TO:	Barry P. Winer	DATE:	February 24, 2020
FROM:	Brian Beisel, PTP Michael Littmen, P.E.	HSH PROJECT NO.:	2019239.00
SUBJECT:	Sight Distance Technical Memorandum Jefferson Mill		

Howard Stein Hudson (HSH) has prepared this technical memorandum to evaluate the sight distance for the Jefferson Mill development (the "Project") located at 1665 Main Street in Holden, Massachusetts (the "Site"). The Project is proposing to utilize the existing Village Way/Mill Pond Place, as the primary site driveway (the "Site Driveway"). The Town of Holden requested the sight distance calculations be based on the observed speeds along Main Street. Two sight distance measurements have been evaluated; The Stopping Sight Distance (SSD) and the The Intersection Sight Distance (ISD). Both sight distance calculations are based on the AASHTO publication *A Policy on Geometric Design of Highways and Streets*, 6th Edition (the "Green Book").

Vehicle Speed Data Collection

The vehicular speed along Main Street is a critical component necessary to calculate sight distance. Automated traffic recorder (ATR) data was used to collect speed data, along with volume data and class data, on Thursday February 20, 2020. The weather was partly cloudy and the roadway was dry, ideal for measuring baseline speeds along the roadway. The sight distance calculations use the 85th percentile speed along the roadway. The 85th percentile speed along Main Street was observed as 41 mph in the northbound direction and 48 mph in the southbound direction. The ATR data is provided as an **Attachment**.

Stopping Sight Distance

SSD is the distance needed for an approaching motorist to perceive an obstruction ahead and be able to stop prior to reaching the obstruction. The minimum SSD at an intersection is a requirement necessary to determine the safety of an intersection as outlined in the Green Book which states, "The provision of stopping sight distance at all locations along each highway or street, including intersection approaches, is fundamental to intersection operation."

SSD calculations also take into consideration grade changes along the approaching roadway. The SSD increases on a downgrade and decreases for an upgrade. The Site Driveway intersects Main Street at a low point therefore both appeaches along Main Street have downgrades. The northbound

approach has a downgrade of approximately 4 percent and the southbound approach has a downgrade of approximately 3 percent.

The SSD measurements were taken from the approaching travel lanes to 10 feet off of the edge of the travel way on the Site Driveway. There was found to be approximately 440 feet of available sight distance as motorists approach in the northbound direction and approximately 650 feet of sight distance as motorists approach in the southbound direction. Both of the approach sight distances are greater than the minimum SSD required. The critical values in the SSD calculation is summarized in **Table 1** and the calculations are provided as an **Attachment**.

Table 1.   Stopping Sight Distance Summary

	Northbound	Southbound
85th Percentile Speed (mph)	41	48
SSD Minimum	316	394
Grade	4% downgrade	3% downgrade
SSD Required (feet)	335	420
SSD Available (feet)	440	650
SSD Satisfied?	**YES**	**YES**

Conclusion

As shown, the SSD is satisfied in both directions. However in order to ensure that sight distance is maximized to the greatest extent possible during all seasons, HSH recommends that the vegitation to the south of the driveway be trimmed and maintained to allow for optimal sight lines.

Speed Report

Job   569_C72_HSH_ATR
Area   Jefferson, MA
Location   Route 122A (Main Street), south of Village Way
Dir   Northbound
Thursday, February 20, 2020

