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PRINCIPALS
Robert J. Michaud, P.E.
Ronald D. Desrosiers, P.E., PTOE
Daniel J. Mills, P.E., PTOE

MEMORANDUM

DATE: October 21, 2009

TO: Mr. Robert Kiley, Trustee
High Oaks Realty Trust
P.O. Box 381
Groton, MA 01450

FROM: Robert J. Michaud, P.E. – Managing Principal
Daniel A. Dumais, E.I.T. – Senior Transportation Engineer

RE: **Proposed Houghton Farm Residential Development**
Sugar Road – Bolton, MA

MDM Transportation Consultants, Inc. (MDM) has prepared this traffic impact assessment (TIA) for the proposed 15-lot single family residential development to be located off of Sugar Road in Bolton, Massachusetts. This memorandum describes existing (baseline) traffic conditions for adjacent roadways, trip generation characteristics of the proposed development, quantifies incremental traffic impacts of the site development on area roadways, and evaluates safety-related conditions at key study locations that provide access to the site.

Key findings of the traffic assessment are as follows:

- *Existing Traffic Characteristics*. The weekday daily traffic volume on Sugar Road to the south of Golden Run Road is approximately 1,430 vehicles per day (vpd) and the daily traffic volume on Sugar Road to the east of Golden Run Road is approximately 840 vpd. Observed peak hour traffic flow on Sugar Road represents up to 100 vehicles per hour (vph) adjacent to the site which represents approximately 12 percent of daily traffic flow. The traffic flow on Sugar Road to the south of Golden Run Road is highly directional with approximately 84 percent of the traffic traveling southbound during the weekday morning peak hour and approximately 62 percent of the traffic traveling northbound during the weekday evening peak hour. The travel pattern is consistent with commuter traffic relative to major travel routes in the area (Route 117 and I-495).

- *Traffic Generation*. The proposed residential development is estimated to generate approximately 11 new vehicle trips (3 entering and 8 exiting) during the morning peak hour and 15 new vehicle trips (9 entering and 6 exiting) during the weekday evening peak hour. On a daily basis, the proposed residential use is estimated to generate approximately 144 vehicle trips on a weekday with 50 percent entering and exiting.

- *Adequate Roadway Capacity.* Adequate capacity is available along Sugar Road and Golden Run Road and at study intersections impacted by the site to accommodate projected traffic increases for the proposed residential development. Vehicle delays at the nearby Sugar Road and Golden Run Road study intersections are projected at less than 10 seconds (LOS A) on average during the critical peak hours. The project is estimated to result in an increase in daily traffic on Sugar Road immediately adjacent to the site from approximately 840 vehicles per day (vpd) to approximately 984 vpd. The resulting Sugar Road traffic volume will remain well under capacity.

- *Safety Characteristics.* No immediate safety countermeasures are required at the study intersection of Sugar Road and Golden Run Road based on historic crash data. Likewise, safe stopping sight distance (SSD) is available for oncoming vehicles to detect, react and stop for vehicles exiting onto Sugar from the proposed site driveway based on regulatory speed limits and observed travel speeds.

  Independent of the project, MDM recommends selective clearing of existing roadside vegetation along the eastern side of Sugar Road, within public way, to enhance sight lines (Intersection Sight Distance) for the Sugar Road westbound approach to the intersection of Sugar Road and Golden Run Road. MDM also recommends that all way STOP control be implemented at the intersection of Sugar Road and Golden Run Road, subject to approval from the Board of Selectmen and independent of the proposed residential project.

PROJECT DESCRIPTION

The project site is an approximate 72-acre tract of land located in the northeast corner of the intersection of Sugar Road and Golden Run Road in Bolton, Massachusetts. There is existing site frontage along Sugar Road, Golden Run Road, and Pinewood Road. The location of the site relative to adjacent roadways is shown in **Figure 1**. The site is comprised of approximately 12 acres of open fields with the remaining area comprised of mature hardwood forest.

Under the proposed development plan the site will be developed as a Farmland and Open Space Planned Residential Development (FOSPRD) and will include 15 single family residential lots and approximately 35 acres of open space. A new cul-de-sac subdivision roadway will connect with Sugar Road approximately 230 feet east of its intersection with Golden Run Road. The proposed roadway is to be 20 feet wide, approximately 1,500 feet in length and will include a fire parking lane located near Sugar Road for access to the existing fire pond. Two (2) of the proposed lots will be frontage lots and will have direct access to Sugar Road and Golden Run Road. The preliminary site layout prepared by Ducharme & Dillis Civil Design Group, Inc. is presented in **Figure 2.**

