



March 11, 2015

Lynnfield Board of Selectmen
Town of Lynnfield
55 Summer Street
Lynnfield, MA 01940

Re: **Walnut Street Traffic Assessment**

Dear Board of Selectmen Members:

As requested, BETA Group, Inc. (BETA) has completed our review of the Walnut Street Traffic Assessment in the Town of Lynnfield, Massachusetts. Five main sources provided necessary input for this study, including:

- The “MeadowWalk at Lynnfield Audubon Rd. & Walnut St. – 5 Locations Functional Design Report” (counts and analysis taken from the MeadowWalk report are referred to as “Forecasted” in this report)
- Turning movement counts taken by Massachusetts Department of Transportation (MassDOT) in July 2014 (referred to as “July 2014 Counts” in this report)
- Turning movement counts taken by MassDOT in October 2014 (referred to as “October 2014 Counts” in this report)
- Revised October 2014 Traffic Signal Plans for Walnut Street Corridor (referred to as “October 2014 Revised Signal Plans” in this report)
- Turning movement counts conducted by BETA Group, Inc. in December of 2014 (referred to as “Existing” and “Build” in this report)

Our findings and recommendations are as follows:

INTRODUCTION

Project Description

The study area consists of a segment of Walnut Street bounded by the intersections of Gianna Drive to the south and Market Street to the north, including three signalized and three unsignalized intersections. The study includes a qualitative study of the Walnut Street intersections with: the I-95 (Exit 43) southbound ramps and Market Street; the northbound ramps; and Salem Street. In addition, an origin-destination study was conducted in the study area. **Figure 1** shows the location of the study intersections along with an Origin-Destination key.

EXISTING CONDITIONS

Study Area Intersections

The study area consists of three signalized and three unsignalized intersections as follows:

- Walnut Street and Market Street/I-95 Southbound Ramps (Exit 43) (Signalized)
- Walnut Street and I-95 Northbound Ramps (Exit 43) (Signalized)
- Walnut Street and Salem Street (Signalized)
- Walnut Street and Sparhawk Drive (Unsignalized)
- Walnut Street and Bluejay Road (Unsignalized)
- Walnut Street and Gianna Drive (Unsignalized)

Turning Movement Counts

Manual Turning Movement Count (TMC) data were collected on Tuesday, December 16, 2014. All Study Area intersections were counted from 7:00 AM to 9:00 AM and from 4:00 PM to 6:00 PM. Passenger cars, heavy vehicles, pedestrians and bicycles were counted.

Based on the peak hours of the project locations, the overall peak hours for the corridor were 7:30-8:30 AM and 4:30-5:30 PM. The peak hour turning movements are shown in **Figure 2**.

OBSERVATIONS

Field Observations

BETA observed the study area for queues, delays, U-Turns and driver behavior during the AM peak period on December 11, 2014, the PM peak period on December 15, 2014 and again for both the AM and the PM peak periods on December 26, 2014. Observations revealed the following:

AM Peak Hour:

- Solar glare is very bright for vehicles traveling southbound through the corridor
- Some speeding was seen along the Walnut Street south of Salem Street
- No pedestrian activity was present
- A lane drop southbound at Salem Street results in a sudden merge for vehicles

PM Peak Hour:

- Peak queues northbound were observed back to Sparhawk Drive at approximately 3:30 PM
- Peak queues southbound were observed back to Market Street from I-95 NB intersection
- Drivers use a shorter gap when making southbound left onto I-95 NB during permitted phase
- No pedestrian activity was present

U-Turns were not observed during any of the observation periods.

Traffic Signal Observations

BETA observed the traffic signals in the network for signal coordination and operation during each of the observation periods. Based on these observations, the following events were seen:

AM Peak Hour:

- Traffic operation is relatively smooth and heavy queuing was not noticed

PM Peak Hour:

- Southbound protected/permitted left turn green time at Salem Street is not always fully utilized.
- Green time for the northbound left turn into Market Street is not long enough to clear the queue on this link. The result is that when northbound traffic from the northbound on- and off-ramps receives a green light, the traffic flow is sometimes impeded.

CAPACITY ANALYSIS

Level of Service Analysis Results

A level of service analysis was performed for the existing project's signalized intersections using Synchro 8. Three sets of turning movement counts were used in the Level of Service Analysis Results and are as follows:

- The MeadowWalk FDR counts taken in 2007 (Forecasted)
- Counts taken by MassDOT in October 2014 (October 2014 Counts)
- Counts taken by BETA Group, Inc. in December 2014 (Existing and Build)

In addition to the three sets of turning movement counts used, October 2014 Revised Signal Plans were provided by MassDOT and were used, along with the Existing counts, to create the roadway network, phasing and timing as input to the Synchro analysis. The Existing (2014) traffic volumes were grown using a 0.5% growth rate over 3 years to obtain 2017 volumes, which creates an equivalent analysis comparison with the Forecasted network provided in the MeadowWalk FDR. The 0.5% growth rate is consistent with the MeadowWalk FDR.

In addition to traffic growth, site generated trips for the remaining retail and office space were calculated. The developer and the Town identified, 70,000 square feet of office space and 100,000 square feet of retail space remaining to be built. The total site generated trips for both land uses were calculated using the Institute of Transportation Engineers (ITE) Trip Generation Manual 7th Edition. To remain consistent with the MeadowWalk analysis, the same pass-by trip, internal trip and trip distribution percentages were used in determining the site generated trips. A summary of trips by land use code are listed in **Tables 1 and 2**.

Site generated trips were added to the traffic growth, to create a Build (2017) network shown in **Figure 3**. These volumes were then analyzed without any changes to the existing signal timing or phasing and compared with the Forecasted results in the MeadowWalk report. After comparison with the Forecasted analysis and the October 2014 Counts, it was determined that a significant portion of the counts from the MeadowWalk report were forecasted higher than expected. The October 2014 Counts were compared with the December 2014 Counts, and were determined to be an accurate representation of the traffic throughout the corridor. It was decided to use the December 2014 data for further analysis and disregard the MeadowWalk results. A complete summary of the results of the signalized capacity analysis are shown in **Table 3**, and a comparison of Build (2017) results are provided in **Table A-1** in the appendix.

