

MEMORANDUM

Date: March 15, 2019 Job No.: 6329

To: Jennifer Caira, Chief Planner
City of Newton Planning & Development Department
1000 Commonwealth Avenue
Newton Centre, MA 02459

From: Jeffrey J. Maxtutis, AICP

**Subject: Oak Street Alternatives Access Evaluation
The Northland Newton Development
Newton, Massachusetts**

INTRODUCTION

The Northland Newton Development is proposing a mixed-use development to be located along Needham Street and Oak Street in Newton, Massachusetts. The proposed site plan currently includes a full access driveway on Oak Street. The BETA Group, Inc. was requested by the City of Newton to review the following site access/egress alternatives:

- Alternative 1: No Access/Egress at Oak Street
- Alternative 2: Exit Only from site onto Oak Street
- Alternative 3: Entrance Only from Oak Street into site
- Alternative 4: No Left Turns allowed to exit site driveway onto Oak Street

All other proposed project site access/egress driveways were assumed to remain unchanged for this evaluation. Traffic volumes developed in the following reports were used for this evaluation:

- The Northland Newton Development, Transportation Impact and Access Study, VHB, October 2018
- The Northland Newton Development, Peer Review Response to Comments, Weekday Midday Peak Hour Analyses, VHB, December 10, 2018
- Revised Building Program, The Northland Newton Development, Needham Street, VHB February 14, 2018

Site generated traffic volumes for the weekday AM, Midday and PM peak hours for the 2025 Build condition were re-assigned to the study driveways and intersections for each of the four alternatives. It is noted that Midday peak hour traffic volumes were not available for the Oak Street/Site Driveway and Needham Street/South Site Driveway intersections. Traffic volumes for both the Existing transit mode share (13%) and Robust transit mode share (30%) were analyzed. Intersection capacity analysis was conducted for the following four study intersections:

- Oak Street/Project Site Driveway
- Needham Street/Oak Street/Christina Street
- Needham Street/South Project Site Driveway (Main Street)
- Needham Street/Charlemont Street/North Site Driveway

Analysis details are provided in the Appendix.

EVALUATION

Peak hour traffic volumes to and from the Oak Street project site driveway under the Build 2025 condition were re-assigned to the four study intersections for each of the access alternatives. The peak project vehicle trips at the Oak Street project site driveway for the Build 2025 condition are shown below.

	Existing Mode Split			Robust Mode Split		
	In	Out	Total	In	Out	Total
AM	82	66	148	62	50	112
Mid-Day	65	62	127	46	48	94
PM	113	137	250	102	121	223

Project-generated vehicle trips that entered or exited from/to Oak Street were shifted to the Needham Street South Project Driveway (Main Street) and the Needham Street North Project Driveway (Charlemont Street) for each alternative. In general, the access alternatives would increase traffic volumes through the intersection of Needham Street/Oak Street/Christina Drive. The Oak Street eastbound left-through movement and the Needham Street southbound through-right movement are critical intersection movements that would experience traffic volume increases which exacerbate delay and queueing (see below). It is noted that eliminating or restricting the project access at Oak Street would not change the traffic volumes traveling on Oak Street.

Intersection capacity analysis was performed for each of the four Oak Street access alternatives for Build 2025 weekday AM, Midday and PM peak hours. The analysis results were compared with the Build 2025 condition capacity results with the proposed full access driveway at Oak Street (as reported in the Transportation Impact and Access Study and Revised Building Program Memo).

Table 1 summarizes LOS and vehicle delay results for Oak Street access alternatives with the Existing Mode Splits for the project. The results for the Robust Mode Split are similar and are provided in the Appendix. Volume-to-capacity ratios and vehicle queue length results are also presented in the Appendix for both the Existing and Robust Mode Split conditions.

The signalized intersection of **Needham Street/Oak Street/Christina Drive** would experience the largest impacts as a result of the Oak Street access alternatives. In the PM peak hour, overall intersection LOS would deteriorate to LOS F from LOS E in the Build 2025 condition for all alternatives. Overall intersection vehicle delays would increase between 44 and 64 seconds. Individual intersection movements such as the Oak Street eastbound left-through and Needham Street southbound through-right movements would experience even more significant increases in delay. In the Midday peak hour, the intersection of Needham Street/Oak Street/Christina Drive would continue to operate at LOS F for all alternatives with delay increases ranging from 38 to 47 seconds. In the AM peak hour for the Alternative 1 – No Access at Oak Street, the intersection of Needham Street/Oak Street/Christina Drive would deteriorate from LOS E to LOS F with a 36 second delay increase. The intersection would remain operating at LOS E overall for all other alternatives with delay increases ranging between 11 and 22 seconds.

The signalized intersection of **Needham Street/Charlemont Street/North Site Driveway** would also experience degradation in LOS and increased delay as a result of the Oak Street access alternatives. In the Midday and PM peak hours, LOS would deteriorate from LOS C to LOS D for all alternatives.