Figure 1

Site Location

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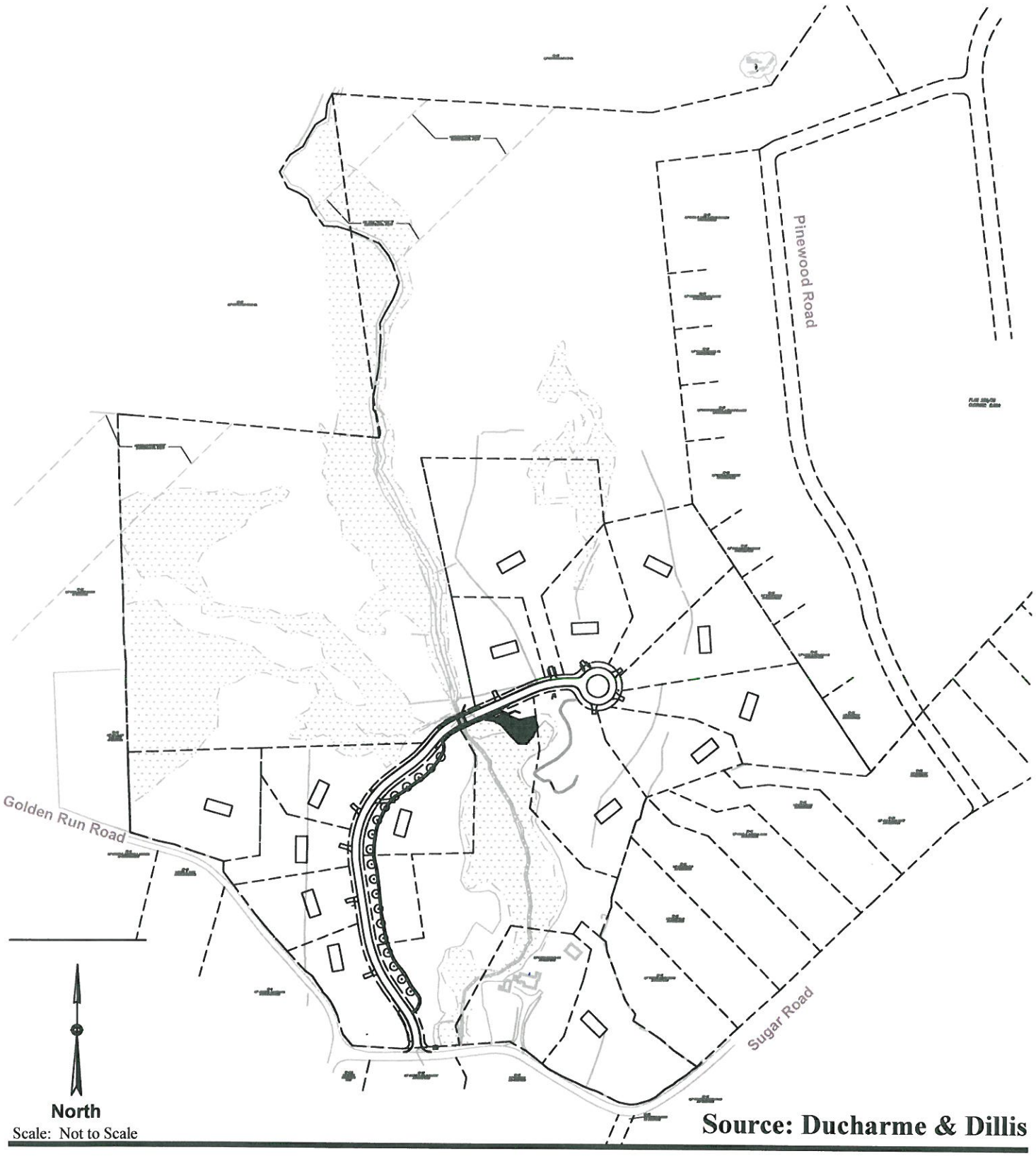

Scale: Not to Scale

Source: Ducharme & Dillis

Figure 2

Preliminary Site Layout

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EXISTING ROADWAY CHARACTERISTICS

An overview of roadway classification and geometric characteristics is provided below for study roadways and intersections.

Roadways

Sugar Road

Sugar Road is classified by the Massachusetts Executive Office of Transportation (EOT) as an Urban Local roadway and is under the Town of Bolton jurisdiction. Sugar Road is designated under the Town of Bolton Zoning Bylaws as a Scenic Road. Sugar Road transitions from a north-south roadway to an east-west roadway at its intersection with Corn Road located to the east of the project area. The roadway width in the immediate project area varies between 18 and 20 feet and provides one lane of travel in each direction with no sidewalk. The posted speed limit along Sugar Road in the study area is 20 miles per hour. Land use along Sugar Road is primarily residential with access points to several parcels of conservation land.

Golden Run Road

Golden Run Road is generally a southeast-northwest roadway under local (Town) jurisdiction and is classified as a Rural Local roadway by the Massachusetts EOT. Golden Run Road is designated under the Town of Bolton Zoning Bylaws as a Scenic Road. This roadway provides a connection between Sugar Road to the south and Harvard Road to the north. Golden Run Road is winding with rolling terrain, has a variable pavement width of approximately 16 feet and provides one lane of travel in each direction with no sidewalk. The regulatory (prima facie) speed limit along Golden Run Road is 20 mph. Land use adjacent to the roadway is primarily single family residential homes.

Intersections

Sugar Road at Golden Run Road

Golden Run Road meets Sugar Road to form a "T"-type unsignalized intersection with the Golden Run Road southbound approach and the Sugar Road westbound approach operating under STOP sign control. The Sugar Road approaches provide single general-purpose travel lanes and are relatively flat near the intersection. Golden Run Road has a down-grade slope of approximately 10 percent and provides a single general-purpose travel lane. There is no sidewalk located along either roadway. Land use at the intersection consists of a residential house (#205 Sugar Road), conservation land (Town of Bolton) and an undeveloped parcel of land (Site). Intersection sight distance looking south from the westbound Sugar Road approach is limited due to vegetation within the right-of-way and Town of Bolton conservation land (Josiah Whitcomb Garrison House) parcel.

