



GREEN INTERNATIONAL AFFILIATES, INC.

100 AMES POND DRIVE, SUITE 200 TEWKSBURY, MA 01876

T: (978) 923-0400 | F: (978) 399-0033 | WWW.GREENINTL.COM

MEMORANDUM

To: Valerie Oorthuys, Planning Director
Cc: Malcolm Ragan, Assistant Planner
From: Thomas Bigelow, P.E.; Green International Affiliates, Inc. (Green)
Date: October 28, 2022
Project Name: Great Road (Route 117) & Hudson Road Intersection Improvements
Project Number: Green Project No. 22094
Subject: Great Road & Hudson Road Intersection Improvements – Design Basis Memorandum

The subject project is located at the intersection of Great Road (Route 117) and Hudson Road in the Town of Stow. The proposed improvements include the installation of a new traffic signal system, pavement milling and overlay, roadway box-widening in select areas and pedestrian improvements. The project limits are anticipated to extend 800-feet along Great Road (400-feet either side of the intersection) and 400 feet along Hudson Road. Great Road (Route 117) is a principal arterial roadway that runs west-to-east and connects the Town of Stow to Interstate 495. Hudson Road is an urban collector roadway that serves mainly residential properties to the south of Great Road. Signalization of the intersection is proposed due to existing capacity and safety concerns at the intersection and to accommodate vehicular trips from new residential developments proposed off Hudson Road.

We have prepared this memorandum to accompany a conceptual design that has been prepared in accordance with MassDOT design standards and in accordance with the traffic analysis performed by Green for this intersection. Green has developed a recommended alternative design as well as two additional alternative designs for the Town's review.

The following design references have been used in preparing the design:

State

- MassDOT 2006 Project Development & Design Guide (PDDG)
- MassDOT Massachusetts Amendments to the 2009 Manual on Uniform Traffic Control Devices and the Standard Municipal Traffic Code
- MassDOT 2017 Construction Standard Details
- MassDOT Notes on Walks and Wheelchair Ramps for Designers and Construction Engineers (3/2012)
- MassDOT 1990 Standard Drawings for Signs and Supports
- MassDOT 1968 Standard Drawings for Traffic Signals and Highway Lighting
- Massachusetts Architectural Access Board Regulations

National Standards

- 2018 AASHTO A Policy on Geometric Design of Highways and Streets (7th Edition)
- 2011 AASHTO Roadside Design Guide
- 2010 Highway Capacity Manual
- 2009 Manual On Uniform Traffic Control Devices (MUTCD)
- ADA Accessibility Guidelines for Buildings and Facilities (ADAAG)
- Public Rights of Way Accessibility Guidelines (PROWAG)
- Traffic Engineering Handbook

- Public Rights of Way Accessibility Guidelines (PROWAG)
- Traffic Engineering Handbook

Design Vehicle

Great Road is classified as an arterial roadway and Hudson Road is classified as a collector roadway. Per the MassDOT PDDG, roadways with these functional classifications should accommodate a WB-50 tractor trailer unit. The proposed geometry in the conceptual designs was developed to accommodate a WB-50 design vehicle and the Town of Stow's fire apparatus for all turning movements between Hudson Road and Great Road. A WB-50 vehicle can be accommodated for all turning movements without encroaching into lanes of opposite travel. Larger vehicles, such as a WB-67, can navigate the intersection; however, some encroachment is anticipated. This is considered acceptable as it matches the existing condition and larger design vehicles are not commonly present at the intersection.

Roadway Design

A roadway cross section for all alternatives was determined in accordance with the MassDOT PDDG. Under existing conditions, Great Road's cross section includes 12-foot to 13-foot travel lanes, and 1-foot to 2-foot shoulders. Hudson Road has 11-foot travel lanes and 4-foot shoulders. In the preferred alternative (Alternative 3), the proposed cross section includes 11-foot lanes and 4-foot shoulders for both roadways to allow for bicycle use of the shoulder. In Alternative 1 and 2 discussed below, 11-foot travel lanes and 2-foot shoulders were used on Great Road to accommodate a left turn lane and to limit impacts. Eleven (11) foot travel lanes and 4-foot shoulders were used on Hudson Road. For all alternatives, sidewalks are proposed on the south side of Great Road, both east and west of the intersection, and extend down Hudson Road on both sides of the roadway. The sidewalk on the west side of Hudson Road will terminate at the existing mid-block crossing location. The sidewalk on the east side of Hudson Road will terminate at the entrance to the Buscemi Holdings, LLC property. All proposed sidewalks will have a width of 5-feet and will have a grass buffer with a minimum width of 3-feet.