Overall intersection delay would increase from 16 to 27 seconds. In the AM peak hour, LOS would remain at LOS B for all alternatives.

The eastbound driveway approach at the unsignalized intersection of **Needham Street/South Site Driveway** would remain operating at LOS F during the PM peak hour with an additional 49 seconds of delay under Alternative 1 – No Access to Oak Street. Delay would not change significantly as a result of the other alternatives for the PM peak hour. In the AM peak hour, all alternatives would improve from LOS D to LOS C.

The unsignalized intersection of Oak Street/Site Driveway would improve under all alternatives as a result of eliminating some or all vehicle movements to and from the site driveway.

SUMMARY

The following study intersections would experience significant impacts in Level of Service and delay as a result of the four Oak Street driveway access/egress alternatives.

Needham Street/Oak Street/Christina Drive

- LOS F for all alternatives in the Midday and PM peak hours, delay increases between 38 and 64 seconds
- LOS F for Alternative 1 in the AM Peak hour, delay increases 36 seconds
- Individual intersection movements such as the Oak Street eastbound left-through and Needham Street southbound through-right movements would experience even more significant increases in delay

Needham Street/Charlemont Street/North Site Driveway

- LOS degrades from LOS C to LOS D for all alternatives in the Midday and PM peak hours, delay increases between 16 to 27 seconds


Needham Street/South Site Driveway

- LOS F for Alternative 1 in the PM peak hour, delay increases 49 seconds

The intersection of **Oak Street/Site Driveway** would improve under all alternatives as a result of eliminating some or all vehicle movements to and from the site driveway. Eliminating or restricting the project access at Oak Street would not change the traffic volumes traveling on Oak Street.

Table 1 - Level of Service Summary - Existing Mode Splits

Intersection	Build 2005		Alternative 1: No Access		Alternative 2: Exit Only		Alternative 3: Enter Only		Alternative 4: No Left-Turns Out	
	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
Oak Street and Site Driveway (South Bound Driveway Approach)										
AM	C	20	--	--	C	17	--	--	B	12
PM	D	26	--	--	C	20	--	--	B	12
Needham Street, Oak Street, and Christina Drive										
AM	E	58	F	94	E	69	E	80	E	75
Mid-Day	F	89	F	136	F	130	F	130	F	127
PM	E	62	F	126	F	108	F	115	F	106
Needham Street, South Site Driveway (East Bound Driveway Approach)										
AM	D	31	C	23	C	20	C	23	C	21
PM	F	53	F	102	E	38	E	45	F	53
Needham Street, Charlemont Street and North Site Driveway										
AM	B	16	B	18	B	18	B	15	B	15
Mid-Day	C	24	D	50	D	51	D	47	D	47
PM	C	21	D	41	D	41	D	37	D	37

 Deterioration in LOS or Significant Increase in Delay

APPENDIX

- Level of Service Summary – Robust Mode Splits
- Intersection Operational Analysis Summary: 2025 Build Traffic-Volume Conditions with Oak Street Access Alternatives (with Existing and Robust Mode Splits)

Level of Service Summary – Robust Mode Splits

Intersection	Build 2005		Alternative 1: No Access		Alternative 2: Exit Only		Alternative 3: Enter Only		Alternative 4: No Left-Turns Out	
	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
Oak Street and Site Driveway (South Bound Driveway Approach)										
AM	C	18	--	--	C	16	--	--	B	11
PM	C	23	--	--	C	18	--	--	B	12
Needham Street, Oak Street, and Christina Drive										
AM	E	57	F	85	E	77	E	71	E	68
Mid-Day	N/A	N/A	F	128	F	124	F	128	F	129
PM	E	67	F	117	F	104	F	107	F	95
Needham Street, South Site Driveway (East Bound Driveway Approach)										
AM	D	30	C	22	C	19	C	23	C	20
PM	E	47	F	72	D	35	F	66	E	43
Needham Street, Charlemont Street and North Site Driveway										
AM	B	15	B	14	B	16	B	14	B	14
Mid-Day	N/A	N/A	D	46	D	46	D	43	D	43
PM	C	29	D	38	D	39	D	35	C	35

Deterioration in LOS or Significant Increase in Delay

Intersection Operational Analysis Summary: 2025 Build Traffic-Volume Conditions with Oak Street Access Alternatives (with Existing Mode Splits)