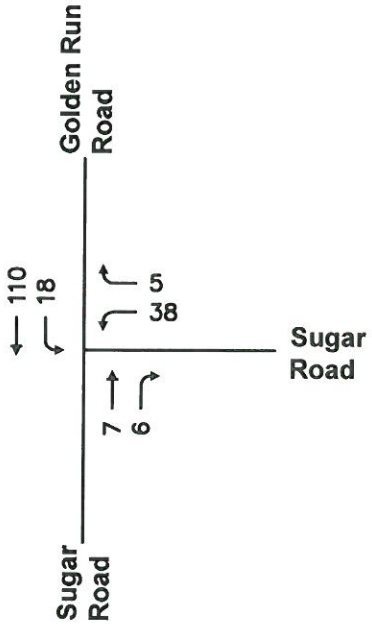
BASELINE TRAFFIC DATA

This traffic memorandum includes evaluation of area roadways likely to sustain a measurable impact from the proposed development which includes the following intersection:

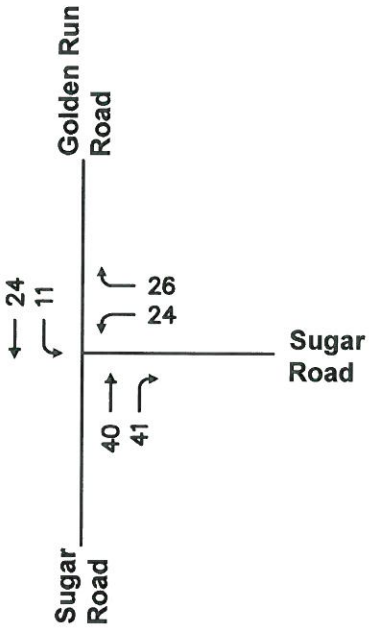
- Golden Run Road at Sugar Road
- Sugar Road at Proposed Site Driveway

Traffic volume data were collected at the study area intersections during the weekday morning (7:00 AM - 9:00 AM) and weekday evening (4:00 PM – 6:00 PM) periods to coincide with peak traffic activity of the proposed residential use and the adjacent streets. Traffic data used in this evaluation were collected in October 2009, which represents above-average traffic conditions based on review of MassHighway permanent count station data for the area. Therefore, no adjustment (reduction) was applied to observed traffic volumes to present a conservative analysis. The weekday morning and evening peak hours of traffic volume for the study intersections are shown in **Figure 3**.

Daily traffic volumes along Sugar Road in the site vicinity were collected using automated traffic recorders (ATR's) in October 2009. Daily traffic count data are summarized in **Table 1.** Traffic count data and MassHighway permanent count station data are provided in the **Attachments.**



Weekday Morning Peak Hour



North
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Weekday Evening Peak Hour

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Figure 3

2009 Existing Conditions
Peak Hour Traffic Volumes

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TABLE 1
EXISTING TRAFFIC VOLUME SUMMARY

Time Period	Daily Volume (vpd)[1]	Percent Daily Traffic[2]	Peak Hour Volume (vph)[3]	Peak Flow Direction[4]	Peak Hour Directional Volume (vph)
Sugar Road east of Golden Run Road					
Weekday Morning Peak Hour	840	10%	85	53% WB	45
Weekday Evening Peak Hour	840	12%	100	60% WB	60
Sugar Road south of Golden Run Road					
Weekday Morning Peak Hour	1,430	13%	185	84% SB	155
Weekday Evening Peak Hour	1,430	9%	130	62% NB	80

[1]Two-way daily traffic expressed in vehicles per day with no seasonal adjustment.
[2]The percent of daily traffic that occurs during the peak hour.
[3]Two-way peak-hour volume expressed in vehicles per hour.
[4]EB = Eastbound, WB = Westbound, NB = Northbound, SB = Southbound

As summarized in **Table 1**:

- The weekday daily traffic volume on Sugar Road to the south of Golden Run Road is approximately 1,430 vehicles per day (vpd) and the daily traffic volume on Sugar Road to the east of Golden Run Road is approximately 840 vpd.

- Peak hour traffic flow on Sugar Road ranges from approximately 85 to 100 vehicles per hour (vph) adjacent to the site which represents 10 to 12 percent of daily traffic flow.

- The traffic flow on Sugar Road to the south of Golden Run Road is highly directional with approximately 84 percent of the traffic traveling southbound during the weekday morning peak hour and approximately 62 percent of the traffic traveling northbound during the weekday evening peak hour. The travel pattern is consistent with commuter traffic relative to major travel routes in the area (Route 117 and I-495).

Measured Travel Speeds

Vehicle speeds were obtained for Sugar Road at the proposed site driveway location approximately 200 feet east of Golden Run Road by timing vehicles over a known distance and then converting the travel times to speeds. These measured travel speeds provide a basis for determining sight line requirements at the proposed subdivision roadway (site driveway) and at the study intersection. **Table 2** presents a summary of the travel speed data collected for Sugar Road in the site vicinity. Collected speed data are provided in the **Attachments**.

TABLE 2
SPEED STUDY RESULTS
SUGAR ROAD (Site Vicinity)

Travel Direction	Speed Limit[1]	Travel Speed	
		Mean[2]	85th Percentile[3]
Eastbound	20	28	30
Westbound	20	27	32

[1] Posted Speed limit in miles per hour (mph)
[2] Arithmetic mean
[3] The speed at or below which 85 percent of the vehicles are traveling

As summarized in **Table 2**, the mean (average) travel speed on Sugar Road eastbound and westbound was observed to be 28 mph and 27 mph respectively; the 85th percentile travel speed eastbound and westbound was observed to be 30 mph and 32 mph respectively. The observed average and 85th percentile travel speeds are travel speeds are considerably higher that the posted regulatory speed limit on limit on Sugar Road in the immediate study area, but consistent with the regulatory posted speed limit of 30 mph away immediately beyond the intersection.

INTERSECTION CRASH HISTORY

In order to identify crash trends and safety characteristics for study area intersections, crash data were obtained from MassHighway for the Town of Bolton for the three-year period 2005 through 2007 (the most recent data currently available from MassHighway). A summary of the crash data with crash rates for the study intersection with reported crashes is detailed in **Table 3**.