Impacts to utilities, right-of-way, pedestrian facilities, environmental resource areas, and traffic operations were evaluated for each alternative. Each alternative proposes to maintain the "country" drainage that is present under existing conditions, to reconstruct the driveway aprons within the project limits, and to provide ADA compliant pedestrian curb ramps at all crossing locations. Alternatives 1 and 2 propose to provide a left turn lane for Great Road westbound traffic for movements onto Hudson Road. However, the addition of a left turn lane on Great Road proved to be unwarranted based on the traffic analysis and these alternatives proved to be infeasible for reasons discussed below. Alternative 3, which is Green's recommended alternative design, does not provide a left turn lane on Great Road westbound and proposes to implement a right turn lane on Hudson Road. Below is a summary of each alternative and the design standards used in developing the designs.

Alternative 1

Alternative 1 proposes a left turn lane on Great Road (Route 117) westbound. Due to the intersection's proximity to the bridge, the largest turn pocket than can be developed is 25-feet long, which is enough storage for 1 vehicle. Due to the required taper length of 240-feet to develop the turn lane per MassDOT design guidance, Hudson Road will need to be realigned to the west to create adequate distance between the intersection and the bridge in order to minimize impacts to the bridge. The realignment of Hudson Road requires full depth reconstruction. This alternative will result in pavement marking modifications across the bridge and will also require modifications to the bridge in the form of roadway widening on the south side.

This alternative proves to be infeasible due to the impacts required on the bridge as well as the full depth reconstruction required on Hudson Road as a result of the realignment. Also as a result of the realignment, the proposed sidewalk on the west side of Hudson Road will need to be constructed outside of the right-of-way heading south to the existing mid-block crossing and will directly impact a 36" tree and a 24" tree. Utility poles on Great Road are not impacted in this design. A location to treat stormwater from the additional impervious area will need to be identified.

Alternative 2

Alternative 2, similar to Alternative 1, proposes a left turn lane on Great Road westbound. However, this alternative proposes to widen Great Road by 4-feet to the north to reduce the required taper length to develop the left turn lane. Due to the intersection's proximity to the bridge, the largest turn pocket than can be developed is 25-feet long, which is enough storage for 1 vehicle. Due to the required taper length of 120-feet to develop the turn lane per MassDOT design guidance, Hudson Road will need to be realigned to the west to create adequate distance between the intersection and the bridge in order to minimize impacts at the bridge. This alternative will result in pavement marking modifications across the bridge but will not require any modifications to the bridge itself as seen in Alternative 1. The bridge is within MassDOT Jurisdiction; therefore, the new pavement markings will require a MassDOT Access Permit. The guardrail on the north side of Great Road (Route 117) will need to be reset and modifications may be needed to the bridge rail transition section of the guardrail. This alternative proves to be infeasible due to the striping modifications required on the bridge, the impacts to the bridge rail transition, the utility pole relocations due to the widening required to the north on Great Road and the full depth reconstruction on Hudson Road. Additionally, the proposed sidewalk on the west side of Hudson Road will need to be constructed outside of the right-of-way heading south to the existing mid-block crossing and will directly impact a 36" tree and a 24" tree. A location to treat stormwater from the additional impervious area will need to be identified.

Alternative 3

Alternative 3, Green's recommended design, proposes one travel lane in each direction on Great Road with no westbound turn lane. Based on our traffic analysis, a lead green phase for westbound traffic will provide left turning vehicles an opportunity to complete their turn movement while resulting in an acceptable Level of Service (LOS). A LOS table for this alternative has been provided in Tables 1 and 2. The existing roadway alignments and crown lines for both Great Road and Hudson Road will be retained, and the pavement will be milled and overlaid within the project limits. Approximately 90-feet of box widening in the eastbound lane of Great Road west of the intersection will be required in order to fully accommodate 11-foot lanes and 4-foot shoulders. Minor box widening will also be required around the radii of both the intersection corners between Hudson Road and Great Road to provide adequate pavement width for WB-50 turning vehicles. The existing edge of pavement on the north side of Great Road will be retained and as a result, the existing guardrail and utility poles will be retained as well. This alternative proposes a right turn lane with 50-feet of storage on Hudson Road to fully utilize the existing pavement width. This right turn lane could be eliminated during the Final Design stage. Eliminating the right turn lane will not have detrimental effects to the final condition LOS and will reduce the length of the pedestrian crossing. No utility impacts are anticipated on Hudson Road as a result of the implementation of the right turn lane. A proposed sidewalk can be accommodated on the west side of Hudson Road with minimal permanent right-of-way impacts. The sidewalk extension does result in a 1550 SF increase in impervious area compared to the existing condition. This increase is may be found to be negligible and is significantly smaller impervious area increase when compared to the other alternatives. Treatment and detention for the additional impervious may not be

required by the Conservation Commission if the additional impervious does not increase peak rates at the outfall to Elizabeth Brook.