In addition to the signalized analysis results, the three remaining unsignalized intersections were analyzed for Existing and Build. Since these intersections were not included in the MeadowWalk report, a comparison was not made. The results are shown in **Table 4** and are included for comparison between the three build-outs.

Based on the capacity analysis results, the three signalized intersections were compared between Existing and Build conditions. Following is a detailed description of operations at each intersection.

1. Walnut Street at Market Street/I-95 SB Ramps

This intersection operates at an overall level of service (LOS) C in both the Existing morning and afternoon peak hours, with average delays of 32.4 seconds and 23.1 seconds, respectively. All individual moves operate at LOS D or better. All queues remain adequately served by available storage.

During Build conditions, all movements remain relatively the same in the morning peak hour, while the northbound left, northbound through, and southbound through movements degrade LOS in the afternoon peak hour. Both northbound movements change slightly to LOS C and the southbound movements to LOS D. The northbound left-turn queue to Market Street in the morning increases to #344 feet and the southbound through queue increases to 296 feet in the afternoon. The “#” sign indicates that the 95th percent volume exceeds the capacity and the queue may actually be longer. All remaining queues are relatively consistent as in the Existing.

2. Walnut Street at I-95 NB Ramps

The Existing average overall LOS for this intersection is LOS B in the morning (15.3 seconds of delay) and LOS D (54.9 seconds) in the afternoon. No individual moves operate below LOS D in the morning; while in the afternoon the northbound through and southbound left operate at LOS E (60.2 seconds) and LOS F (121.8 seconds), respectively. Queues for the northbound through movement (#863 feet) as well as the southbound left-turn (#294 feet) exceed the available capacity in the afternoon peak hour, but intersections are not blocked because traffic signals meter traffic flow. All other queues remain adequately served by available storage.

During Build conditions, the intersection remains unchanged in the morning peak hour (LOS B). The afternoon peak hour, however, degrades to 77.8 seconds of delay (LOS E). This increase in delay is due the southbound left-turn from Walnut Street to I-95 NB which operates at LOS F and experiences a significant delay, degrading to 260.2 seconds. All other movements remain relatively the same in the both peak hours. Queues for the northbound through movement and the southbound left-turn continue to exceed the available capacity in the afternoon peak hour. The northbound queue decreases to #780 feet, while the southbound left-turn queue increases to #440 feet. Traffic signal operation forces vehicles to stop when the lights turn red; therefore when vehicles that were already in the intersection clear, vehicles that were stopped by the red light cannot move up to block the intersection. All remaining queues are relatively the same.

3. Walnut Street at /Salem Street

This intersection operates at an overall LOS C (28.3 seconds) in the morning peak hour and LOS D (38.5 seconds) in the afternoon. All individual moves operate at LOS D or better, except for the westbound through movement in the morning and the northbound through movement in the afternoon, both operating at LOS E. Queues for the northbound through movement (#557 feet) as well as the southbound left-turn (#315 feet) exceed the available capacity in the morning peak hour. Northbound queues in the afternoon also exceed capacity with queue lengths totaling #576 feet. All other queues remain adequately served by available storage.

The morning peak hour at this intersection degrades in the Build conditions, resulting in a change in LOS from C to D (36.8 seconds). The northbound through movement changes to LOS F (81.9 seconds) in the morning and to LOS F (119.5) in the afternoon. All other movements operate the same as the Existing. The northbound queue increases to #639 feet in the morning and to #940 feet in the afternoon. All remaining queues are relatively the same.

Based on the capacity analysis results for the three unsignalized intersections comparisons between Existing and Build were performed. All intersections and individual moves operate at LOS D or better, while queues are adequately served by available storage. These results remain consistent through all three conditions.

MARKET STREET COMPLEX ACCESS

The MeadowWalk report states that 75% of project site traffic would enter the Market Street Complex via Walnut Street, while the remaining 25% would enter via Audubon Road. The distribution of vehicle trips, when averaged, is consistent with these percentages, when calculated using the July 2014 Counts provided by MassDOT.

TRIP DISTRIBUTION

Origin-Destination Study

Origin-Destination (O-D) data were collected on Wednesday, December 17, 2014. In total, thirteen different turning movements were chosen for license plate captures and are listed as follows:

1. Walnut Street Northbound Through (south of Gianna Drive)
2. Gianna Drive Eastbound Left Turn
3. Bluejay Drive Eastbound Left Turn
4. Sparhawk Drive Eastbound Left Turn
5. Salem Street Eastbound Left Turn
6. Salem Street Westbound Right Turn
7. Montrose Avenue Northbound Right Turn
8. I-95 Northbound (Exit 42) Southbound Left Turn
9. Salem Street Eastbound Through (West of Montrose Avenue)
10. I-95 Northbound (Exit 43) Southbound Left Turn
11. Walnut Street Southbound Right Turn (at intersection with Market Street)
12. I-95 Southbound (Exit 43) Westbound Through
13. Walnut Street Northbound Left Turn (at intersection with Market Street)

The results of the Origin-Destination Study were calculated into traffic percentages entering Market Street from Walnut Street and the I-95 southbound off-ramps from Exit 43. It was then calculated further into traffic percentages of the Walnut Street northbound left turn at Market Street (Location 13) from surrounding roadways. The results of these two calculations are as follows and can be seen in **Figure 4**:

Traffic Percentages at Market Street based on O-D Location with unmatched vehicles:

Location 11 -	199 vehicles	or	27.5%
Location 12 -	207 vehicles	or	28.5%
Location 13 -	198 vehicles	or	27.3%
Unmatched -	121 vehicles	or	16.7%
TOTAL	725 vehicles	or	100%

Traffic Percentages at Market Street based on O-D Location without unmatched vehicles:

Location 11 -	199 vehicles	or	32.9%
Location 12 -	207 vehicles	or	34.3%
Location 13 -	198 vehicles	or	32.8%
TOTAL	604 vehicles	or	100%