Crash rates were calculated for the study intersection as reported in **Table 3**. This rate quantifies the number of crashes per million entering vehicles. MassHighway has determined the official statewide and District 3 (which includes the Town of Bolton) crash rate to be 0.69 for unsignalized intersections. This rate represent MassHighway's "average" crash rate and serves as a basis for comparing the reported crash rate for the study intersection.

As summarized in **Table 3**, only one (1) crash was reported for the unsignalized Sugar Road at Golden Run Road intersection resulting in a sideswipe type accident under dark wet conditions. The crash resulted in property damage only. The resulting crash rate of 0.50 is below the District 3 average crash rate for unsignalized intersections no immediate safety countermeasures are warranted based on the crash history at the study location.

TABLE 3
INTERSECTION CRASH SUMMARY
2005 THROUGH 2007[1]

Data Category	INTERSECTION Sugar Road at Golden Run Road
Traffic Control	Unsignalized
Crash Rate[2]	**0.50**
MHD District 3 Avg.[2]	0.69
Year:	
2005	1
2006	0
2007	0
Total	**1**
Type:	
Angle	0
Rear-End	0
Head-On	0
Sideswipe	1
Single Vehicle	0
Unknown/Other	0
Severity:	
P. Damage Only	1
Personal Injury	0
Fatality	0
Hit and Run	0
Conditions:	
Dry	0
Wet	1
Snow	0
Other/Unreported	0
Time:	
7:00 to 9:00 AM	0
4:00 to 6:00 PM	0
Rest of Day	1

[1] Source: MassHighway Crash Database.
[2] Crashes per million entering vehicles (MEV)
[3] District 3 Average Crash Rate

Trip Generation

The trip generation estimates for the proposed residential development are provided for the weekday morning and weekday evening periods, which correspond to the critical weekday analysis periods for the proposed use and adjacent street traffic flow. New traffic generated by the project was estimated using trip rates published in ITE's *Trip Generation*[1] for the Land Use Code (LUC) 220 – Single Family Detached Housing. **Table 4** presents the trip-generation estimate for the proposed development based on ITE methodology.

TABLE 4
TRIP-GENERATION SUMMARY

Period/Direction	Site Trips[1]
Weekday Morning Peak Hour	
Entering	3
Exiting	8
Total	11
Weekday Evening Peak Hour	
Entering	9
Exiting	6
Total	15
Weekday Daily	144

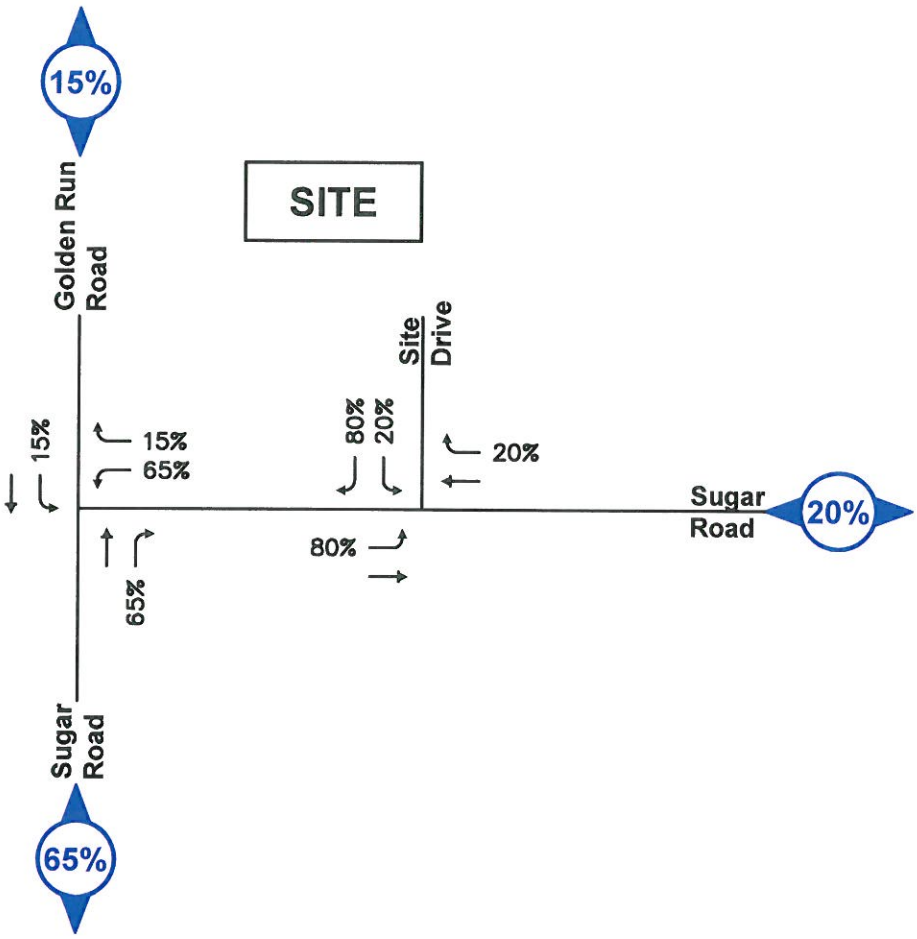
Source: ITE *Trip Generation*, Eighth Edition; 2008.
[1]Based on ITE LUC 210 (Single-Family Detached Housing) applied to 15 units.

As summarized in **Table 3**, the proposed residential subdivision is estimated to generate approximately 11 vehicle trips (3 entering and 8 exiting) during the weekday morning peak hour and 15 vehicle trips (9 entering and 6 exiting) during the weekday evening peak hour. On a daily basis, the proposed residential use is estimated to generate approximately 144 vehicle trips on a weekday with 50 percent entering and exiting. Trip generation calculations are provided in the **Attachments**.

Trip Distribution

The distribution for projected traffic for the residential development is based on existing travel patterns of the adjacent roadway system and Journey to Work data published by the US Census for the Town of Bolton. The resulting trip distribution is presented in **Figure 4**.