Traffic Signal Design

The proposed traffic signal design includes constructing one traffic signal at the Great Road (Route 117)/Hudson Road intersection. The proposed traffic signal will be coordinated with the existing traffic signal located at Great Road (Route 117) at Harvest Drive.

Operational Analysis

To reflect the new operations, the signal phasing sequence and timings were adjusted to optimize traffic signal operations and traffic flow through the signalized system. The preferred alternative proposes a lead phase for the westbound direction to allow some left-turning vehicles to complete their turns before eastbound traffic is released. Updated Level of Service (LOS) analyses were completed for the proposed traffic signal system. The results of the LOS analyses are shown in Tables 1 and 2 below. The LOS analyses reports are attached to this memo.

Table 1 – Summary of Level of Service Analysis – AM Peak Hour

	2020 Existing Conditions					2029 No-Build Conditions					2029 Build Conditions				
	Delay (S)	LOS	V/C	50th Q (FT)	95th Q (FT)	Delay (S)	LOS	V/C	50th Q (FT)	95th Q (FT)	Delay (S)	LOS	V/C	50th Q (FT)	95th Q (FT)
AM Peak Hour															
Great Road (Route 117) at Hudson Road															
Great Road EB T	0.0	A	0.00	-	0	0.0	A	0.00	-	0	10.5	B	0.56	112	216
Great Road EB R															
Great Road WB L	9.2	A	0.119	-	10	9.3	A	0.14	-	13	4.7	A	0.46	36	78
Great Road WB T															
Hudson Road NB L	29.6	D	0.674	-	120	43.0	E	0.809	-	180	26.3	C	0.28	21	49
Hudson Road NB R											1.8	A	0.25	0	26
Overall Intersection	-	-	-	-	-	-	-	-	-	-	7.8	A	-	-	-
Abbreviations: EB = Eastbound L = Left S = Seconds WB = T = FT = Feet Westbound Through NB = R = Right LOS = Level of Service Northbound SB = v/c = Volume-to-Capacity Southbound Ratio															
Notes: Delay = Average delay per vehicle (measured in seconds) 50th Q = 50th percentile queue length, assumes 25 feet per vehicle 95th Q = 95th percentile queue length, assumes 25 feet per vehicle															



Table 2 – Summary of Level of Service Analysis – PM Peak Hour

	2020 Existing Conditions					2029 No-Build Conditions					2029 Build Conditions				
	Delay (S)	LOS	V/C	50th Q (FT)	95th Q (FT)	Delay (S)	LOS	V/C	50th Q (FT)	95th Q (FT)	Delay (S)	LOS	V/C	50th Q (FT)	95th Q (FT)
PM Peak Hour															
Great Road (Route 117) at Hudson Road															
Great Road EB T	0.0	A	0.00	-	0	0.0	A	0.00	-	0	6.5	A	0.35	73	135
Great Road EB R															
Great Road WB L	9.0	A	0.24	-	25	9.5	A	0.29	-	30	32.1	C	1	134	503
Great Road WB T															
Hudson Road NB L	78.6	F	0.90	-	193	245.7	F	1.28	-	380	38.0	D	0.4	33	69
Hudson Road NB R											1.3	A	0.17	0	21
Overall Intersection	-	-	-	-	-	-	-	-	-	-	21.8	C	-	-	-
Abbreviations: EB = Eastbound L = Left S = Seconds WB = T = Westbound Through FT = Feet NB = R = Right LOS = Level of Service Northbound = SB = v/c = Volume-to-Capacity Southbound Ratio															
Notes: Delay = Average delay per vehicle (measured in seconds) 50th Q = 50th percentile queue length, assumes 25 feet per vehicle 95th Q = 95th percentile queue length, assumes 25 feet per vehicle															

The intersection capacity analyses indicate the following:

- A proposed traffic signal is expected to improve the LOS, delay, and queue on the northbound approach for both the weekday morning and afternoon peak hours.
- A proposed traffic signal is expected to increase the LOS, delay, and queue at the eastbound and westbound approach since vehicles traveling along Great Road would be required to stop during the Hudson Road phase. These approaches are expected to operate at LOS 'C' or better for both the weekday morning and afternoon peak hours, which is generally considered an acceptable LOS for traffic signals.
- With the installation of a proposed traffic signal, the weekday morning peak hour LOS for the intersection is expected to be an 'A' and the weekday afternoon peak hour LOS for the intersection is expected to be a 'C.'