Traffic Percentages of Walnut Street northbound left turns to Market Street based on O-D Location:

Location 10 -	78 vehicles	or	12.9%
Location 6 -	33 vehicles	or	5.5%
Location 5 -	9 vehicles	or	1.5%
Location 4 -	0 vehicles	or	0%
Location 3 -	0 vehicles	or	0%
Location 2 -	1 vehicles	or	0.2%
Location 1 -	77 vehicles	or	12.7%
TOTAL	198 vehicles	or	32.8%

IMPROVEMENT ALTERNATIVES

U-Turns Along Walnut Street

Sparhawk Drive was the only one of the three residential side streets observed to have U-Turns. These U-turns all headed southbound, with two U-Turns occurring in the morning peak hour and five occurring in the afternoon peak hour. **Figure 5** shows the breakdown of U-Turns by 15-minute interval as well as the movement of these U-Turns. No U-Turns occurred at either Bluejay Road or Gianna Drive.

Potential improvements to restrict these U-Turns include:

- Install delineators along the centerline of Walnut Street in the vicinity of Sparhawk Drive. This would prevent U-Turns for either northbound or southbound vehicles. It would also, however, prevent left turns out or into Sparhawk Drive, and would divert these moves to Bluejay Road or Gianna Drive. Delineators are suggested because the Walnut Street is not wide enough to have a raised island. See **Figure 6**.

- Install delineators along the centerline of Sparhawk Drive at the approach to Walnut Street. This would prevent U-Turns. Delineators could be damaged during plowing activity and could therefore provide a less permanent solution. An advantage of this measure is that access/egress for residents would not be disrupted. See **Figure 7**.
- Install a raised median island. This would also prevent U-Turns, and would not disrupt access/egress for residents. The estimated construction cost would approximately \$10,000, including signage and striping. See **Figure 8**.
- Narrow Sparhawk Drive to physically prevent U-Turns. This would only prevent U-Turns within the roadway limits. Private drives to residences exist on each side of Sparhawk Drive, and it is likely that motorists would use these drives to make a three-point turn to change directions. See **Figure 9**.

The raised median island is recommended by BETA because it would be an effective treatment that would provide a permanent solution. A temporary treatment with delineators could provide a trial period to assess the overall solution, although the median island is our ultimate recommendation.

One-Way Conversion of Walnut Street

Walnut Street carries both local and regional traffic. Conversion to one-way operation, in either direction, would result in significant displacement of vehicles for residents and commuters. This would be a significant change with wide-reaching impacts that would require a much broader discussion and State approval. This change is not recommended at this time.

Widening of Walnut Street

Roadway widening of Walnut Street would have significant and costly impacts along the corridor, with significant environmental issues. Property acquisitions would most likely be needed as well as slope work in the form of retaining walls and driveways. Survey would be required to establish Right-of-Way and identify costs and construction viability. The widening of Walnut Street would not significantly reduce the queuing at the signalized intersection with Salem Street since that would result in two through lanes approaching the intersection with only one through lane departing; if an additional departure lane were added, then this treatment would need to continue through the Market Street intersection – which is not possible due to the bridge abutments. Due to these constraints, it is recommended at this time that Walnut Street not be widened.

Walnut Street at Salem Street Intersection Blocking

A common issue along congested corridors is Intersection Blockage, a condition in which motorists enter a signalized intersection without sufficient green signal time to actually clear the intersection. This condition results in a blockage for the next phase of traffic that becomes blocked by the vehicles from the previous phase that did not get through the intersection. Efforts to avoid the intersection blocking include bold striping in a hatch pattern and “Do Not Block” signage. Due to the width and skew of the Walnut Street at Salem Street intersection, striping the hatch pattern for intersection blocking is not recommended. Installation of “Do Not Block Intersection” signage on all approaches is recommended. Police enforcement, however, is needed to ensure that drivers adhere to the signage. Additional strategies to modify traffic signal timing/phasing only exacerbated the condition.

Walnut Street at Gianna Drive

The intersection of Walnut Street and Gianna Drive presents several issues regarding sight distance for exiting vehicles. The lack of sight distance is mainly due to the horizontal roadway curve of Walnut Street north of the intersection in conjunction with the steep grade on the northwest corner of the intersection. Vehicles exiting Gianna Drive have very limited sight distance of southbound traffic on Walnut Street. A flashing warning sign for southbound traffic is located approximately 500 feet north of the intersection on Walnut Street, flashing only when triggered by an exiting vehicle on Gianna Drive to alert drivers.

It was stated by the town that the overgrown vegetation on the northwest corner was trimmed back recently, but with the steep grade still presenting an issue, other improvements are being considered. One such improvement involves the installation of traffic signals at the intersection. Due to the significantly low volumes on Gianna Drive, the intersection would not meet signal warrants defined in the Manual on Uniform Traffic Control Devices (MUTCD). Installation of unwarranted traffic signals would violate the MUTCD and put the Town at risk if a crash occurred and caused significant injury or property damage. Signal installation, therefore, should not be considered.

Another improvement discussed was removing part of the hill on the northwest corner of the intersection. This improvement would require significant grading work and a retaining wall. In addition, improvements would need to be made to the existing driveway at the intersection. These improvements to reduce the sightline impacts would be costly and are not recommended at this time. Field survey would be required to determine right-of-way and actual slope conditions, which in turn would be necessary to develop a reasonable construction/right-of-way cost.

Walnut Street at Salem Street Southbound Merge

The intersection of Walnut Street and Salem Street provides two southbound through lanes at the intersection which merge into one just through the intersection. An existing “Right Lane Ends” sign is posted at the merge point, although no advanced signage exists north on Walnut Street. It is recommended that the existing sign be moved further north on Walnut Street and a new diagrammatic W4-2 sign be installed where the existing sign is located. The existing pavement markings are striped typical to a lane drop location and no further striping is recommended at the intersection. In addition, the “Right Lane Ends” language is deceiving because it is actually the left lane that ends. The correct language should be inserted.