[1]*Trip Generation*, Eighth Edition; Institute of Transportation Engineers; Washington, DC; 2008.



North
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Figure 4

Trip Distribution
Peak Hour Traffic Volumes

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Figure 5 presents projected site-generated traffic volumes for the proposed residential development based on trip generation presented in **Table 3** and projected travel patterns presented in **Figure 4**.

Build Traffic Volume Networks

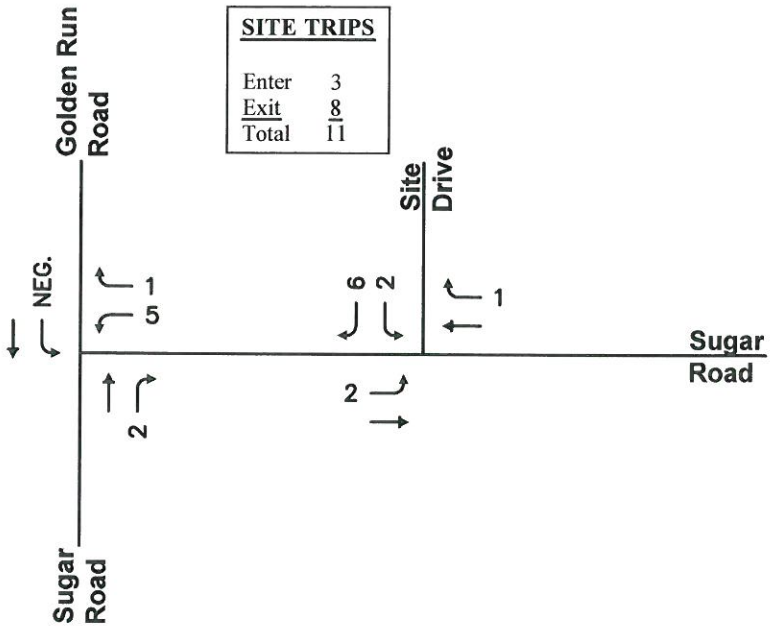
Analysis traffic volumes are developed by adding site-generated traffic volumes presented in **Figure 5** to existing traffic volumes at study intersections. The resulting Build traffic volumes used for analysis are shown in **Figure 6**.

TRAFFIC OPERATIONS ANALYSIS

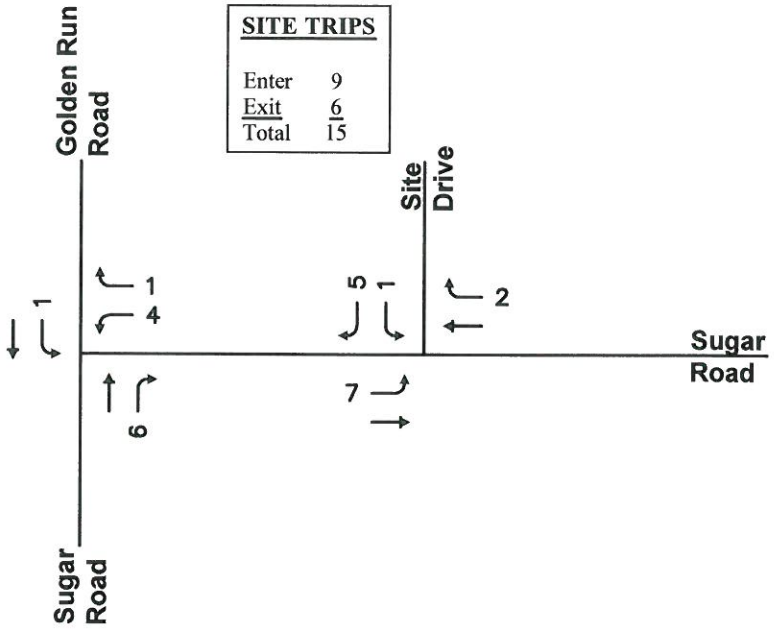
Intersection capacity analyses are presented in this section for the Existing and Build traffic-volume conditions. Capacity analyses, conducted in accordance with EOEEA/EOT guidelines, provide an index of how well the roadway facilities serve the traffic demands placed upon them. The operational results provide the basis for recommended access and roadway improvements in the following section.

Capacity analysis of intersections is developed using the Synchro® Version 6 computer software, which implements the methods of the 2000 Highway Capacity Manual (HCM). The resulting analysis presents a level-of-service (LOS) designation for individual intersection movements and (for signalized intersections) for the entire intersection. The LOS is a letter designation that provides a qualitative measure of operating conditions based on several factors including roadway geometry, speeds, ambient traffic volumes, traffic controls, and driver characteristics. Since the LOS of a traffic facility is a function of the traffic flows placed upon it, such a facility may operate at a wide range of LOS, depending on the time of day, day of week, or period of year. A range of six levels of service are defined on the basis of average delay, ranging from LOS A (the least delay) to LOS F (delays greater than 50 seconds for unsignalized movements). The specific control delays and associated LOS designations are presented in the **Appendix**.

LOS analyses were conducted for Existing and Build conditions for the study intersections. The results of the intersection capacity analyses are summarized in **Table 5**.