Traffic Signal Equipment

The proposed traffic signal layout includes a dual mast arm for all approaches as well as a supplemental 10-foot traffic signal post for the northbound approach. Pedestrian signal heads with associated APS equipment are proposed for the crosswalk on the northbound approach. An advanced transportation controller (ATC) and cabinet are proposed to facilitate traffic signal operations. GPS synchronization devices are included at both the proposed traffic signal at Hudson Road and the existing traffic signal at Harvest Drive for coordination. A new controller may be required at the Harvest Drive intersection if it is determined that the existing controller is not capable of supporting a GPS device.

Sidewalk Extension

We evaluated the feasibility of extending the existing sidewalk along the west side of Hudson Road. The sidewalk extension would extend approximately 320-feet along Hudson Road and would terminate at the existing mid-block crossing in front of the Stow Villages property. In Alternative 3, a 5-foot sidewalk with a 3-foot grass buffer can be accommodated within the existing right of way, except at the corner of Great Road and Hudson Road. Due to the expanded pavement area required to accommodate a WB-50 vehicle, the proposed sidewalk will require approximately 35 SF of permanent rights on the Koop Realty, LLC property at 636 Great Road. Temporary rights will be required on both the Koop Realty, LLC property and the Stow Villages, LLC property for the purposes of construction. The proposed sidewalk will require the removal of two shrubs which are currently within the right-of-way. It may also require the removal of a 24-inch diameter tree, which is currently outside of the right-of-way and a 36-inch diameter tree which is currently inside the right-of-way. These trees are outside of the proposed sidewalk area, however, the excavation required for the sidewalk installation may damage the root systems of these trees thus potentially requiring complete removal of the tree itself. We do not anticipate the removal of these trees to trigger MEPA review or other state or local permits. No utility impacts are anticipated; however, there will be a conflict with the proposed sidewalk and an existing catch basin within the driveway of the Koop Realty, LLC property. We reviewed an alternative sidewalk configuration at this location to avoid the catch basin (See Alternative 3, Figure 2). We determined that the alternative design will require a permanent taking on the Koop Realty, LLC property. We recommend proceeding with this alternative design if the costs associated with the permanent taking are minimal. If costs to acquire the rights are excessive, it will be more feasible to relocate this drainage structure out of the pedestrian path. The existing sidewalk on the east side of Hudson Road will be replaced to follow the new roadway geometry and will terminate at the bridge and at the Buscemi Holdings, LLC property on Hudson Road. This sidewalk is currently outside of the existing right-of-way and will require both permanent and temporary rights to construct. No existing easement for this sidewalk was found in the property research we conducted at the Registry of Deeds. The existing sidewalk on the south side of Great Road west of the intersection will be retained and replaced in-kind if impacted by construction. No permanent or temporary easements are anticipated west of the intersection.

Commercial Driveway Access Control

We have evaluated the feasibility of combining the driveway openings on the Leontine, LLC property and the Buscemi Holdings, LLC property on Hudson Road. Based on the site evaluation for the Town's preferred location of this driveway, a combined driveway will be a costly addition to the project. A combined driveway at this location will require ledge removal and extensive grading between the two properties. Impacts to the existing retaining wall between the two properties are anticipated. Impacts to the existing guy wire and light pole on the Leontine, LLC property are anticipated. Coordination with Hudson Light and Power will be required. An alternative driveway reconfiguration is presented in Alternative 3, Figure 1 that proposes to close off the liquor store driveway entrance closest to the gas station. This will provide separation between the two properties and will improve operations within the Buscemi Holdings, LLC property parking lot. Costs associated with the closing of this driveway will be minimal and impacts will be minimal in comparison to combining the two driveways.

Recommendation and Cost Estimate

We recommend the Town proceed with the design presented in Alternative 3. This design presents the lowest overall project cost and the fewest impacts to existing utilities, infrastructure, right-of-way, environmental resource areas and traffic operations. It achieves the project goal of installing a signalized intersection while providing a Level of Service of C for operations at the intersection.