Intersection/Peak Hour/Lane Group or Critical Movement	VHB's Traffic Study RTC ^a					Alternative 1: No Access					Alternative 2: Exit Only					Alternative 3: Enter Only					Alternative 4: No Left-Turns Out				
	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue
5. Oak Street and Site Driveway																									
Weekday AM Peak Hour:																									
Oak St EB L	A	8.6	0.04	--	2	--	--	--	--	--	--	--	--	--	--	A	1.2	0.04	--	3	A	1.2	0.04	--	3
Site Driveway SB Approach	C	19.7	0.24	--	22	--	--	--	--	--	C	16.6	0.16	--	14	--	--	--	--	--	B	11.5	0.06	--	4
Weekday PM Peak Hour:																									
Oak St EB L	A	8.6	0.06	--	5	--	--	--	--	--	--	--	--	--	--	A	1.4	0.05	--	4	A	1.6	0.06	--	5
Site Driveway SB Approach	D	25.5	0.47	--	60	--	--	--	--	--	C	20.2	0.39	--	46	--	--	--	--	--	B	11.9	0.12	--	10
6. Needham Street, Oak Street, and Christina Street																									
Weekday AM Peak Hour:																									
Oak St EB L/T	F	203.3	1.30	~286	#478	F	336.7	1.60	~351	#533	F	233.3	1.36	~290	#466	F	227.1	1.34	~282	#457	F	227.1	1.34	~282	#457
Oak St EB R	A	7.9	0.26	21	73	C	27.6	0.16	24	72	C	27.9	0.17	22	74	C	27.0	0.14	17	63	C	27.0	0.14	17	63
Christina St WB L	E	64.8	0.73	99	#224	F	131.8	1.04	~117	#248	F	83.0	0.89	105	#229	E	75.9	0.86	104	#225	E	75.9	0.86	104	#225
Christina St WB T/R	D	43.8	0.52	158	267	D	41.8	0.61	173	264	D	41.5	0.60	169	259	D	41.5	0.60	171	262	D	41.5	0.60	171	262
Needham St NB L	E	55.2	0.81	85	#225	D	49.1	0.75	63	#159	D	45.8	0.73	58	#146	E	75.3	0.90	95	#233	E	75.3	0.90	95	#233
Needham St NB T/R	C	24.2	0.81	497	877	C	32.8	0.93	635	#1,003	C	32.8	0.93	635	#1,003	C	27.2	0.89	571	#929	C	27.2	0.89	571	#929
Needham St SB L	C	24.4	0.24	14	45	B	18.4	0.31	17	49	B	17.7	0.27	14	42	B	17.7	0.26	16	44	B	17.7	0.26	16	44
Needham St SB T/R	E	62.7	0.97	629	#1,053	F	107.3	1.14	~866	#1,120	E	78.5	1.06	~768	#1,018	F	113.3	1.16	~866	#1,120	F	98.8	1.12	~822	#1,074
Overall Intersection	E	57.9	--	--	--	F	94.0	--	--	--	E	69.4	--	--	--	E	80.0	--	--	--	E	75.1	--	--	--
Weekday Midday Peak Hour:																									
Oak St EB L/T	F	185.0	1.28	~288	#491	F	232.1	1.38	~312	#492	F	250.4	1.42	~334	#514	F	199.8	1.30	~288	#465	F	199.8	1.30	~288	#465
Oak St EB R	A	9.3	0.33	28	82	C	24.0	0.18	26	73	C	24.4	0.23	35	89	C	23.8	0.18	24	70	C	23.8	0.18	24	70
Christina St WB L	F	170.3	1.17	~116	#255	F	206.4	1.26	~123	#249	F	266.5	1.40	~131	#258	F	164.0	1.15	~115	241	F	164.0	1.15	~115	#241
Christina St WB T/R	D	35.4	0.46	111	194	C	33.9	0.46	100	171	C	33.9	0.46	100	171	C	33.9	0.46	104	176	C	33.9	0.46	104	176
Needham St NB L	D	51.5	0.83	81	#222	D	46.6	0.79	67	#179	D	46.6	0.79	67	#179	F	88.3	0.98	99	#252	F	88.3	0.98	99	#252
Needham St NB T/R	C	27.7	0.88	491	#965	D	50.2	1.01	~708	#1,017	D	50.2	1.01	~708	#1,017	D	39.5	0.97	605	#953	D	39.5	0.97	605	#953
Needham St SB L	E	70.4	0.70	27	#107	D	43.0	0.66	21	#87	F	80.0	0.83	30	#112	D	54.4	0.77	37	#127	D	54.4	0.77	37	#127
Needham St SB T/R	F	137.6	1.22	~879	#1,207	F	231.6	1.44	~1,051	#1,306	F	204.7	1.38	~981	#1,234	F	233.3	1.44	~1,051	#1,306	F	226.7	1.43	~1,034	#1,289
Overall Intersection	F	88.5	--	--	--	F	136.1	--	--	--	F	130.0	--	--	--	F	129.9	--	--	--	F	127.3	--	--	--
Weekday PM Peak Hour:																									
Oak St EB L/T	F	130.8	1.12	~270	#475	F	263.5	1.44	~363	#550	F	283.5	1.49	~386	#576	F	182.2	1.24	~295	#474	F	214.0	1.32	~335	#520
Oak St EB R	B	10.6	0.33	34	93	C	27.5	0.18	33	83	C	28.2	0.24	47	107	C	27.3	0.17	27	76	C	28.6	0.28	52	122
Christina St WB L	F	88.8	0.86	96	#225	F	164.1	1.12	~115	#242	F	209.4	1.24	~123	#251	F	90.1	0.90	97	#220	F	138.9	1.05	~109	#237
Christina St WB T/R	D	39.0	0.42	118	200	D	38.6	0.47	124	201	D	38.6	0.47	124	201	D	38.7	0.48	127	204	D	38.7	0.48	127	204
Needham St NB L	E	55.3	0.82	89	#226	D	54.4	0.80	75	#189	D	54.4	0.80	75	#189	F	93.6	0.97	108	#262	F	93.6	0.97	108	#262
Needham St NB T/R	C	22.3	0.78	453	800	C	28.4	0.90	594	#959	C	28.4	0.90	594	#959	C	24.5	0.87	542	#833	C	24.5	0.87	542	#833
Needham St SB L	C	25.1	0.31	21	59	C	21.8	0.48	31	84	B	19.4	0.36	22	59	C	20.0	0.40	30	75	C	20.0	0.40	30	75
Needham St SB T/R	F	92.7	1.11	~887	#1,217	F	210.7	1.39	~1,186	#1,448	F	151.6	1.25	~1,008	#1,266	F	209.2	1.38	~1,179	#1,440	F	177.7	1.31	~1,087	#1,347
Overall Intersection	E	62.4	--	--	--	F	126.4	--	--	--	F	107.8	--	--	--	F	114.7	--	--	--	F	105.8	--	--	--
^a Unsignalized intersection results from VHB's TIAS, signalized intersection results from VHB's 2/14/19 Revised Building Program and Trip Generation Memorandum.																									
~ volume exceeds capacity, queue is theoretically infinite and blocking problems may occur. Queue shown is maximum after 2 cycles.																									
# 95 th percentile volume exceeds capacity, queue may be longer. Queue shown is maximum after 2 cycles. Value is valid if v/c ratio <1.00.																									