Weekday Morning Peak Hour



North
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Weekday Evening Peak Hour

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Figure 5

Site-Generated Trips
Peak Hour Traffic Volumes

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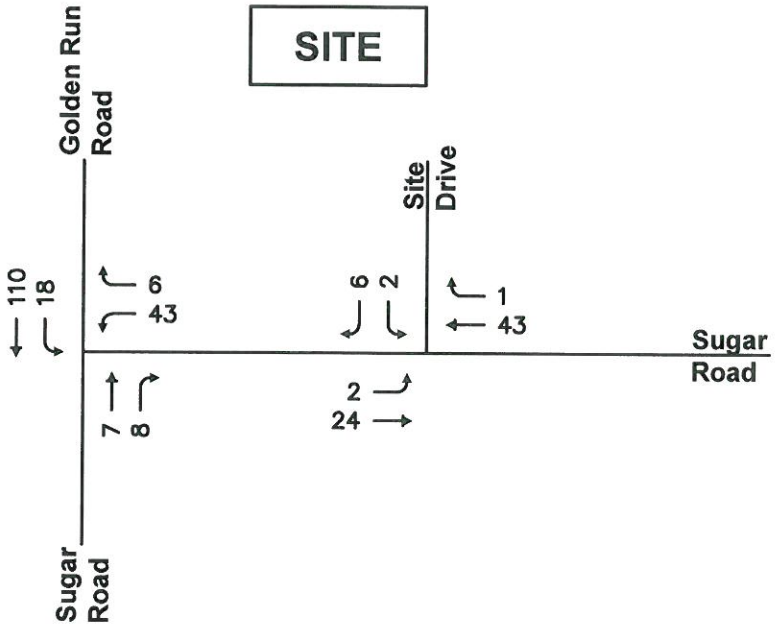
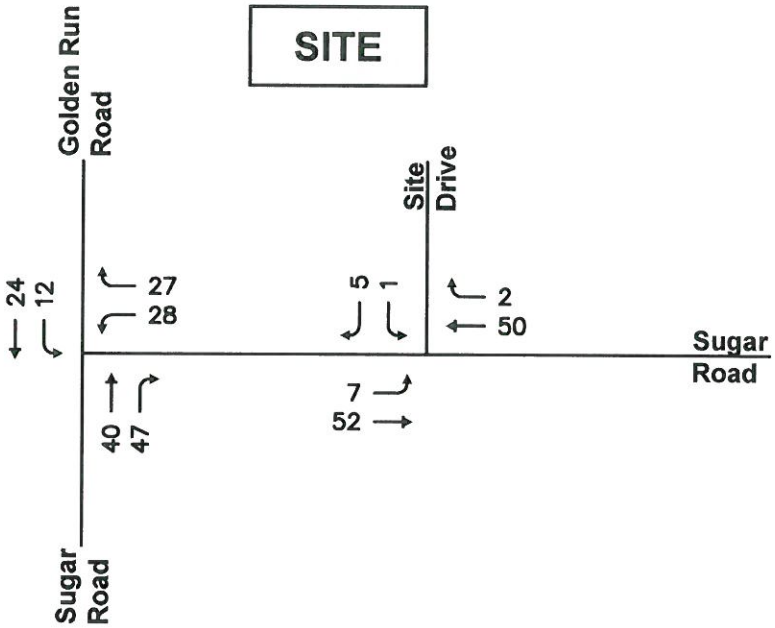


Weekday Morning Peak Hour



North
Scale: Not to Scale

Weekday Evening Peak Hour

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Figure 6

Build Conditions
Peak Hour Traffic Volumes

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TABLE 5
INTERSECTION CAPACITY ANALYSIS RESULTS

Period	Approach	2009 Existing v/c[1]	2009 Existing Delay[2]	2009 Existing LOS[3]	Build v/c	Build Delay	Build LOS
Weekday Morning Peak Hour							
Sugar Road at Site Driveway	Eastbound	n/a[4]	n/a	n/a	0.00	<5	A
	Southbound	n/a	n/a	n/a	0.01	9	A
Sugar Road at Golden Run Road	Westbound	0.06	8	A	0.07	8	A
	Northbound	0.02	<5	A	0.02	<5	A
	Southbound	0.16	8	A	0.16	8	A
Weekday Evening Peak Hour							
Sugar Road at Site Driveway	Eastbound	n/a	n/a	n/a	0.01	<5	A
	Southbound	n/a	n/a	n/a	0.01	9	A
Sugar Road at Golden Run Road	Westbound	0.06	7	A	0.07	7	A
	Northbound	0.09	<5	A	0.10	<5	A
	Southbound	0.04	7	A	0.05	7	A

[1]Volume-to-capacity ratio
[2]Average control delay per vehicle (in seconds)
[3]Level of service
[4]n/a = Not Applicable

As summarized in **Table 5**:

- Under Build conditions, the site driveway intersection with Sugar Road will operate with minimal delay at a level of service (LOS) 'A' or better during the peak hours.

- Under Build conditions the intersection of Sugar Road and Golden Run Road will continue to operate at a LOS A or better during the weekday morning and evening peak hours. There will be no change in operations or level of service at this location due to the project.

SIGHT LINE EVALUATION

The evaluation documents existing sight distances for vehicles exiting the proposed site driveway onto Sugar Road with comparison to recommended guidelines for the posted speed limit and measured travel speeds.

The American Association of State Highway and Transportation Officials' (AASHTO) standards[2] reference two types of sight distance which are relevant at the proposed site driveway intersection with Sugar Road: stopping sight distance (SSD) and intersection sight distance (ISD). Sight lines for critical vehicle movements at the Sugar Road and proposed site driveway intersection were compared to minimum SSD and ISD for the regulatory speed limit and measured travel speeds along Sugar Road in the site vicinity.

Stopping Sight Distance

Sight distance is the length of roadway visible to the motorist to a fixed object. The minimum sight distance available on a roadway should be sufficiently long enough to enable a below-average operator, traveling at or near a regulatory speed limit, to stop safely before reaching a stationary object in its path, in this case, a vehicle exiting from the proposed site driveway onto Sugar Road. The SSD criteria are defined by AASHTO based on design and operating speeds, anticipated driver behavior and vehicle performance, as well as physical roadway conditions. SSD includes the length of roadway traveled during the perception and reaction time of a driver to an object, and the distance traveled during brake application on wet, level pavements. Adjustment factors are applied to account for roadway grades.