We have prepared a preliminary itemized cost estimate for all anticipated items. The pay items utilize the MassDOT Standard Nomenclature for pay items and Standard Specifications for measurement and payment. The unit prices are based on MassDOT's weighted average unit bid prices for the prior 6 months. A contingency of 30% has been added to the estimated cost which is commensurate with this design stage. The total estimated cost of this project is \$750,000.00.




y:\shared\engineering\projects\2022\22094\docs\bod\01 conceptual submission\design basis memo_hudson road_concept submittal.docx

LEVEL OF SERVICE ANALYSIS REPORTS

HCM 6th TWSC
10: Hudson Road & Great Road (Route 117)




2022 Existing - AM

10/05/2022

Intersection						
Int Delay, s/veh	7.5					
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	464	66	110	253	42	198
Future Vol, veh/h	464	66	110	253	42	198
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	89	89	94	94	85	85
Heavy Vehicles, %	6	5	2	7	5	2
Mvmt Flow	521	74	117	269	49	233
Major/Minor	Major1	Major2		Minor1		
Conflicting Flow All	0	0	595	0	1061	558
Stage 1	-	-	-	-	558	-
Stage 2	-	-	-	-	503	-
Critical Hdwy	-	-	4.12	-	6.45	6.22
Critical Hdwy Stg 1	-	-	-	-	5.45	-
Critical Hdwy Stg 2	-	-	-	-	5.45	-
Follow-up Hdwy	-	-	2.218	-	3.545	3.318
Pot Cap-1 Maneuver	-	-	981	-	245	529
Stage 1	-	-	-	-	567	-
Stage 2	-	-	-	-	601	-
Platoon blocked, %	-	-	-	-	-	-
Mov Cap-1 Maneuver	-	-	981	-	211	529
Mov Cap-2 Maneuver	-	-	-	-	211	-
Stage 1	-	-	-	-	567	-
Stage 2	-	-	-	-	517	-
Approach	EB		WB		NB	
HCM Control Delay, s	0		2.8		29.6	
HCM LOS					D	
Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT	
Capacity (veh/h)	419	-	-	981	-	
HCM Lane V/C Ratio	0.674	-	-	0.119	-	
HCM Control Delay (s)	29.6	-	-	9.2	0	
HCM Lane LOS	D	-	-	A	A	
HCM 95th %tile Q(veh)	4.8	-	-	0.4	-	




HCM 6th TWSC
10: Hudson Road & Great Road (Route 117)

2022 Existing - PM
10/05/2022

Intersection						
Int Delay, s/veh	13.4					
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	309	61	258	529	53	150
Future Vol, veh/h	309	61	258	529	53	150
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	96	96	90	90	93	93
Heavy Vehicles, %	1	2	1	1	0	0
Mvmt Flow	322	64	287	588	57	161
Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	386	0	1516	354
Stage 1	-	-	-	-	354	-
Stage 2	-	-	-	-	1162	-
Critical Hdwy	-	-	4.11	-	6.4	6.2
Critical Hdwy Stg 1	-	-	-	-	5.4	-
Critical Hdwy Stg 2	-	-	-	-	5.4	-
Follow-up Hdwy	-	-	2.209	-	3.5	3.3
Pot Cap-1 Maneuver	-	-	1178	-	133	694
Stage 1	-	-	-	-	715	-
Stage 2	-	-	-	-	300	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1178	-	85	694
Mov Cap-2 Maneuver	-	-	-	-	85	-
Stage 1	-	-	-	-	715	-
Stage 2	-	-	-	-	191	-
Approach	EB		WB		NB	
HCM Control Delay, s	0		3		78.6	
HCM LOS					F	
Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT	
Capacity (veh/h)	242	-	-	1178	-	
HCM Lane V/C Ratio	0.902	-	-	0.243	-	
HCM Control Delay (s)	78.6	-	-	9	0	
HCM Lane LOS	F	-	-	A	A	
HCM 95th %tile Q(veh)	7.7	-	-	1	-	




HCM 6th TWSC
10: Hudson Road & Great Road (Route 117)