Walnut Street Truck Exclusion South of Salem Street

There is an existing truck exclusion along Walnut Street south of Salem Street. Turning movement counts showed approximately 1% of traffic or 8 trucks per hour traveling southbound on Walnut Street where they are prohibited. These trucks originate mainly from the north on Walnut Street and taking a left westbound from Salem Street, which are consistent with the MassDOT counts taken.

Existing signage for the truck exclusion include several signs:

- An advanced sign just south of the Market Street intersection heading southbound on Walnut Street that reads “No Trucks Walnut Street South of Salem Street”;
- A diagrammatic no truck sign with the wording “2 ½ Ton or Over” on Walnut Street at the intersection with Salem Street facing the southbound traffic on Walnut Street.
- A sign on the eastbound Salem Street approach to Walnut Street, approximately 1,200 feet from the intersection.
- A sign on the westbound Salem Street approach to Walnut Street, approximately 800 feet from the intersection.
- A sign on the northbound off-ramp from I-95 NB to Walnut Street.

Recommended improvements include:

- Replace the existing sign just south of the Market Street intersection with a diagrammatic R5-2 sign with a supplemental “South of Salem Street” plaque.
- Add a diagrammatic R5-2 sign with a supplemental “South of Salem Street” plaque sign on the southbound off-ramp from I-95 southbound.
- Add diagrammatic R5-2 signs with a supplemental “South of Salem Street” plaque on both the eastbound and westbound approaches of Salem Street at the intersection of Walnut Street.
- It would also be beneficial to notify truck operators before they commit to a ramp that a truck exclusion exists. This, however, would require coordination with MassDOT to receive permission, to determine the locations, and to review the sign design.

Traffic Signal Improvements

The following alternatives were analyzed to improve traffic signal operations throughout the corridor:

- Proposed change of Market Street eastbound left turn from a permitted phase to a protected phase. This proposed change would degrade several approach delays in both the AM and PM peak hours, especially the westbound through movement. Therefore, this is not recommended.
- Proposed change of Walnut Street southbound left turn from protected/permitted to protected only at Salem Street. This proposed change would significantly degrade several approach delays in both the AM and PM peak hours, especially the AM southbound left and the PM northbound through which would both degrade from LOS D to LOS F. Therefore, this is not recommended.
- BETA also explored timing changes in existing and modified phasing. These also did not improve traffic operations. We therefore do not recommend phasing or timing modifications to these traffic signals.

SUMMARY OF RECOMMENDATIONS

- Install a raised median island along the centerline of Sparhawk Drive for 50 feet, beginning from the intersection with Walnut Street.
- Install “Do Not Block Intersection” signage at each approach of the intersection of Walnut Street and Salem Street. In addition, increased police enforcement at the intersection should be provided.
- Replace and add additional signage for the southbound merge on Walnut Street, south of Salem Street. A diagrammatic sign (W4-2L), which indicates that the left lane will be dropped, should be installed where the existing “Right Lane Ends” sign is located. A new “Left Lane Ends” sign should be installed southbound on Walnut Street between the intersections of the I-95 Northbound Ramps and Salem Street.
- Replace existing truck exclusion signage on Walnut Street with diagrammatic R5-2 signs with a supplemental “South of Salem Street” plaque.
- Install diagrammatic R5-2 signs with a supplemental “South of Salem Street” plaque for both eastbound and westbound intersection approaches on Salem Street and on the southbound off-ramp from I-95 southbound.
- It would also be beneficial to notify truck operators on Route I-95, before they commit to a ramp, that a truck exclusion exists. This, however, would require coordination with MassDOT to receive permission, to determine the locations, and to review the sign design.

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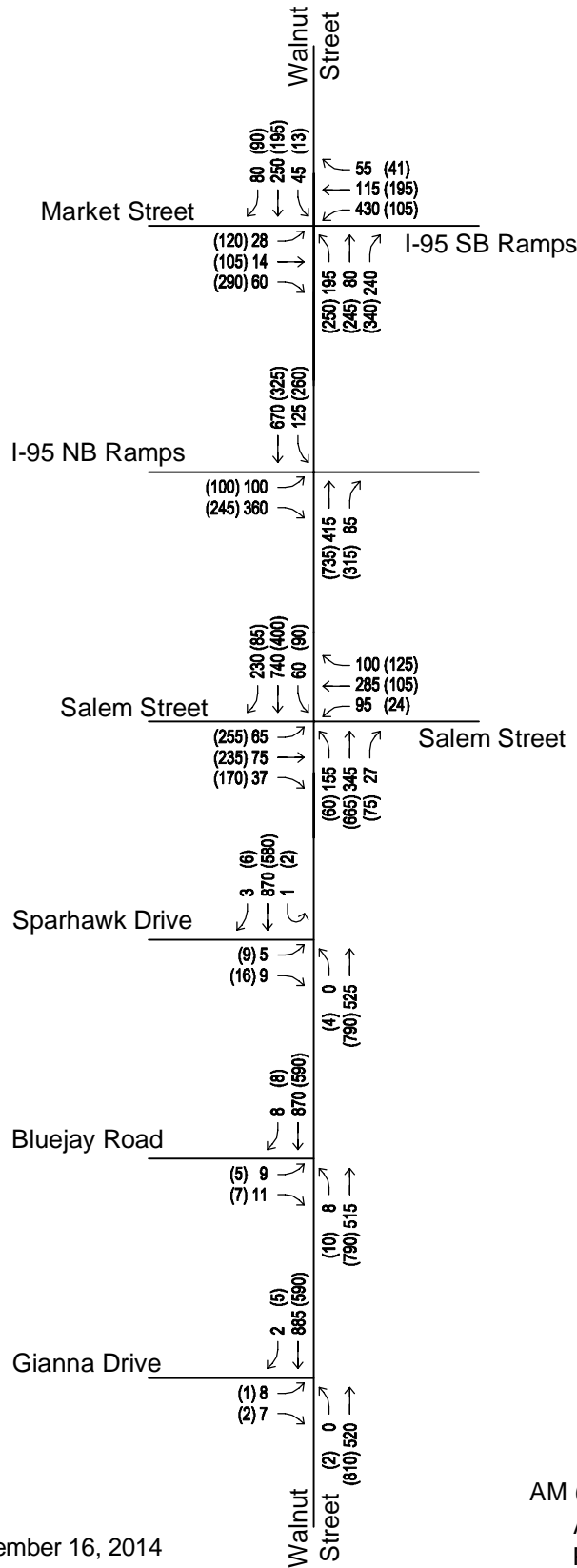