SSD was estimated in the field using AASHTO standards for driver's eye (3.5 feet) and object height equivalent to the taillight height of a passenger car (2.0 feet) for the eastbound and westbound Sugar Road approaches to the proposed site driveway. **Table 6** presents a summary of the available SSD for the Sugar Road roadway segments approaching the proposed site driveway and AASHTO's recommended SSD for the posted (regulatory) speed limit and observed average and 85th percentile travel speeds.

[2] *A policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials (AASHTO), 2004.

TABLE 6
Stopping Sight Distance Summary
Sugar Road Approaches to Site Driveway

Approach/ Travel Direction	Available Stopping Sight Distance	AASHTO Recommended[1]		
		Regulatory Speed (20 mph)	Average Travel Speed[2]	85th Percentile Travel Speed[3]
Eastbound	245± Feet[4]	115 Feet	173 Feet	200 Feet
Westbound	265± Feet	115 Feet	182 Feet	220 Feet

[1]Recommended sight distance based on AASHTO, A Policy on Geometric Design of Highways and Streets. Based on driver height of eye of 3.5 feet to object height of 2.0 feet and adjustments for roadway grade.
[2]Average Speed is 28 mph EB and 27 mph WB.
[3]85th Percentile travel speed is 30 mph EB and 32 mph WB
[4]This location is the approximate decision point location for right turn movements from Sugar Road; however, sight lines are available up to 375 feet traveling northbound on Sugar Road. Based on field observations the regulatory speed limit of 20 mph provides a conservative estimate for travel speeds at the decision point.

As summarized in **Table 6** analysis results indicate that the existing available sight lines exceed AASHTO's recommended SSD criteria for both travel directions along Sugar Road based on the regulatory speed limit and observed average and 85th percentile travel speeds.

Intersection Sight Distance

Clear sight lines provide sufficient sight distance for a stopped driver on a minor-road approach to depart from the intersection and enter or cross the major road. As stated under AASHTO's Intersection Sight Distance (ISD) considerations, "*...If the available sight distance for an entering ...vehicle is at least equal to the appropriate stopping sight distance for the major road, then drivers have sufficient sight distance to avoid collisions...To enhance traffic operations, intersection sight distances that exceed stopping sight distances are desirable along the major road.*" AASHTO's ISD criteria are defined into several "cases". Each case depends on the type of traffic control at the intersection (e.g. no control, *Yield* sign, *Stop* sign, and signal control), and the specific vehicle maneuver in question (crossing, right- or left-turn). AASHTO Cases B1 (left turns) and B2 (right turns) from the proposed site driveway were utilized in determining the recommended intersection sight distance summarized in **Table 7** below.

Available ISD was estimated in the field using AASHTO standards for driver's eye (3.5 feet), object height (3.5 feet) and decision point (14.5 feet from edge of travel way) for the eastbound and westbound directions along Sugar Road. **Table 7** presents a summary of the available ISD for the departure from the proposed site driveway and AASHTO's recommended ISD for the regulatory speed limit and measured travel speeds.

TABLE 7
Intersection Sight Distance Summary
Site Driveway Departure to Sugar Road

Approach/ Travel Direction	Available Intersection Sight Distance	AASHTO Recommended[1]		
		Regulatory Speed (20 mph)	Average Travel Speed[2]	85th Percentile Travel Speed[3]
Looking East	265± Feet	115 Feet	182 Feet	220 Feet
Looking West	245± Feet[4]	115 Feet	173 Feet	200 Feet

[1]Recommended sight distance based on AASHTO, A Policy on Geometric Design of Highways and Streets. Based on driver height of eye of 3.5 feet to object height of 3.5 feet and adjustments for roadway grade.
[2]Average Speed is 28 mph EB and 27 mph WB.
[3]85th Percentile travel speed is 30 mph EB and 32 mph WB
[4]This location is the approximate decision point location for right turn movements from Sugar Road; however, sight lines are available up to 375 feet for vehicles approaching on the Sugar Road northbound approach. Based on field observations the regulatory speed limit of 20 mph provides a conservative estimate for travel speeds at the decision point. The intersection of Sugar Road and Golden Run Road will be clearly visible assuming sight lines are cleared with the installation of the proposed subdivision roadway.

The results of the ISD analysis presented in **Table 7** indicate that the existing available sight lines looking east and west from the proposed site driveway onto Sugar Road exceed the recommended sight line requirements from AASHTO for the posted speed limit and observed travel speeds. MDM recommends clearing of the existing vegetation within the driveway sight line triangles to ensure sight lines are maximized. New plantings (shrubs, bushes) or physical landscape features to be located within the driveway sight lines should also be maintained at a height of 2 feet or less to ensure unobstructed line of sight.

CONCLUSIONS AND RECOMMENDATIONS

In summary, adequate capacity is available along Sugar Road and at study intersections impacted by the site to accommodate projected traffic increases for the proposed residential development. Vehicle delays at Sugar Road and nearby study intersections are projected to be minimal during the weekday morning and weekday evening peak hours. No immediate safety countermeasures are required at the study location based on historic crash data. Likewise, safe stopping sight distance (SSD) is available for oncoming vehicles to detect, react and stop for vehicles exiting onto Sugar from the proposed site driveway based on regulatory speed limits and observed travel speeds.

Independent of the project, MDM recommends selective clearing of existing roadside vegetation along the eastern side of Sugar Road, within the public way, to enhance sight lines (Intersection Sight Distance) for the Sugar Road westbound approach to the intersection of Sugar Road and Golden Run Road. MDM also recommends that all way STOP control be implemented at the intersection of Sugar Road and Golden Run Road, subject to approval from the Board of Selectmen and independent of the proposed residential project.