2029 No Build - AM
10/05/2022

Intersection						
Int Delay, s/veh	11.2					
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	475	74	126	259	58	236
Future Vol, veh/h	475	74	126	259	58	236
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	516	80	137	282	63	257
Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	596	0	1112	556
Stage 1	-	-	-	-	556	-
Stage 2	-	-	-	-	556	-
Critical Hdwy	-	-	4.12	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.218	-	3.518	3.318
Pot Cap-1 Maneuver	-	-	980	-	231	531
Stage 1	-	-	-	-	574	-
Stage 2	-	-	-	-	574	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	980	-	193	531
Mov Cap-2 Maneuver	-	-	-	-	193	-
Stage 1	-	-	-	-	574	-
Stage 2	-	-	-	-	479	-
Approach	EB		WB		NB	
HCM Control Delay, s	0		3		43	
HCM LOS	E					
Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT	
Capacity (veh/h)	395	-	-	980	-	
HCM Lane V/C Ratio	0.809	-	-	0.14	-	
HCM Control Delay (s)	43	-	-	9.3	0	
HCM Lane LOS	E	-	-	A	A	
HCM 95th %tile Q(veh)	7.2	-	-	0.5	-	

HCM 6th TWSC
10: Hudson Road & Great Road (Route 117)











2029 No Build - PM
10/05/2022

Intersection						
Int Delay, s/veh	41.7					
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	317	80	300	542	64	175
Future Vol, veh/h	317	80	300	542	64	175
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	-	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	345	87	326	589	70	190
Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	432	0	1630	389
Stage 1	-	-	-	-	389	-
Stage 2	-	-	-	-	1241	-
Critical Hdwy	-	-	4.12	-	6.42	6.22
Critical Hdwy Stg 1	-	-	-	-	5.42	-
Critical Hdwy Stg 2	-	-	-	-	5.42	-
Follow-up Hdwy	-	-	2.218	-	3.518	3.318
Pot Cap-1 Maneuver	-	-	1128	-	112	659
Stage 1	-	-	-	-	685	-
Stage 2	-	-	-	-	273	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1128	-	~ 64	659
Mov Cap-2 Maneuver	-	-	-	-	~ 64	-
Stage 1	-	-	-	-	685	-
Stage 2	-	-	-	-	156	-
Approach	EB		WB		NB	
HCM Control Delay, s	0		3.4		245.7	
HCM LOS	F					
Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT	
Capacity (veh/h)	189	-	-	1128	-	
HCM Lane V/C Ratio	1.375	-	-	0.289	-	
HCM Control Delay (s)	245.7	-	-	9.5	0	
HCM Lane LOS	F	-	-	A	A	
HCM 95th %tile Q(veh)	15.2	-	-	1.2	-	
Notes						
~: Volume exceeds capacity \$: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon						

Lanes, Volumes, Timings

10: Hudson Road & Great Road (Route 117)

2029 Build - AM
10/05/2022

						
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	475	74	126	259	58	236
Future Volume (vph)	475	74	126	259	58	236
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	12	12	12
Grade (%)	0%			0%	0%	
Storage Length (ft)		0	100		0	50
Storage Lanes		0	0		1	1
Taper Length (ft)			25		25	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor						
Frt	0.982					0.850
Flt Protected				0.984	0.950	
Satd. Flow (prot)	1829	0	0	1833	1770	1583
Flt Permitted				0.620	0.950	
Satd. Flow (perm)	1829	0	0	1155	1770	1583
Right Turn on Red		Yes				Yes
Satd. Flow (RTOR)	17					257
Link Speed (mph)	30			30	30	
Link Distance (ft)	681			225	380	
Travel Time (s)	15.5			5.1	8.6	
Confl. Peds. (#/hr)						
Confl. Bikes (#/hr)						
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%
Bus Blockages (#/hr)	0	0	0	0	0	0
Parking (#/hr)						
Mid-Block Traffic (%)	0%			0%	0%	
Adj. Flow (vph)	516	80	137	282	63	257
Shared Lane Traffic (%)						
Lane Group Flow (vph)	596	0	0	419	63	257
Turn Type	NA		pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	4	
Permitted Phases			6			2
Total Split (s)	32.0		8.0	40.0	20.0	32.0
Total Lost Time (s)	4.0			4.0	4.0	4.0
Act Effect Green (s)	34.9			44.4	7.6	34.9
Actuated g/C Ratio	0.58			0.74	0.13	0.58
v/c Ratio	0.56			0.46	0.28	0.25
Control Delay	10.5			4.7	26.3	1.8
Queue Delay	0.0			0.0	0.0	0.0
Total Delay	10.5			4.7	26.3	1.8
LOS	B			A	C	A
Approach Delay	10.5			4.7	6.6	
Approach LOS	B			A	A	
Queue Length 50th (ft)	112			36	21	0
Queue Length 95th (ft)	216			78	49	26
Internal Link Dist (ft)	601			145	300	