Walnut Street Traffic Assessment

Lynnfield, MA

Figure 1

Project Key



AM (PM) Peak Hour Traffic Volumes
 AM Peak Hour = 7:30 - 8:30
 PM Peak Hour = 4:30 - 5:30

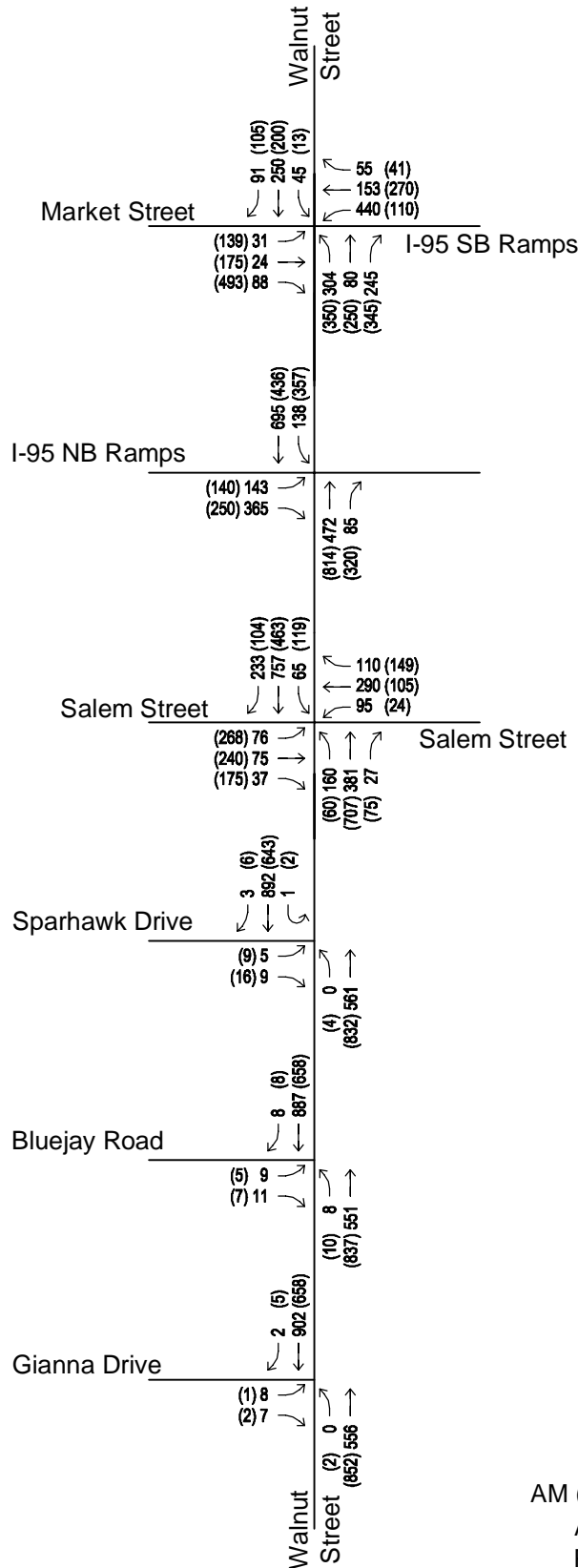


Walnut Street Traffic Assessment

Lynnfield, MA

Figure 2

Existing (2014) Peak Hour
Turning Movement Volumes



**Walnut Street
Traffic Assessment**

Lynnfield, MA

Figure 3

Build (2017) Peak Hour
Turning Movement Volumes

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Walnut Street Traffic Assessment

Lynnfield, MA

Figure 4

Origin - Destination Study Results

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Morning Peak Hour

TIME	SB U-TURNS
7:00 - 7:15 AM	0
7:15 - 7:30 AM	0
7:30 - 7:45 AM	0
7:45 - 8:00 AM	1
8:00 - 8:15 AM	0
8:15 - 8:30 AM	0
8:30 - 8:45 AM	1
8:45 - 9:00 AM	0
TOTAL	2

Afternoon Peak Hour

TIME	SB U-TURNS
4:00 - 4:15 PM	0
4:15 - 4:30 PM	2
4:30 - 4:45 PM	0
4:45 - 5:00 PM	0
5:00 - 5:15 PM	1
5:15 - 5:30 PM	1
5:30 - 5:45 PM	0
5:45 - 6:00 PM	1
TOTAL	5



