X	X
17. Florence Street and Main Street	S	X		X				X		X	X	X	X	X
18. Florence Street and Washington Street	S	X		X		X		X		X	X	X	X	X
19. Eastern Avenue at Wyeth Street	U										X	X		
20. Pleasant Street at Abbot Street	U										X	X		

- **14. Centre Street (Route 60) at Ferry Street:**
 - Install a new 5-section traffic signal cluster for the northbound left-turn movement.
- Maintain concurrent pedestrian phasing at intersections where concurrent pedestrian phasing is utilized because of the severe degradation to vehicular level of service that would be caused by the added exclusive pedestrian signal phase.
- Replace air filters in all traffic signal cabinets.

Long Term Improvements

- Implement traffic signal coordination at all of the traffic signals within the study area.
- Install enhanced crosswalks at intersections within the Central Business District.
- Work with the MBTA to improve the pedestrian pathways around the Malden Center Station and along Commercial and Pleasant Streets.
- All recommendations presented in this report have been made assuming that the existing traffic signal controllers would be utilized. Traffic signal controller technology, like personal computer technology, is always evolving. New features and capabilities are always being developed. The traffic signal controllers within the Central Business District could be replaced when the opportunity presents itself. New controllers, however, are not necessary to implement the recommended improvements. While new controllers can enhance future capabilities, they would result in negligible additional improvements to traffic operations.

APPENDIX A

Traffic Signal Glossary

All-Red Interval – A short period in a signal phase where traffic is stopped in all directions and all signals display a “RED BALL” or “RED ARROW”.

Accessible Pedestrian Signal (APS) - A device that communicates information about pedestrian timing in a nonvisual format such as audible tones, verbal messages, and/or vibrating surfaces.

Concurrent Pedestrian Phase – A signal phase where pedestrians may cross parallel to the vehicles that have a green signal.

Controller – An electrical device mounted in a cabinet for controlling the operation of a traffic signal.

Crosswalk – Any portion of a roadway distinctly designated for pedestrian crossing by lines or other markings on the surface.

Cycle Length – The time required to complete a full sequence of traffic movements.

Detector – A sensing device (usually either embedded in the pavement or from video camera locations) used for determining the presence or passage of vehicles or pedestrians. Detectors are used in an actuated or semi-actuated operation.

Exclusive Pedestrian Phase – A signal phase where vehicular traffic is stopped in all directions and pedestrians are allowed to cross in all directions.

Fully-Actuated Operation – Type of traffic signal control operation in which all signal phases are called and extended by detectors.

Interval – A portion of a signal cycle where signal indications do not change.

Level Of Service (LOS) – A measurement of vehicle operation through a single intersection based on delay. This measurement is similar to a report card – A is excellent operation, F is poor operation.

Offset – The time duration between the initiation of the progressed movement (phase) common to any two signals at the two intersections. It is generally measured at the downstream intersection relative to the upstream intersection.

Optimization - Improvements and adjustments to signalized intersections that add additional reliability and efficiency. Optimizing traffic signals involves the assessment and allocation of green time to all signal phases.

Overlap Phase - A signal phase which operates concurrently with one or more other phases that would not normally run together.

Patterns of Operation – A set of cycle lengths, splits, and offsets part of a signal coordination plan.

Peak Period – the time of day when the highest volume of vehicles, pedestrians, and/or cyclists are typically encountered on a roadway. An intersection usually has three peak periods: morning, mid-day, and evening.

Pedestrian Change Interval - An interval during which the flashing UPRAISED HAND (symbolizing DONT WALK) signal indication is displayed. When a verbal message is provided at an accessible pedestrian signal, the verbal message is “Wait”.

Permissive Mode – A mode of traffic control signal operation in which, when a green light is displayed, left or right turns may be made after yielding to oncoming traffic and/or pedestrians.

Phase Sequence – The order of appearance of signal phases during a signal cycle.

Platoon – A group of vehicles traveling together as a group, because of traffic control signals, roadway geometry, and other factors.

Pre-timed Operation – Type of signal control operation where a signal cycle follows a fixed sequence, the intervals of which are of fixed length.

Progression – A time relationship between adjacent traffic signals permitting continuous operation of platoons of vehicles at a planned rate of speed.

Protected Mode – A mode of traffic signal operation in which left or right turns are protected from oncoming vehicular traffic. Under this operation, a “GREEN ARROW” is displayed and opposing traffic must be stopped.

Semi-Actuated Operation – A type of traffic control signal in which at least one, but not all, signal phases function on the basis of actuation.

Signal Coordination – The establishment of timed relationships between adjacent traffic control signals.

Signal Phase – The portion of a signal cycle that serves a combination of traffic movements.

Signal System – Two or more traffic control signals operating in signal coordination.

Signal Timing – The amount of time allocated for the display of a signal indication.

Split – A portion of the cycle length allocated to each phase that may occur.

Walk Interval – An interval during which the WALKING PERSON (symbolizing WALK) signal indication is displayed. When a verbal message is provided at an accessible pedestrian signal, the verbal message is “WALK sign”.

Yellow Interval – This interval follows the green interval and is a warning for motorists to slow down before the red interval is displayed.

APPENDIX B

Photos of Existing Traffic Signal Controllers

1. Pleasant Street at Florence Street/
Commercial Street

This Controller Cabinet Could
Not be Opened

3. Commercial Street at Centre Street (Route 60)



4. Commercial Street at Exchange Street



7. Centre Street (Route 60) at Jackson Street



10 & 15. Exchange Street at Main Street
& Centre Street (Route 60) at Main Street



12. Pleasant Street at Main Street



13. Main Street at Salem Street and Ferry Street



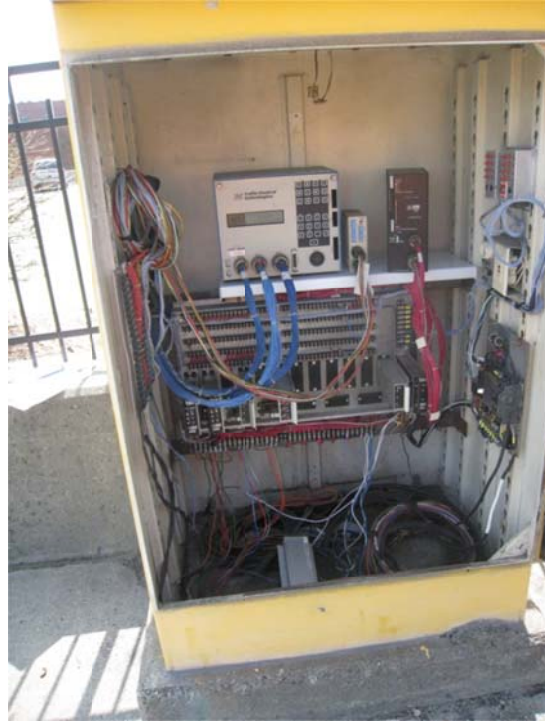
14. Centre Street (Route 60) at Ferry Street



16. Centre Street (Route 60) at Eastern Avenue



17. Florence Street at Main Street



18. Florence Street at Washington Street