Lanes, Volumes, Timings

10: Hudson Road & Great Road (Route 117)

10/05/2022

	→	↘	↙	←	↖	↗
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Turn Bay Length (ft)						50
Base Capacity (vph)	1070			916	472	1027
Starvation Cap Reductn	0			0	0	0
Spillback Cap Reductn	0			0	0	0
Storage Cap Reductn	0			0	0	0
Reduced v/c Ratio	0.56			0.46	0.13	0.25

Intersection Summary

Area Type: Other

Cycle Length: 60

Actuated Cycle Length: 60

Offset: 22 (37%), Referenced to phase 2:EBT and 6:WBTL, Start of Green

Control Type: Actuated-Coordinated

Maximum v/c Ratio: 0.56

Intersection Signal Delay: 7.8

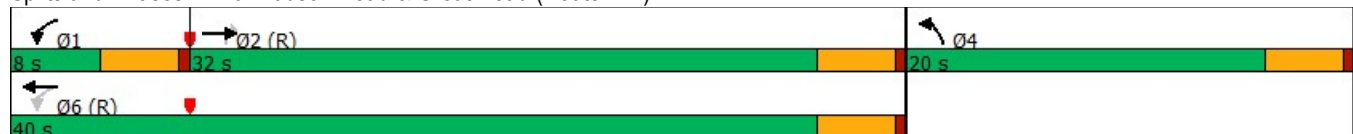
Intersection LOS: A

Intersection Capacity Utilization 63.4%

ICU Level of Service B











Analysis Period (min) 15

Splits and Phases: 10: Hudson Road & Great Road (Route 117)



Lanes, Volumes, Timings
10: Hudson Road & Great Road (Route 117)

2029 Build - PM
10/05/2022

						
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	317	80	300	542	64	175
Future Volume (vph)	317	80	300	542	64	175
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width (ft)	12	12	12	12	12	12
Grade (%)	0%			0%	0%	
Storage Length (ft)		0	100		0	50
Storage Lanes		0	0		1	1
Taper Length (ft)			25		25	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00
Ped Bike Factor						
Frt	0.973					0.850
Flt Protected				0.982	0.950	
Satd. Flow (prot)	1812	0	0	1829	1770	1583
Flt Permitted				0.609	0.950	
Satd. Flow (perm)	1812	0	0	1134	1770	1583
Right Turn on Red		Yes				Yes
Satd. Flow (RTOR)	28					190
Link Speed (mph)	30			30	30	
Link Distance (ft)	681			225	380	
Travel Time (s)	15.5			5.1	8.6	
Confl. Peds. (#/hr)						
Confl. Bikes (#/hr)						
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Growth Factor	100%	100%	100%	100%	100%	100%
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%
Bus Blockages (#/hr)	0	0	0	0	0	0
Parking (#/hr)						
Mid-Block Traffic (%)	0%			0%	0%	
Adj. Flow (vph)	345	87	326	589	70	190
Shared Lane Traffic (%)						
Lane Group Flow (vph)	432	0	0	915	70	190
Turn Type	NA		pm+pt	NA	Prot	Perm
Protected Phases	2		1	6	4	
Permitted Phases			6			2
Total Split (s)	52.0		8.0	60.0	20.0	52.0
Total Lost Time (s)	4.0			4.0	4.0	4.0
Act Effect Green (s)	54.0			63.5	8.5	54.0
Actuated g/C Ratio	0.68			0.79	0.11	0.68
v/c Ratio	0.35			0.97	0.37	0.17
Control Delay	6.5			32.1	38.0	1.3
Queue Delay	0.0			0.0	0.0	0.0
Total Delay	6.5			32.1	38.0	1.3
LOS	A			C	D	A
Approach Delay	6.5			32.1	11.2	
Approach LOS	A			C	B	
Queue Length 50th (ft)	73			134	33	0
Queue Length 95th (ft)	135			#503	69	21
Internal Link Dist (ft)	601			145	300	

Lanes, Volumes, Timings

10: Hudson Road & Great Road (Route 117)

10/05/2022

	→	↘	↙	←	↖	↗
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Turn Bay Length (ft)						50
Base Capacity (vph)	1231			947	354	1129
Starvation Cap Reductn	0			0	0	0
Spillback Cap Reductn	0			0	0	0
Storage Cap Reductn	0			0	0	0
Reduced v/c Ratio	0.35			0.97	0.20	0.17