Walnut Street Traffic Assessment

Lynnfield, MA

Figure 5

U-Turns at Sparhawk Drive



**Walnut Street
Traffic Assessment**

Lynnfield, MA

Figure 6

Proposed Improvements
at Sparhawk Drive -
Walnut Street Delineators



**Walnut Street
Traffic Assessment**

Lynnfield, MA

Figure 7

Proposed Improvements
at Sparhawk Drive -
Sparhawk Drive Delineators

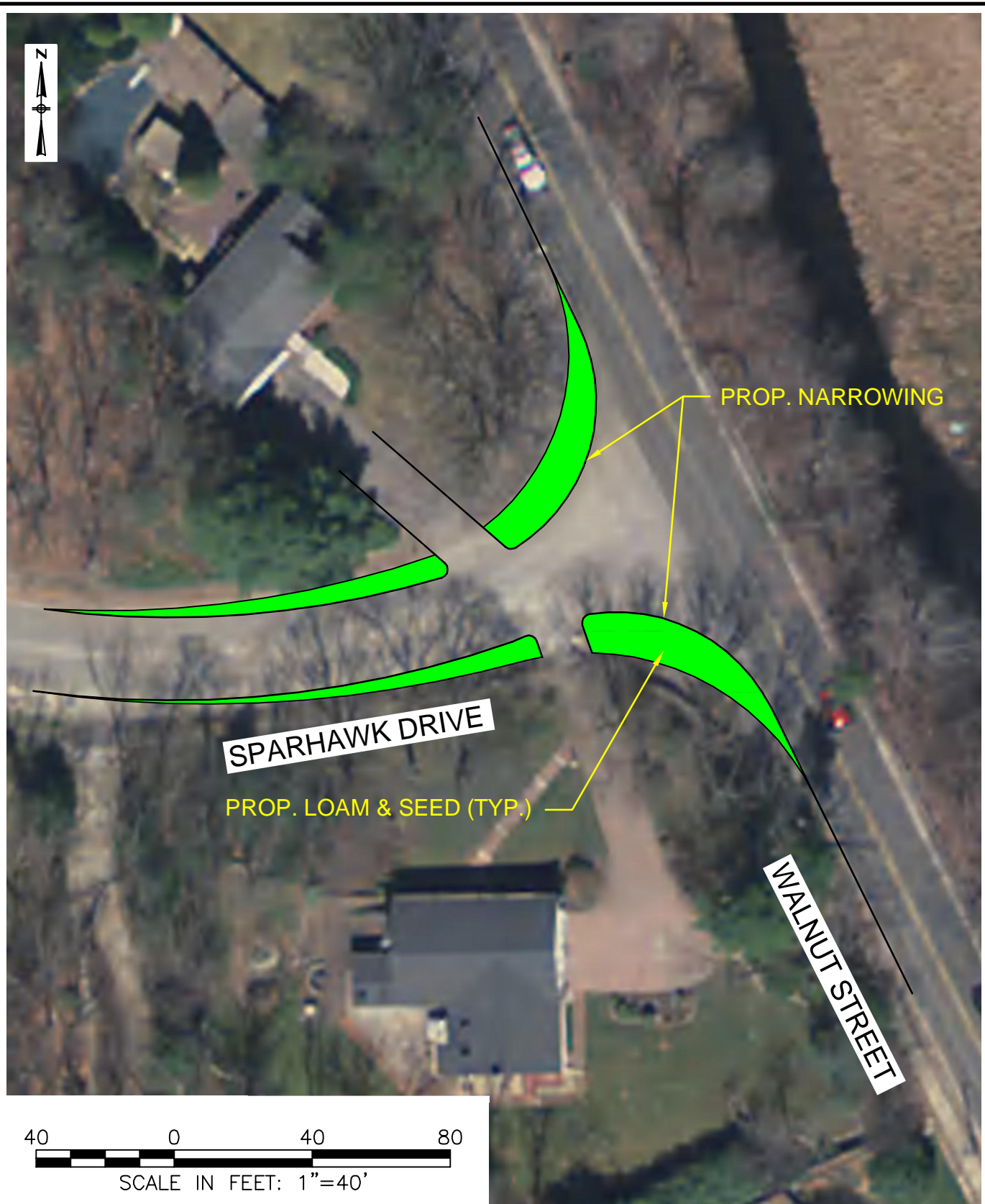


**Walnut Street
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Figure 8

Proposed Improvements
at Sparhawk Drive -
Sparhawk Drive Raised Median



**Walnut Street
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Lynnfield, MA

Figure 9

Proposed Improvements
at Sparhawk Drive -
Narrowing of Sparhawk Drive

Table 1: Office Trip Generation Calculations

Development Type ITE Land Use Code Size	Office 710 70 KSF	Internal Trips	New	75% Split for Walnut St Site Driveway
Weekday Daily	1,014	198	816	612
Weekday Morning				
IN	125	4	121	91
OUT	<u>18</u>	<u>4</u>	<u>14</u>	<u>11</u>
Total	142	8	134	101
Weekday Evening				
IN	27	12	15	11
OUT	<u>132</u>	<u>12</u>	<u>120</u>	<u>90</u>
Total	158	24	134	101
Saturday Daily	169	33	136	102
Saturday Midday				
IN	16	5	11	8
OUT	<u>13</u>	<u>3</u>	<u>10</u>	<u>8</u>
Total	28	8	20	15

Table 2: Retail Trip Generation Calculations

Development Type ITE Land Use Code Size	Retail 820 100 KSF	External Trips	Pass-by	Internal Trips	New	75% Split for Walnut St Site Driveway
Weekday Daily	6,792	6,520	717	272	5,803	4352
Weekday Morning						
IN	96	89	18	7	71	53
OUT	<u>62</u>	<u>57</u>	<u>18</u>	<u>5</u>	<u>39</u>	<u>30</u>
Total	157	145	36	12	109	82
Weekday Evening						
IN	301	287	50	14	237	178
OUT	<u>327</u>	<u>312</u>	<u>50</u>	<u>15</u>	<u>262</u>	<u>197</u>
Total	627	599	100	28	499	374
Saturday Daily	9,240	9,055	335	185	8,720	6540
Saturday Midday						
IN	451	442	25	9	417	313
OUT	<u>416</u>	<u>408</u>	<u>25</u>	<u>8</u>	<u>383</u>	<u>287</u>
Total	866	849	50	17	799	599

Table 3: Walnut Street Traffic Assessment - Lynnfield, MA - Signalized Level of Service Analysis Results