Time	Total	Speed Bins (mph)															
		0 5	5 10	10 15	15 20	20 25	25 30	30 35	35 40	40 45	45 50	50 55	55 60	60 65	65 70	70 75	75 80
0000	42	0	0	0	1	1	2	14	13	10	1	0	0	0	0	0	0
0100	26	0	0	0	1	0	2	4	14	3	2	0	0	0	0	0	0
0200	16	0	0	0	0	0	0	2	7	6	1	0	0	0	0	0	0
0300	11	0	0	0	0	0	0	1	8	2	0	0	0	0	0	0	0
0400	18	0	0	0	1	0	0	1	8	6	1	1	0	0	0	0	0
0500	33	0	0	0	1	1	0	4	23	4	0	0	0	0	0	0	0
0600	109	0	0	0	1	1	2	8	52	40	5	0	0	0	0	0	0
0700	149	0	0	0	0	2	1	11	77	54	4	0	0	0	0	0	0
0800	211	0	0	0	2	4	4	19	119	58	5	0	0	0	0	0	0
0900	247	0	0	0	0	5	3	30	142	63	4	0	0	0	0	0	0
1000	288	0	0	0	4	11	5	36	172	55	4	1	0	0	0	0	0
1100	346	0	0	0	2	2	9	60	180	86	7	0	0	0	0	0	0
1200	378	0	0	1	2	4	4	34	250	81	2	0	0	0	0	0	0
1300	398	0	0	0	0	3	3	49	250	90	3	0	0	0	0	0	0
1400	487	0	0	0	2	11	13	76	274	102	8	1	0	0	0	0	0
1500	628	0	0	0	0	5	4	115	391	106	7	0	0	0	0	0	0
1600	720	0	0	1	3	3	18	83	434	174	4	0	0	0	0	0	0
1700	771	0	0	0	2	7	8	126	498	128	2	0	0	0	0	0	0
1800	595	0	0	0	5	15	21	128	346	78	2	0	0	0	0	0	0
1900	390	0	0	0	5	6	15	69	234	60	1	0	0	0	0	0	0
2000	303	0	0	0	3	5	3	50	197	42	3	0	0	0	0	0	0
2100	245	0	0	0	2	2	3	62	145	31	0	0	0	0	0	0	0
2200	167	0	0	0	2	7	0	23	91	39	5	0	0	0	0	0	0
2300	74	0	0	0	0	0	4	11	41	16	2	0	0	0	0	0	0
Total	**6652**	**0**	**0**	**2**	**39**	**95**	**124**	**1016**	**3966**	**1334**	**73**	**3**	**0**	**0**	**0**	**0**	**0**
	100.00%	**0.00%**	**0.00%**	**0.03%**	**0.59%**	**1.43%**	**1.86%**	**15.27%**	**59.62%**	**20.05%**	**1.10%**	**0.05%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**

Maximum = 52.7 mph, Minimum = 14.7 mph, Mean = 37.3 mph
85% Speed = 40.66 mph, 95% Speed = 42.50 mph, Median = 37.64 mph
10 mph Pace = 33 - 43, Number in Pace = 5876 (88.33%)
Variance = 15.74, Standard Deviation = 3.97 mph

Speed Report

Job 569_C72_HSH_ATR
Area Jefferson, MA
Location Route 122A (Main Street), south of Village Way
Dir Southbound
Thursday, February 20, 2020

Time	Total	Speed Bins (mph)															
		0 5	5 10	10 15	15 20	20 25	25 30	30 35	35 40	40 45	45 50	50 55	55 60	60 65	65 70	70 75	75 80
0000	9	0	0	0	0	0	1	0	0	3	5	0	0	0	0	0	0
0100	9	0	0	0	0	1	0	0	4	1	2	1	0	0	0	0	0
0200	11	0	0	0	0	0	0	0	0	2	2	4	3	0	0	0	0
0300	30	0	0	0	0	1	0	0	4	10	8	7	0	0	0	0	0
0400	106	0	0	0	0	2	3	0	6	35	43	13	4	0	0	0	0
0500	334	0	0	0	0	2	1	2	55	153	106	12	3	0	0	0	0
0600	618	0	0	1	2	5	3	1	48	283	230	43	2	0	0	0	0
0700	673	0	0	0	1	14	10	14	96	302	206	30	0	0	0	0	0
0800	637	0	0	0	1	7	3	7	79	319	194	22	4	1	0	0	0
0900	477	0	0	0	2	10	8	6	87	191	146	25	2	0	0	0	0
1000	417	0	0	2	4	4	6	8	72	194	110	15	1	1	0	0	0
1100	452	0	0	1	1	3	4	6	72	207	133	24	1	0	0	0	0
1200	406	0	0	0	3	15	4	9	77	190	94	12	1	1	0	0	0
1300	360	0	0	0	1	3	2	5	51	181	91	23	3	0	0	0	0
1400	341	0	0	0	2	3	1	6	57	141	114	15	2	0	0	0	0
1500	381	0	0	0	2	3	3	9	54	176	113	20	1	0	0	0	0
1600	356	0	0	1	3	5	5	5	42	177	92	23	3	0	0	0	0
1700	353	0	0	0	1	1	6	9	62	174	88	11	1	0	0	0	0
1800	256	0	0	0	1	8	1	5	61	119	50	10	1	0	0	0	0
1900	173	0	0	0	2	4	0	4	42	79	32	9	1	0	0	0	0
2000	125	0	0	0	2	3	2	1	20	58	34	5	0	0	0	0	0
2100	101	0	0	0	1	2	1	3	14	41	27	11	1	0	0	0	0
2200	72	0	0	0	0	2	0	0	7	28	25	7	2	1	0	0	0
2300	43	0	0	0	0	0	0	0	6	11	13	5	6	2	0	0	0
Total	**6740**	**0**	**0**	**5**	**29**	**98**	**64**	**100**	**1016**	**3075**	**1958**	**347**	**42**	**6**	**0**	**0**	**0**
		0.00%	0.00%	0.07%	0.43%	1.45%	0.95%	1.48%	15.07%	45.62%	29.05%	5.15%	0.62%	0.09%	0.00%	0.00%	0.00%