Table 1 (continued) – Intersection Operational Analysis Summary: 2025 Build Traffic-Volume Conditions with Oak Street Access Alternatives (with Existing Mode Splits)

Intersection/Peak Hour/Lane Group or Critical Movement	VHB's Traffic Study & RTC ^a					Alternative 1: No Access					Alternative 2: Exit Only					Alternative 3: Enter Only					Alternative 4: No Left-Turns Out				
	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue
7. Needham Street and South Site Driveway (Main Street)																									
Weekday AM Peak Hour:																									
Site Driveway EB Approach	D	30.8	0.34	--	35	C	23.0	0.35	--	39	C	19.6	0.22	--	21	C	23.0	0.35	--	39	C	21.3	0.30	--	30
Needham St NB L	A	9.9	0.03	--	2	B	11.3	0.05	--	4	B	10.9	0.05	--	4	B	11.1	0.04	--	3	B	10.9	0.04	--	3
Weekday PM Peak Hour:																									
Site Driveway EB Approach	F	52.5	0.72	--	122	F	101.8	1.01	--	249	E	38.1	0.65	--	106	E	45.3	0.78	--	156	F	53.0	0.78	--	148
Needham St NB L	B	10.5	0.06	--	5	B	13.4	0.13	--	11	B	12.5	0.12	--	10	B	11.8	0.08	--	7	B	12.8	0.10	--	9
9. Needham Street, Charlemont Street, and North Site Driveway (Charlemont Street Extension)																									
Weekday AM Peak Hour:																									
Site Driveway EB L	D	37.3	0.34	26	49	D	42.3	0.47	28	64	D	42.3	0.47	28	64	D	40.4	0.47	27	63	D	40.5	0.47	27	63
Site Driveway EB T/R	A	0.4	0.10	0	0	D	38.0	0.05	0	0	D	37.9	0.03	0	0	D	36.3	0.05	0	0	D	36.3	0.04	0	0
Charlemont St WB L	D	35.5	0.20	14	37	D	39.7	0.25	14	39	D	39.6	0.24	14	39	D	37.9	0.24	13	38	D	37.9	0.24	13	38
Charlemont St WB T/R	A	0.2	0.04	0	0	D	37.8	0.01	0	0	D	37.8	0.01	0	0	D	36.1	0.01	0	0	D	36.2	0.01	0	0
Needham St NB L	A	9.9	0.19	8	46	C	20.1	0.38	19	69	C	20.1	0.38	19	69	B	14.6	0.23	10	41	B	14.5	0.23	10	41
Needham St NB T/R	B	12.6	0.63	154	#727	A	9.4	0.70	181	#582	A	9.4	0.70	181	#582	A	9.8	0.71	179	#603	A	9.8	0.71	179	#603
Needham St SB L	A	8.8	0.06	3	14	B	12.7	0.09	3	13	B	12.7	0.09	3	13	B	11.1	0.08	3	12	B	11.1	0.08	3	12
Needham St SB T/R	B	18.0	0.70	267	#708	C	22.1	0.84	348	#675	C	22.1	0.84	348	#675	B	16.6	0.79	312	#660	B	16.4	0.79	312	#660
Overall Intersection	B	15.5	--	--	--	B	17.9	0.85	--	--	B	17.6	0.85	--	--	B	15.3	0.82	--	--	B	15.0	0.82	--	--
Weekday Midday Peak Hour:																									
Site Driveway EB L	D	51.9	0.67	70	138	E	58.5	0.82	114	#210	E	58.5	0.82	114	#210	E	56.1	0.81	110	#210	E	56.1	0.81	110	#210
Site Driveway EB T/R	A	0.5	0.13	0	0	C	34.6	0.07	0	0	C	34.4	0.05	0	0	C	33.7	0.07	0	0	C	33.7	0.07	0	0
Charlemont St WB L	D	35.2	0.22	21	53	D	35.6	0.19	22	52	D	35.5	0.19	22	52	C	34.7	0.19	21	52	C	34.7	0.19	21	52
Charlemont St WB T/R	B	18.7	0.16	7	37	C	34.5	0.07	8	37	C	34.5	0.07	8	37	C	33.7	0.07	8	37	C	33.7	0.07	8	37
Needham St NB L	B	19.9	0.37	12	49	D	38.7	0.61	62	#193	D	38.7	0.61	62	#193	D	36.1	0.45	26	94	D	36.1	0.45	26	94
Needham St NB T/R	B	16.0	0.74	248	#829	B	16.9	0.79	331	#786	B	16.9	0.79	331	#786	B	17.3	0.80	328	#786	B	17.3	0.80	328	#786
Needham St SB L	A	9.8	0.02	1	7	C	20.4	0.05	2	7	C	20.4	0.05	2	7	B	19.8	0.05	1	7	B	19.8	0.05	1	7
Needham St SB T/R	C	28.5	0.88	426	#929	F	85.0	1.10	~709	#963	F	85.0	1.10	~709	#963	E	76.3	1.08	~667	#963	E	76.3	1.08	~667	#963
Overall Intersection	C	23.6	--	--	--	D	50.4	1.06	--	--	D	50.6	--	--	--	D	46.8	--	--	--	D	46.9	--	--	--
Weekday PM Peak Hour:																									
Site Driveway EB L	D	52.0	0.68	73	141	E	60.8	0.83	118	#218	E	60.0	0.83	118	#218	E	58.1	0.82	114	#218	E	58.1	0.82	114	#218
Site Driveway EB T/R	A	0.5	0.14	0	0	C	34.9	0.10	0	0	C	34.6	0.06	0	0	C	34.0	0.10	0	0	C	33.8	0.08	0	0
Charlemont St WB L	C	34.5	0.19	18	48	D	35.9	0.20	20	49	D	35.5	0.17	20	48	C	34.9	0.20	19	48	C	34.6	0.17	19	48
Charlemont St WB T/R	B	18.5	0.15	8	37	C	34.7	0.07	8	37	C	34.7	0.07	8	37	C	33.7	0.07	8	37	C	33.7	0.07	8	37
Needham St NB L	B	13.5	0.26	11	45	D	39.9	0.65	73	#219	D	40.0	0.64	73	#219	C	34.7	0.42	25	89	C	34.7	0.42	25	89
Needham St NB T/R	B	14.4	0.68	214	#719	B	14.5	0.72	282	604	B	14.6	0.72	282	604	B	14.7	0.73	281	604	B	14.7	0.73	281	604
Needham St SB L	A	9.8	0.02	1	7	B	18.3	0.04	2	7	B	18.4	0.04	2	7	B	17.5	0.04	1	7	B	17.5	0.04	1	7
Needham St SB T/R	C	24.1	0.82	371	#808	E	62.0	1.03	~568	#860	E	62.8	1.03	~568	#860	D	54.2	1.00	526	#860	D	54.2	1.00	526	#860
Overall Intersection	C	20.9	--	--	--	D	40.8	--	--	--	D	41.2	--	--	--	D	37.2	--	--	--	D	37.2	--	--	--
^a Unsignalized intersection results from VHB's TIAS, signalized intersection results from VHB's 2/14/19 Revised Building Program and Trip Generation Memorandum.																									
~ volume exceeds capacity, queue is theoretically infinite and blocking problems may occur. Queue shown is maximum after 2 cycles.																									
# 95 th percentile volume exceeds capacity, queue may be longer. Queue shown is maximum after 2 cycles. Value is valid if v/c ratio <1.00.																									