	Existing (2014) - BETA Signalized				Build (2017) - BETA Signalized				Build (2017) - BETA Signalized w/Mitigation: Market Street Protected EBL				Build (2017) - BETA Signalized w/Mitigation: Walnut Street Protected Only SBL at Salem Street			
	AM		PM		AM		PM		AM		PM		AM		PM	
1. Walnut Street @ Market Street/ I-95 SB	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)
Overall	C	32.4			C	23.1			C	33.7			C	30.6		
Walnut Street NBL	D	41.2	0.64	177	B	15.4	0.31	103	D	45.8	0.81	#344	C	26.8	0.64	75
Walnut Street NB	D	45.5	0.41	191	B	17.3	0.62	326	D	39.0	0.38	209	C	27.1	0.76	#300
Walnut Street SBL	C	28.0	0.31	44	C	23.5	0.14	20	C	27.7	0.31	43	C	29.6	0.13	223
Walnut Street SB	D	41.3	0.80	256	C	28.2	0.53	238	D	41.5	0.80	259	D	51.6	0.82	340
Market Street EBL	D	43.5	0.52	41	D	45.0	0.70	121	D	43.3	0.43	49	D	43.7	0.65	22
Market Street EBT	D	40.0	0.18	26	C	33.8	0.36	98	D	42.5	0.31	40	C	28.0	0.39	#296
Market Street EBR	C	31.9	0.06	1	B	18.7	0.19	28	C	30.0	0.06	14	B	14.4	0.40	144
I-95 SB Ramps WBL	B	19.9	0.63	308	C	24.4	0.33	77	C	23.6	0.65	312	C	24.4	0.30	146
I-95 SB Ramps WB	B	13.4	0.20	101	C	26.3	0.48	159	B	16.7	0.26	127	D	49.9	0.85	57
2. Walnut Street @ I-95 NB	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)
Overall	B	15.3			D	54.9			B	15.6			E	74.1		
Walnut Street NB	B	10.9	0.48	95	E	60.2	1.07	#863	B	10.2	0.55	87	D	54.3	1.08	#780
Walnut Street SBL	A	5.8	0.21	43	F	121.8	1.12	#294	A	8.0	0.26	46	F	262.4	1.46	#440
Walnut Street SB	A	9.4	0.61	197	A	6.1	0.28	142	B	10.6	0.62	290	A	9.1	0.38	216
Market Street EBL	D	42.5	0.61	109	D	41.2	0.57	105	D	41.4	0.66	141	D	42.5	0.66	137
Market Street EBR	C	28.3	0.16	40	C	28.4	0.09	31	C	26.0	0.14	35	C	26.7	0.10	30
3. Walnut Street @ Salem Street	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)
Overall	C	28.3			D	38.5			D	40.4			D	54.7		
Walnut Street NB	D	53.3	0.97	#557	E	67.7	1.04	#841	F	119.5	1.18	#940	F	119.5	1.18	#940
Walnut Street SBL	A	8.2	0.13	29	B	11.4	0.31	51	A	10.0	0.15	35	B	12.7	0.43	48
Walnut Street SB	A	7.7	0.39	173	A	8.7	0.21	108	A	8.9	0.39	193	A	8.2	0.25	77
Salem Street EBL	C	24.9	0.37	58	C	27.0	0.66	172	C	25.1	0.42	66	C	26.7	0.65	180
Salem Street EB	C	23.7	0.20	79	C	31.1	0.75	271	C	23.7	0.20	79	C	29.9	0.71	278
Salem Street WBL	C	32.6	0.43	104	D	37.1	0.27	38	C	32.6	0.43	101	D	37.1	0.25	37
Salem Street WBT	E	56.6	0.88	#315	D	39.9	0.57	111	E	56.6	0.88	#313	D	39.5	0.55	111
Salem Street WBR	C	29.9	0.07	38	D	35.9	0.09	46	C	30.0	0.08	44	D	36.1	0.10	54

- 95th percentile volume exceeds capacity, queue may be longer. Queue shown is maximum after two cycles.

Table 4: Walnut Street Traffic Assessment - Lynnfield, MA - Unsignalized Level of Service Analysis Results

	Existing (2014) - BETA Unsignalized								Build (2017) - BETA Unsignalized							
	AM				PM				AM				PM			
4. Walnut Street @ Sparhawk Drive	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)
Walnut Street NB	A	0.0	0.00	0	A	0.1	0.00	0	A	0.0	0.00	0	A	0.1	0.00	0
Walnut Street SB	A	0.0	0.60	0	A	0.0	0.37	0	A	0.0	0.57	0	A	0.0	0.41	0
Sparhawk Drive EB	D	25.3	0.10	8	C	21.8	0.13	11	D	25.1	0.08	6	C	23.8	0.12	10
5. Walnut Street @ Bluejay Road	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)
Walnut Street NB	A	0.3	0.01	1	A	0.3	0.01	1	A	0.3	0.01	1	A	0.3	0.01	1
Walnut Street SB	A	0.0	0.60	0	A	0.0	0.39	0	A	0.0	0.57	0	A	0.0	0.43	0
Bluejay Road EB	D	28.7	0.16	14	C	22.9	0.09	7	D	28.0	0.12	10	C	25.0	0.07	5
6. Walnut Street @ Gianna Drive	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)
Walnut Street NB	A	0.0	0.00	0	A	0.1	0.00	0	A	0.0	0.00	0	A	0.1	0.00	0
Walnut Street SB	A	0.0	0.61	0	A	0.0	0.37	0	A	0.0	0.58	0	A	0.0	0.42	0
Gianna Drive EB	D	31.7	0.15	13	C	19.7	0.03	2	D	30.1	0.10	8	C	21.7	0.01	1

- 95th percentile volume exceeds capacity, queue may be longer. Queue shown is maximum after two cycles.

