146 Dascomb Road
Andover, MA 01810
978.794.1792
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MEMORANDUM

TO: Timothy B. Kilhart – DPW Director *and*
Christopher J. Ryan, AICP –
Director of Community and Economic Development
Town of Harvard

DATE: September 23, 2020

FROM: Elizabeth Oltman, PE

PROJECT NO.: T0904

RE: Ayer Road (Route 110/111) – MassDOT Project No. 609213
Supplemental Roundabout Analysis with MassDOT SPICE/ICE Tool

The following details an evaluation of the potential installation of a roundabout at the intersection of Ayer Road / Gebo Lane, as compared to maintaining the existing traffic control conditions, with Gebo Lane under stop control and Ayer Road with free-flow conditions.

Project Background

TEC, Inc. (TEC) has been retained by the Town of Harvard to prepare roadway and intersection improvement plans for approximately 9,000 feet of Ayer Road, from the Route 2 interchange north to the Harvard-Ayer Town Line. The proposed improvements are needed to address the existing safety and operational deficiencies regarding intersection geometry, conflicting turning movements, multi-modal accommodations and vehicle delays. One of the focal points of the project is the improvements proposed in the vicinity of the intersections of Ayer Road / Gebo Lane and Ayer Road / Lancaster County Road. Proposed geometric improvements include the reconfiguration of the intersecting roadways to allow for the realignment of the Gebo Lane approach to Ayer Road, the closure of a segment of Lancaster County Road between the Post Office rear access driveway and Ayer Road, and reassigning the egress from the adjacent Post Office to Gebo Lane. These improvements are proposed to reduce the number of conflict points along this section of the corridor.

Methodology

TEC performed a comprehensive alternatives analysis as per MassDOT's *Alternative Analysis Guide* (July 2020), using the Massachusetts-specific Safety Performance for Intersection Control Evaluation (SPICE) Tool version 1.3.4 and Intersection Control Evaluation (ICE) Tool version 1.2.

Existing Conditions

Gebo Lane intersects Ayer Road (Route 110/111) at a skewed angle to form a three-legged unsignalized intersection. The Ayer Road northbound and southbound approaches are free-flowing, while the Gebo Lane approach is under STOP-control. The Ayer Road northbound and southbound approaches both consist of a single general-purpose travel lane with directional flow

separated by a marked double-yellow centerline. The Gebo Lane approach consists of a single general-purpose lane with directional flow not delineated. Turn lanes are not present on any approach.

Ayer Road is classified as an urban principal arterial roadway with a posted speed limit of 40 miles per hour (MPH) in the study area. The 85th percentile speed along Ayer Road was recorded in July 2019 as 43 MPH northbound and 38 MPH southbound, or within 5 MPH of the posted speed limit. Ayer Road carries approximately 14,350 vehicles per day (VPD) on an average weekday south of Gebo Lane, with 3.5% trucks over class 5 daily.

Gebo Lane is classified as a local roadway with a statutory speed limit of 30 MPH. Under the analysis scenario, Gebo Lane carries approximately 500 vehicles per day, including the diverted traffic from the aforementioned closure of Lancaster County Road.

Alternate 1 – Unsignalized Stop-Controlled Intersection

Alternate 1 is the currently proposed / recommended alternative. Lancaster County Road intersects Ayer Road approximately 900 feet to the north of Gebo Lane. The proposed improvments consist of the elimination of the segment of Lancaster County Road between the Post Office rear access driveway and Ayer Road. Therefore, Lancaster County Road will be eliminated from the Ayer Road / Lancaster County Road / Poor Farm Road intersection, which is negatively offset. By eliminating the Lancaster County Road approach, the intersection is expected to operate at a more efficient and safer manner. Additionally, the front exit of the Post Office onto Ayer Road will be removed. All vehicles will exit through the rear access drive onto Lancaster County Road. The Gebo Lane approach at Ayer Road will be realigned to provide a standard T-intersection alignment to improve sight distances for vehicles exiting Gebo Lane.

Alternate 2 - Roundabout

Alternate 2 includes the installation of a single-lane roundabout at the realigned intersection of Gebo Lane / Ayer Road. The closure of the Lancaster County Road approach to Ayer Road and the closure of the Post Office exit onto Ayer Road would remain as currently proposed.

Analyses

TEC performed a comprehensive alternatives analysis as per MassDOT's *Alternative Analysis Guide* (July 2020) using the following assumptions:

- The intersection is a Three-Leg Stop-Controlled Intersection (3ST)
- The design year is 2029, with a background growth rate of 1.9% per year from 2019 volumes
- Design year AADT on Ayer Road, the major roadway, of 17,300 vpd
- Design year AADT on Gebo Lane, the minor roadway, of 605 vpd
- Crash data was obtained at the intersections of Gebo Lane / Ayer Road and Lancaster County Road / Ayer Road for a seven-year period (2013 - 2019) from the MassDOT IMPACT database

The above data was input into the Safety Performance for Intersection Control Evaluation (SPICE) Tool, which calculates Safety Performance Functions (SPF) and uses Massachusetts-specific Crash Modification Factors (CMF). The SPF predicts crash frequency for a given crash severity and crash type as a function of traffic volume and intersection characteristics. The CMFs are factors used to quantify the expected change in crash frequency for a potential improvement. The SPICE Tool results predict the type and number of crashes anticipated in the opening year, design year, and project life cycle for each alternative proposed for an intersection.

For the Ayer Road / Gebo Lane intersection, the SPICE Tool results indicate that, over the project life cycle, a roundabout would be expected to have approximately 44% fewer predicted number of crashes than a standard unsignalized T-intersection.