Table 2 – Intersection Operational Analysis Summary: 2025 Build Traffic-Volume Conditions with Oak Street Access Alternatives (with Robust Shuttle)

Intersection/Peak Hour/Lane Group or Critical Movement	VHB's Traffic Study ^a					Alternative 1: No Access					Alternative 2: Exit Only					Alternative 3: Enter Only					Alternative 4: No Left-Turns Out				
	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue
5. Oak Street and Site Driveway																									
Weekday AM Peak Hour:																									
Oak St EB L	A	8.5	0.03	--	2	--	--	--	--	--	--	--	--	--	--	A	1.0	0.03	--	3	A	0.9	0.03	--	2
Site Driveway SB Approach	C	17.7	0.18	--	15	--	--	--	--	--	C	16.4	0.16	--	14	--	--	--	--	--	B	11.4	0.05	--	4
Weekday PM Peak Hour:																									
Oak St EB L	A	8.6	0.05	--	5	--	--	--	--	--	--	--	--	--	--	A	1.2	0.04	--	3	A	1.2	0.04	--	3
Site Driveway SB Approach	C	22.8	0.40	--	48	--	--	--	--	--	C	17.9	0.28	--	28	--	--	--	--	--	B	11.8	0.11	--	9
6. Needham Street, Oak Street, and Christina Street																									
Weekday AM Peak Hour:																									
Oak St EB L/T	F	203.0	1.30	~286	#478	F	283.5	1.48	~333	#513	F	286.0	1.49	~341	#523	F	201.4	1.28	~275	#449	F	201.4	1.28	~275	#449
Oak St EB R	A	7.9	0.26	21	71	C	27.2	0.16	24	72	C	27.7	0.18	28	79	C	27.0	0.14	17	63	C	27.0	0.14	17	63
Christina St WB L	E	64.7	0.73	99	#224	F	124.7	1.01	~110	#244	F	129.1	1.03	~116	#247	E	75.9	0.86	104	#225	E	75.9	0.86	104	#225
Christina St WB T/R	D	43.8	0.52	158	267	D	40.8	0.57	161	249	D	40.3	0.57	161	249	D	40.6	0.57	161	248	D	40.6	0.57	161	248
Needham St NB L	D	52.7	0.79	81	#215	E	63.5	0.85	85	#212	D	44.2	0.72	58	#146	E	63.5	0.85	85	#212	E	63.0	0.85	85	#212
Needham St NB T/R	C	23.6	0.81	485	854	C	28.3	0.90	586	#948	C	28.6	0.91	586	#948	C	25.5	0.88	549	#903	C	25.5	0.88	549	#903
Needham St SB L	C	23.6	0.23	14	44	B	17.9	0.27	16	45	B	17.1	0.23	14	39	B	17.4	0.24	16	43	B	17.4	0.24	16	43
Needham St SB T/R	E	60.6	0.97	623	#1,043	F	100.3	1.12	~822	#1,075	E	74.9	1.05	~743	#993	F	97.3	1.11	~811	#1,063	F	86.9	1.09	~776	#1,028
Overall Intersection	E	57.2	--	--	--	F	85.0	1.28	--	--	E	77.2	1.25	--	--	E	71.2	1.22	--	--	E	67.7	1.20	--	--
Weekday Midday Peak Hour:																									
Oak St EB L/T	F	217.5	1.36	~309	#515	F	244.0	1.40	~301	#478	F	263.3	1.45	~322	#500	F	249.4	1.42	~309	#485	F	249.4	1.42	~309	#485
Oak St EB R	A	9.7	0.34	31	87	C	23.9	0.18	24	70	C	24.2	0.22	31	84	C	23.9	0.19	25	72	C	23.9	0.18	25	72