Table A-1: Walnut Street Traffic Assessment - Lynnfield, MA - Signalized Level of Service Analysis Results

	Existing (2007) - Meadowwalk Unsignalized/Signalized								Existing (2014) - BETA Signalized								Build (2017) - VHB Signalized								Build (2017) - BETA Signalized							
	AM				PM				AM				PM				AM				PM				AM				PM			
1. Walnut Street @ Market Street/ I-95 SB	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)
Overall	-	-			-	-			C	32.4			C	23.1			D	39.1			C	22.2			C	33.7			C	25.4		
Walnut Street NBL	-	-	-	-	-	-	-	-	D	41.2	0.64	177	B	15.4	0.31	103	D	49.1	0.84	#180	B	18.6	0.56	188	D	45.8	0.81	#344	C	22.2	0.57	223
Walnut Street NB	A	2.2	0.06	5	A	0.7	0.02	1	D	45.5	0.41	191	B	17.3	0.62	326	B	14.5	0.19	104	B	14.5	0.25	144	D	39.0	0.38	209	C	20.8	0.68	340
Walnut Street SBL	-	-	-	-	-	-	-	-	C	28.0	0.31	44	C	23.5	0.14	20	C	21.7	0.04	21	C	22.5	0.11	50	C	27.7	0.31	43	C	26.5	0.13	22
Walnut Street SB	A	0.0	0.31	0	A	0.0	0.13	0	D	41.3	0.80	256	C	28.2	0.53	238	D	53.6	0.93	#579	C	27.3	0.44	241	D	41.5	0.80	259	D	35.3	0.64	#296
Market Street EBL	C	18.0	0.02	2	B	13.4	0.07	6	D	43.5	0.52	41	D	45.0	0.70	121	D	50.4	0.48	51	D	44.1	0.71	153	D	43.3	0.43	49	D	47.6	0.75	135
Market Street EBT	-	-	-	-	-	-	-	-	D	40.0	0.18	26	C	33.8	0.36	98	E	60.6	0.67	84	D	44.6	0.76	217	D	42.5	0.31	40	C	33.5	0.52	146
Market Street EBR	B	12.1	0.07	5	B	10.1	0.16	14	C	31.9	0.06	1	B	18.7	0.19	28	D	37.0	0.05	35	C	20.9	0.27	23	C	30.0	0.06	14	B	18.0	0.43	60
I-95 SB Ramps WBL	F	**	2.44	1317	D	30.0	0.50	66	B	19.9	0.63	308	C	24.4	0.33	77	E	59.0	1.00	#565	C	27.1	0.58	109	C	23.6	0.65	312	C	22.9	0.36	75
I-95 SB Ramps WB	B	11.9	0.20	19	B	12.6	0.14	12	B	13.4	0.20	101	C	26.3	0.48	159	B	16.3	0.12	63	C	21.7	0.15	73	B	16.7	0.26	127	C	26.0	0.55	199
2. Walnut Street @ I-95 NB	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)
Overall	-	-			-	-			B	15.3			D	54.9			B	18.6			C	22.8			B	15.6			E	77.8		
Walnut Street NB	A	0.0	0.34	0	A	0.0	0.60	0	B	10.9	0.48	95	E	60.2	1.07	#863	A	8.0	0.52	139	B	19.6	0.85	495	B	10.2	0.55	87	E	62.8	1.08	#780
Walnut Street SBL	-	-	-	-	-	-	-	-	A	5.8	0.21	43	F	121.8	1.12	#294	A	7.7	0.25	27	C	24.4	0.70	#173	A	8.0	0.26	46	F	260.2	1.46	#440
Walnut Street SB	A	2.9	0.09	7	A	3.5	0.12	10	A	9.4	0.61	197	A	6.1	0.28	142	B	12.9	0.88	367	A	9.6	0.40	252	B	10.6	0.62	290	A	7.9	0.38	216
Market Street EBL	F	**	2.07	209	F	212.8	0.98	119	D	42.5	0.61	109	D	41.2	0.57	105	D	40.3	0.55	150	D	38.3	0.66	211	D	41.4	0.66	141	D	42.5	0.66	137
Market Street EBR	F	237.7	1.39	483	C	23.3	0.75	171	C	28.3	0.16	40	C	28.4	0.09	31	D	52.7	0.83	#192	D	44.1	0.83	228	C	26.0	0.14	35	C	26.7	0.10	30
3. Walnut Street @ Salem Street	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)	LOS	Delay	V/C	Queue (95th)
Overall	F	**			F	175.1			C	28.3			D	38.5			E	57.7			D	43.8			D	36.8			D	54.5		
Walnut Street NB	F	**	6.18	#731	F	114.9	1.20	#697	D	53.3	0.97	#557	E	67.7	1.04	#841	F	144.9	1.22	#676	D	46.0	0.96	#758	F	81.9	1.08	#639	F	119.5	1.18	#940
Walnut Street SBL	-	-	-	-	-	-	-	-	A	8.2	0.13	29	B	11.4	0.31	51	B	16.0	0.24	21	F	81.3	1.01	186	A	10.0	0.15	35	B	10.3	0.43	43
Walnut Street SB	E	65.6	1.11	#852	F	**	1.73	#566	A	7.7	0.39	173	A	8.7	0.21	108	B	15.6	0.52	236	B	14.0	0.34	215	A	8.9	0.39	193	A	7.3	0.25	83
Salem Street EBL	-	-	-	-	-	-	-	-	C	24.9	0.37	58	C	27.0	0.66	172	D	49.1	0.50	61	D	38.1	0.75	167	C	25.1	0.42	66	C	26.7	0.65	180
Salem Street EB	B	16.8	0.34	100	F	136.5	1.22	#566	C	23.7	0.20	79	C	31.1	0.75	271	C	22.5	0.29	115	F	84.5	1.04	#473	C	23.7	0.20	79	C	29.9	0.71	278
Salem Street WBL	-	-	-	-	-	-	-	-	C	32.6	0.43	104	D	37.1	0.27	38	C	34.4	0.58	152	D	48.0	0.56	#74	C	32.6	0.43	101	D	37.1	0.25	37
Salem Street WBT	E	58.3	1.00	#541	B	16.8	0.34	135	E	56.6	0.88	#315	D	39.9	0.57	111	F	119.6	1.13	#552	D	40.3	0.53	153	E	56.6	0.88	#313	D	39.5	0.55	111
Salem Street WBR	-	-	-	-	-	-	-	-	C	29.9	0.07	38	D	35.9	0.09	46	C	27.6	0.12	41	D	36.2	0.12	57	C	30.0	0.08	44	D	36.1	0.10	54

- 95th percentile volume exceeds capacity, queue may be longer. Queue shown is maximum after two cycles.

** - Average vehicle delay is greater than 300 seconds per vehicle