100.00%

Maximum = 61.5 mph, Minimum = 10.5 mph, Mean = 43.1 mph
85% Speed = 47.65 mph, 95% Speed = 50.44 mph, Median = 43.45 mph
10 mph Pace = 38 - 48, Number in Pace = 5222 (77.48%)
Variance = 28.29, Standard Deviation = 5.32 mph

Table 3-1. Stopping Sight Distance on Level Roadways

Metric					U.S. Customary				
Design Speed (km/h)	Brake Reaction Distance (m)	Braking Distance on Level (m)	Stopping Sight Distance Calculated (m)	Stopping Sight Distance Design (m)	Design Speed (mph)	Brake Reaction Distance (ft)	Braking Distance on Level (ft)	Stopping Sight Distance Calculated (ft)	Stopping Sight Distance Design (ft)
20	13.9	4.6	18.5	20	15	55.1	21.6	76.7	80
30	20.9	10.3	31.2	35	20	73.5	38.4	111.9	115
40	27.8	18.4	46.2	50	25	91.9	60.0	151.9	155
50	34.8	28.7	63.5	65	30	110.3	86.4	196.7	200
60	41.7	41.3	83.0	85	35	128.6	117.6	246.2	250
70	48.7	56.2	104.9	105	40	147.0	153.6	300.6	305
80	55.6	73.4	129.0	130	45	165.4	194.4	359.8	360
90	62.6	92.9	155.5	160	50	183.8	240.0	423.8	425
100	69.5	114.7	184.2	185	55	202.1	290.3	492.4	495
110	76.5	138.8	215.3	220	60	220.5	345.5	566.0	570
120	83.4	165.2	248.6	250	65	238.9	405.5	644.4	645
130	90.4	193.8	284.2	285	70	257.3	470.3	727.6	730
					75	275.6	539.9	815.5	820
					80	294.0	614.3	908.3	910

Note: Brake reaction distance predicated on a time of 2.5 s; deceleration rate of 3.4 m/s² [11.2 ft/s²] used to determine calculated sight distance.

Design Values

The stopping sight distance is the sum of the distance traversed during the brake reaction time and the distance to brake the vehicle to a stop. The computed distances for various speeds at the assumed conditions on level roadways are shown in Table 3-1 and were developed from the following equation:

Metric	U.S. Customary	
$$SSD = 0.278Vt + 0.039\frac{V^2}{a}$$	$$SSD = 1.47Vt + 1.075\frac{V^2}{a}$$	(3-2)

where:

SSD	=	stopping sight distance, m	SSD	=	stopping sight distance, ft
V	=	design speed, km/h	V	=	design speed, mph
t	=	brake reaction time, 2.5 s	t	=	brake reaction time, 2.5 s
a	=	deceleration rate, m/s²	a	=	deceleration rate, ft/s²

Stopping sight distances exceeding those shown in Table 3-1 should be used as the basis for design wherever practical. Use of longer stopping sight distances increases the margin for error for all drivers and, in particular, for those who operate at or near the design speed during wet pavement conditions. New pavements should have initially, and should retain, friction coefficients consistent with the deceleration rates used to develop Table 3-1.

Equations Used:

$$SSD = 1.47ut + \frac{u^2}{30\left(\frac{a}{32.2} \pm G\right)}$$

Inputs: Direction

		Northbound	Southbound	Units
Speed	u	41	48	mph
Break Reaction Time (AASHTO Recomended)	t	2.5	2.5	seconds
Deceleration Rate (AASHTO Recomended)	a	11.2	11.2	ft/second^2
Roadway Grade	G	-0.04	-0.03	ft/ft

Final Results: Direction

		Northbound	Southbound
Stopping Sight Distance	**SSD**	**335**	**420**