Christina St WB L	F	203.2	1.26	~122	#262	F	164.0	1.15	~115	#241	F	210.8	1.27	~123	#250	F	178.1	1.19	~118	#244	F	178.1	1.19	~118	#244
Christina St WB T/R	D	35.9	0.49	118	204	C	34.7	0.52	116	194	C	34.7	0.52	116	194	C	34.8	0.52	120	198	C	34.8	0.52	120	198
Needham St NB L	C	58.9	0.88	89	#241	D	46.6	0.79	67	#179	D	48.9	0.81	70	#186	F	81.3	0.96	95	#244	F	81.3	0.96	95	#244
Needham St NB T/R	E	28.8	0.89	508	#990	D	45.9	1.00	647	#993	D	45.9	1.00	647	#993	D	37.1	0.96	588	#937	D	44.7	0.99	640	#985
Needham St SB L	F	91.9	0.79	29	#113	F	88.3	0.88	37	#127	D	49.4	0.72	28	#105	D	35.1	0.66	32	#110	E	77.1	0.84	36	#125
Needham St SB T/R	F	142.2	1.23	~894	#1,224	F	216.7	1.41	~1,012	#1,267	F	197.5	1.36	~958	#1,210	F	218.4	1.41	~1,012	#1,267	F	214.8	1.40	~1,005	#1,260
Overall Intersection	F	95.8	--	--	--	F	127.9	1.47	--	--	F	123.8	1.45	--	--	F	128.3	1.47	--	--	F	129.3	1.47	--	--
Weekday PM Peak Hour:																									
Oak St EB L/T	F	154.9	1.19	~293	#500	F	256.6	1.42	~360	#547	F	283.6	1.49	~386	#576	F	182.2	1.24	~295	#474	F	182.2	1.24	~295	#474
Oak St EB R	B	11.1	0.34	37	97	C	27.5	0.19	34	85	C	28.1	0.24	46	105	C	27.3	0.17	28	78	C	27.3	0.17	28	78
Christina St WB L	F	101.7	0.92	97	232	F	160.6	1.11	~114	#242	F	209.5	1.24	~124	#252	F	90.1	0.90	97	#220	F	90.1	0.90	97	#220
Christina St WB T/R	D	39.4	0.45	125	210	D	38.6	0.47	124	201	D	38.6	0.47	124	201	D	38.7	0.48	127	204	D	38.7	0.48	127	204
Needham St NB L	E	62.8	0.87	98	#248	D	54.4	0.80	75	#189	D	54.0	0.79	75	#189	F	86.3	0.95	104	#254	F	86.3	0.95	104	#254
Needham St NB T/R	C	23.0	0.79	469	#832	C	28.0	0.90	587	#949	C	26.1	0.88	563	#920	C	23.8	0.86	527	#779	C	23.8	0.86	527	#779
Needham St SB L	C	26.5	0.33	22	61	C	21.5	0.47	31	82	B	18.7	0.33	22	56	B	19.7	0.39	30	73	B	19.7	0.39	30	73
Needham St SB T/R	F	94.7	1.11	~895	#1,225	F	190.8	1.34	~1,125	#1,386	F	141.2	1.22	~972	#1,229	F	192.3	1.34	~1,125	#1,386	F	160.5	1.27	~1,033	#1,291
Overall Intersection	E	66.8	--	--	--	F	117.3	1.40	--	--	F	104.0	1.34	--	--	F	107.2	1.34	--	--	F	94.7	1.30	--	--
^a Unsignalized and signalized intersection results from VHB's TIAS. Weekday Midday from VHB's 12/10/18 Peer Review Response to Comments Memorandum.																									
~ volume exceeds capacity, queue is theoretically infinite and blocking problems may occur. Queue shown is maximum after 2 cycles.																									
# 95 th percentile volume exceeds capacity, queue may be longer. Queue shown is maximum after 2 cycles. Value is valid if v/c ratio <1.00.																									