Safety Performance for Intersection Control Evaluation Tool

Results

Summary of crash prediction results for each alternative

Project Information

Project Name:	Ayer Road	**Intersection Type**	At-Grade Intersections
Intersection:	Ayer Road / Gebo Lane / Lancaster County Road	**Opening Year**	2020
Agency:	Town of Harvard / TEC	**Design Year**	2029
Project Reference:	T0904	**Facility Type**	On Urban and Suburban Arterial
City:	Harvard	**Number of Legs**	3-leg
State:	MA		
Date:	9/1/2020		
Analyst:	EMO		

Crash Prediction Summary

Control Strategy	Crash Type	Opening Year	Design Year	Total Project Life Cycle	AADT Within Prediction Range?	Source of Prediction
1-lane Roundabout	Total	0.31	0.47	3.90	N/A	HSM CMF
	Fatal & Injury	0.10	0.15	1.22		
2-lane Roundabout	Total	0.31	0.47	3.90	N/A	HSM CMF
	Fatal & Injury	0.10	0.15	1.22		
Minor Road Stop	Total	0.90	1.37	6.96	Yes	MassDOT SPF w/ Emperical Bayes
	Fatal & Injury	0.28	0.43	2.18		

Figure 1 – Screenshot of the SPICE Tool Results for Ayer Road / Gebo Lane

An additional evaluation of the types of crashes recorded at the intersection and their ability to be reduced by the installation of a roundabout will also be provided within the Functional Design Report to be submitted with the 25% design plans.

The results from the SPICE Tool were then input into the Intersection Control Evaluation (ICE) Tool to provide a comprehensive economic analysis of the two alternatives. The ICE Tool calculates the life cycle costs of the alternatives proposed for an intersection and considers safety, vehicular delay, operations and maintenance, design and construction, and right-of-way. Additional information included to complete this analysis:

- Actual turning movement counts from July 16, 2019 were uploaded for use by the Tool in calculating delay for the unsignalized intersection operation
- Delay for the roundabout was uploaded using the previous evaluation performed by TEC with the GDOT Roundabout Analysis Tool provided by MassDOT

- The design and construction cost for the Ayer Road project, including a standard unsignalized T-intersection is currently estimated at approximately $6,475,000*
- The design and construction cost for the Ayer Road project, including a one-lane roundabout without right-of-way acquisition, is $8,180,000*

  * Note that neither alternative cost includes right-of-way acquisition costs; however, the ROW cost for the roundabout alternative is anticipated to be significantly greater than the standard unsignalized T-intersection.

For the Ayer Road / Gebo Lane intersection, the ICE Tool results indicate that, considering all cost/benefit items, the roundabout will cost 26% more than the standard unsignalized T-intersection over the project life cycle. As shown in Figure 2, the Tool results indicate that for the safety line item, the benefit / cost (B/C) ratio is 0.40, indicating a higher safety benefit. However, for the delay and overall B/C ratio calculation, the roundabout is not preferred, as the benefits are lower and the costs higher than the unsignalized intersection.

Analysis Summary

Cost Categories	Net Present Value of Costs	
	Two-Way Stop Control	Roundabout
Planning, Construction & Right of Way Costs	$ 6,475,000	$ 8,180,000
Post-Opening Costs	$ 10,645	$ 43,484
Auto Passenger Delay	$ 300,238	$ 1,930,974
Truck Delay	$ 32,610	$ 209,728
Safety	$ 1,055,162	$ 364,641
Total cost	**$7,873,655**	**$10,728,827**
Select Base Case for Benefit-Cost Comparison:	Two-Way Stop Control	
Benefit Categories	**Net Present Value of Benefits Relative to Base Case**	
	Two-Way Stop Control	**Roundabout**
Auto Passenger Delay		$ (1,630,736)
Truck Delay		$ (177,118)
Safety		$ 690,522
Net Present Value of Benefits		**$ (1,117,333)**
Net Present Value of Costs		**$ 1,737,839**
Net Present Value of Improvement		**$ (2,855,171)**
Benefit-Cost (B/C) Ratio		**preferred. Benefits are less than base case and cost is greater than base**
Delay B/C		**preferred. Benefits are less than base case and cost is greater than base**
Safety B/C		**0.40**

Figure 2 – Screenshot of the ICE Tool Results for Ayer Road / Gebo Lane

Environmental Impacts

Neither the SPICE Tool nor the ICE Tool consider a significant concern with the implementation of the roundabout alternative, which is the environmental impacts to Article 97 restricted conservation land located immediately to the east of the Ayer Road right-of-way in the vicinity of Gebo Lane. The one-lane roundabout design would result in approximately an additional 500 SF of wetland fill and would impact approximately 10,000 SF of Article 97 restricted conservation land. Modification of the disposition of the Article 97 conservation land would require action by the Massachusetts State Legislature. The standard T-intersection geometry as proposed would not result in these environmental impacts. TEC considered locating the roundabout to the west to remove all Article 97 impacts. This roundabout location would cause a significant shift in the alignment of Ayer Road, creating additional wetlands and property acquisition impacts.

Summary

After performing the alternatives analysis using the MassDOT-recommended Tools, TEC has found that the roundabout alternative provides a benefit in the reduction of future crashes. However, the alternative with the best overall cost benefit is the unsignalized T-intersection. In addition, significant environmental concerns regarding the roundabout alignment exist. TEC continues to recommend that the current design alternative, including a standard unsignalized T-intersection, be advanced to 25% Design, as the roundabout alternative does not provide an overall cost benefit to the public.