Intersection Summary

Area Type: Other

Cycle Length: 80

Actuated Cycle Length: 80

Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBTL, Start of Green

Control Type: Actuated-Coordinated

Maximum v/c Ratio: 0.97

Intersection Signal Delay: 21.8

Intersection LOS: C

Intersection Capacity Utilization 80.2%

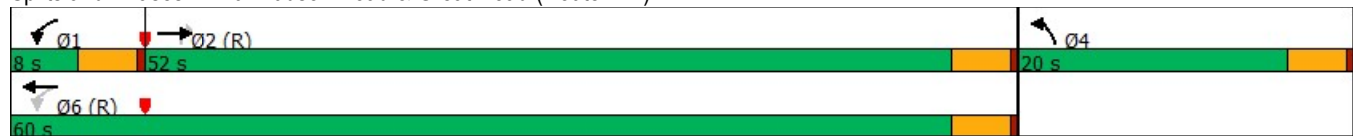
ICU Level of Service D

Analysis Period (min) 15

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Splits and Phases: 10: Hudson Road & Great Road (Route 117)



**Great Road/Hudson Road Improvements
Stow, MA
Town of Stow
ENGINEER'S ESTIMATE - Conceptual**

Prepared by: Green International Affiliates



GREEN INTERNATIONAL AFFILIATES, INC.
Civil and Structural Engineers

Date: 10/28/2022

Green Project No: 22094.00

ITEM NO.	QUANTITY	UNIT	ITEM DESCRIPTION	UNIT PRICE	AMOUNT
100.	1	LS	SCHEDULE OF OPERATIONS - FIXED PRICE \$	\$34,000.00	\$34,000.00
104.	2	EA	TREE REMOVED - DIAMETER 24 INCHES AND OVER	\$3,500.00	\$7,000.00
120.	330	CY	EARTH EXCAVATION	\$50.00	\$16,500.00
121.	35	CY	CLASS A ROCK EXCAVATION	\$150.00	\$5,250.00
151.	130	CY	GRAVEL BORROW	\$65.00	\$8,450.00
170.	825	SY	FINE GRADING AND COMPACTING	\$8.50	\$7,012.50
402.	20	CY	DENSE GRADED CRUSHED STONE FOR SUB-BASE	\$85.00	\$1,700.00
415.3	2625	SY	PAVEMENT MICROMILLING	\$36.00	\$94,500.00
450.23	340	TON	SUPERPAVE SURFACE COURSE - 12.5 (SSC - 12.5)	\$130.00	\$44,200.00
510.	120	FT	GRANITE EDGING TYPE SA	\$50.00	\$6,000.00
697.1	4	EA	SILT SACK	\$250.00	\$1,000.00
701.2	40	SY	CEMENT CONCRETE PEDESTRIAN CURB RAMP	\$105.00	\$4,200.00
702.	100	TON	HOT MIX ASPHALT SIDEWALK OR DRIVEWAY	\$245.00	\$24,500.00
740.	6	MO	ENGINEERS FIELD OFFICE AND EQUIPMENT (TYPE A)	\$3,800.00	\$22,800.00
748.	1	LS	MOBILIZATION	\$15,000.00	\$15,000.00
751.	75	CY	LOAM BORROW	\$85.00	\$6,375.00
765.	660	SY	SEEDING	\$4.00	\$2,640.00
804.3	400	FT	3 INCH ELECTRICAL CONDUIT TYPE NM - PLASTIC -(UL)	\$66.00	\$26,400.00
811.31	4	EA	PULL BOX 12 X 12 INCHES - SD2.031	\$1,350.00	\$5,400.00
815.1	1	LS	TRAFFIC CONTROL SIGNAL LOCATION NO. 1	\$145,000.00	\$145,000.00
816.01	1	LS	TRAFFIC SIGNAL RECONSTRUCTION LOCATION NO. 1	\$30,000.00	\$30,000.00
866.106	1400	FT	6 INCH REFLECTORIZED WHITE LINE (THERMOPLASTIC)	\$1.50	\$2,100.00
866.112	350	FT	12 INCH REFLECTORIZED WHITE LINE (THERMOPLASTIC)	\$5.50	\$1,925.00
867.106	900	FT	6 INCH REFLECTORIZED YELLOW LINE (THERMOPLASTIC)	\$1.50	\$1,350.00

SUBTOTAL: \$513,302.50
30% Contingency & Inflation: \$153,991.00
10% Construction & Engineering: \$51,330.00
6% Police Details: \$30,798.00
TOTAL: \$750,000.00