Table 2 (continued) – Intersection Operational Analysis Summary: 2025 Build Traffic-Volume Conditions with Oak Street Access Alternatives (with Robust Shuttle)

Intersection/Peak Hour/Lane Group or Critical Movement	VHB's Traffic Study ^a					Alternative 1: No Access					Alternative 2: Exit Only					Alternative 3: Enter Only					Alternative 4: No Left-Turns Out				
	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue	LOS	Delay	v/c	50th % Queue	95th % Queue
7. Needham Street and South Site Driveway (Main Street)																									
Weekday AM Peak Hour:																									
Site Driveway EB Approach	D	30.3	0.30	--	30	C	21.9	0.29	--	29	C	18.6	0.19	--	17	C	23.3	0.31	--	32	C	20.2	0.24	--	23
Needham St NB L	A	9.8	0.03	--	2	B	11.0	0.05	--	4	B	10.8	0.04	--	3	B	11.3	0.04	--	3	B	10.8	0.03	--	3
Weekday PM Peak Hour:																									
Site Driveway EB Approach	E	46.8	0.67	--	105	F	72.1	0.89	--	197	D	34.8	0.62	--	96	F	66.2	0.87	--	184	E	43.2	0.70	--	120
Needham St NB L	B	10.4	0.06	--	50	B	12.0	0.11	--	9	B	12.3	0.12	--	10	B	12.9	0.11	--	9	B	12.6	0.10	--	8
9. Needham Street, Charlemont Street, and North Site Driveway (Charlemont Street Extension)																									
Weekday AM Peak Hour:																									
Site Driveway EB L	D	36.6	0.33	25	48	D	39.4	0.39	20	53	D	39.9	0.40	21	54	D	39.6	0.40	20	53	D	39.7	0.40	20	53
Site Driveway EB T/R	A	0.4	0.09	0	0	D	36.2	0.03	0	0	D	36.5	0.02	0	0	D	36.3	0.03	0	0	D	36.3	0.03	0	0
Charlemont St WB L	C	34.8	0.20	13	37	D	38.0	0.25	13	38	D	38.3	0.25	13	39	D	38.1	0.26	13	38	D	38.1	0.25	13	38
Charlemont St WB T/R	A	0.2	0.04	0	0	D	36.0	0.01	0	0	D	36.4	0.01	0	0	D	36.1	0.01	0	0	D	36.2	0.01	0	0
Needham St NB L	A	9.4	0.17	7	41	B	12.8	0.18	8	34	B	16.6	0.29	14	53	B	12.5	0.17	7	32	B	12.5	0.17	7	32
Needham St NB T/R	B	12.7	0.63	154	#725	A	9.6	0.71	170	#582	A	9.4	0.70	172	557	A	9.5	0.71	170	#589	A	9.4	0.71	170	#589
Needham St SB L	A	8.7	0.06	3	13	B	10.8	0.08	3	11	B	12.3	0.09	3	12	B	10.7	0.08	3	11	B	10.6	0.08	3	11
Needham St SB T/R	B	17.6	0.69	259	#685	B	15.2	0.77	293	533	C	20.2	0.82	302	#601	B	15.1	0.77	293	528	B	14.9	0.76	293	528
Overall Intersection	B	15.4	--	--	--	B	14.1	0.80	--	--	B	16.2	0.84	--	--	B	14.0	0.80	--	--	B	13.8	0.79	--	--
Weekday Midday Peak Hour:																									
Site Driveway EB L	E	58.2	0.77	100	#202	D	54.8	0.79	105	#193	D	54.8	0.79	105	#193	D	54.1	0.78	101	#193	D	54.2	0.78	101	#193
Site Driveway EB T/R	A	0.6	0.15	0	0	C	34.2	0.07	0	0	C	34.1	0.05	0	0	C	33.9	0.07	0	0	C	33.9	0.06	0	0
Charlemont St WB L	C	34.4	0.19	21	54	D	35.3	0.19	22	52	D	35.2	0.19	22	52	C	35.0	0.19	21	52	D	35.0	0.19	21	52
Charlemont St WB T/R	B	18.2	0.13	8	37	C	34.2	0.07	8	37	C	34.2	0.07	8	37	C	33.9	0.07	8	37	C	34.0	0.07	8	37
Needham St NB L	C	34.6	0.57	20	84	D	36.4	0.52	38	#131	D	36.4	0.52	38	#131	D	35.9	0.41	21	80	D	35.9	0.40	21	80
Needham St NB T/R	B	17.4	0.75	296	#814	B	16.6	0.79	316	#786	B	16.6	0.79	316	#786	B	16.7	0.79	312	#786	B	16.7	0.79	312	#786
Needham St SB L	B	11.4	0.03	1	7	B	19.5	0.05	1	7	B	19.5	0.05	1	7	B	19.1	0.05	1	7	B	19.1	0.05	1	7
Needham St SB T/R	D	49.0	0.99	532	#1,001	E	74.5	1.07	~671	#957	E	74.5	1.07	~671	#957	E	67.8	1.05	~589	#957	E	68.2	1.06	~589	#957
Overall Intersection	C	34.3	--	--	--	D	45.6	1.04	--	--	D	45.8	1.04	--	--	D	43.0	1.03	--	--	D	43.2	1.04	--	--
Weekday PM Peak Hour:																									
Site Driveway EB L	E	59.1	0.79	104	#210	E	57.5	0.81	110	#199	E	57.6	0.81	110	#199	E	55.5	0.80	105	#199	E	55.6	0.80	105	#199
Site Driveway EB T/R	A	0.6	0.17	0	0	C	34.9	0.09	0	0	C	34.7	0.06	0	0	C	34.0	0.09	0	0	C	34.0	0.07	0	0
Charlemont St WB L	C	34.2	0.16	19	50	D	35.9	0.19	20	48	D	35.7	0.17	20	48	C	34.9	0.18	19	48	C	34.8	0.17	19	48
Charlemont St WB T/R	B	18.2	0.13	8	37	C	34.8	0.07	8	37	C	34.8	0.07	8	37	C	33.9	0.07	8	37	C	34.0	0.07	8	37
Needham St NB L	C	33.0	0.54	21	83	D	37.9	0.62	65	#202	D	37.9	0.61	65	#202	C	33.5	0.39	22	80	C	33.6	0.39	22	80
Needham St NB T/R	B	15.3	0.68	253	#641	B	14.2	0.72	271	604	B	14.1	0.72	271	604	B	14.4	0.72	266	604	B	14.3	0.72	266	604
Needham St SB L	B	11.4	0.02	1	7	B	17.8	0.04	1	7	B	17.9	0.04	1	7	B	17.0	0.04	1	7	B	17.0	0.04	1	7
Needham St SB T/R	D	37.4	0.93	471	#893	E	57.3	1.01	541	#851	E	57.7	1.01	541	#851	D	49.5	0.99	494	#851	D	48.9	0.99	494	#851
Overall Intersection	C	28.8	--	--	--	D	38.3	--	--	--	D	38.5	--	--	--	C	34.8	0.98	--	--	C	34.5	0.98	--	--
^a Unsignalized and signalized intersection results from VHB's TIAS. Weekday Midday from VHB's 12/10/18 Peer Review Response to Comments Memorandum.																									
~ volume exceeds capacity, queue is theoretically infinite and blocking problems may occur. Queue shown is maximum after 2 cycles.																									
# 95 th percentile volume exceeds capacity, queue may be longer. Queue shown is maximum after 2 cycles. Value is valid if v/c ratio <1.00.																									