Attachments

- □ Traffic Volume Data
- □ Spot Speed Data
- □ Crash Data
- □ Seasonal Data
- □ Trip Generation Calculations
- □ Trip Distribution Calculations
- □ Capacity Analyses

□ Traffic Volume Data

Transportation Data Corporation
Mario Perone, mperone1@verizon.net
t. (781) 587-0086 f. (781) 587-0189

Sugar Road north of
Golden Run Road
City, State: Bolton, MA
Client: MDM/D. Dumais

03961Avolume
Site Code: 509

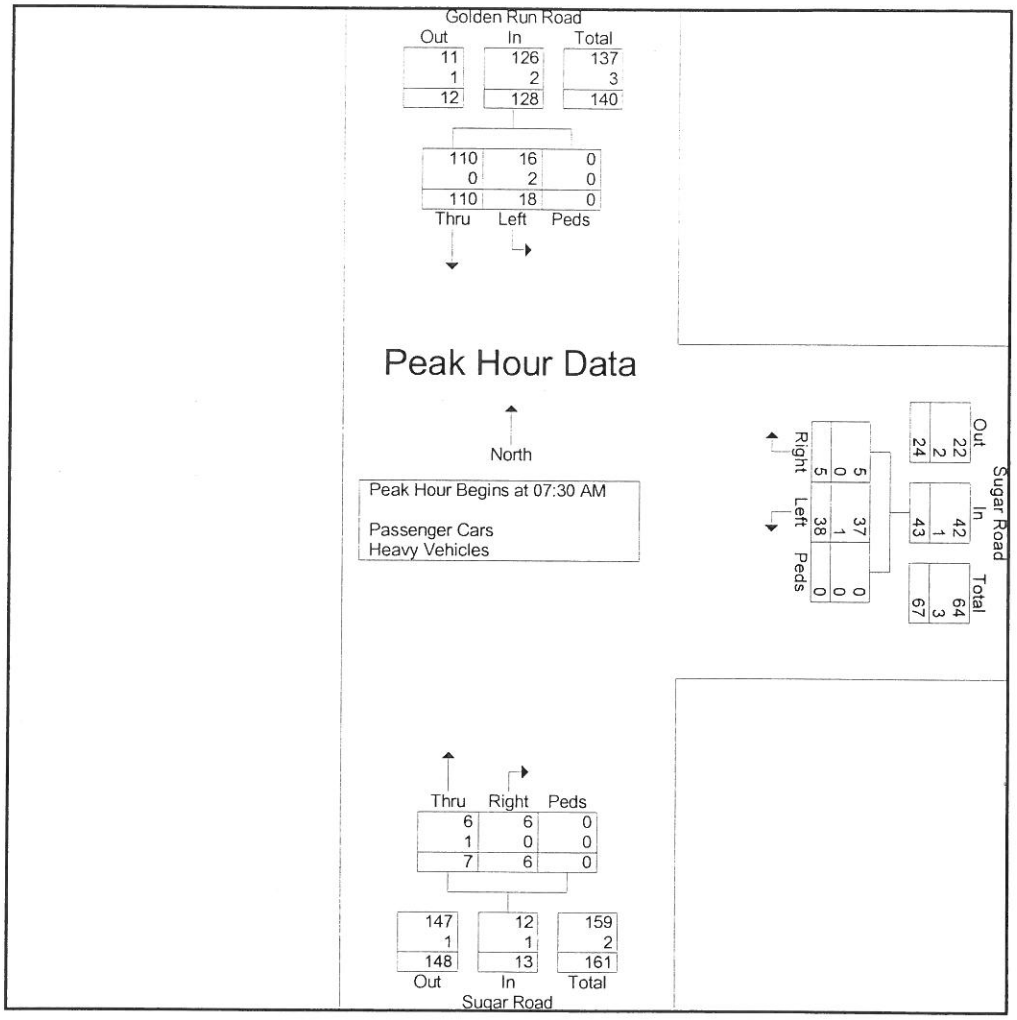
Start Time	06-Oct-09 Tue	NB Morning	NB Afternoon	Hour Totals Morning	Hour Totals Afternoon	SB Morning	SB Afternoon	Hour Totals Morning	Hour Totals Afternoon	Combined Totals Morning	Combined Totals Afternoon
12:00		1	4			0	4				
12:15		0	6			0	5				
12:30		0	6			0	3				
12:45		0	5	1	21	0	4	0	16	1	37
01:00		0	3			0	7				
01:15		0	4			0	6				
01:30		0	3			0	6				
01:45		0	6	0	16	0	3	0	22	0	38
02:00		0	2			0	5				
02:15		0	8			0	5				
02:30		0	8			0	5				
02:45		0	9	0	27	0	2	0	17	0	44
03:00		0	4			0	8				
03:15		0	8			1	4				
03:30		0	6			0	10				
03:45		0	10	0	28	0	14	1	36	1	64
04:00		0	7			0	7				
04:15		0	6			0	5				
04:30		0	9			1	5				
04:45		0	7	0	29	1	12	2	29	2	58
05:00		2	8			3	15				
05:15		0	9			0	19				
05:30		0	11			0	16				
05:45		1	7	3	35	4	12	7	62	10	97
06:00		1	10			1	18				
06:15		2	12			2	12				
06:30		2	10			4	11				
06:45		7	10	12	42	4	9	11	50	23	92
07:00		4	9			5	6				
07:15		2	6			9	3				
07:30		7	6			18	3				
07:45		13	5	26	26	16	4	48	16	74	42
08:00		12	4			6	0				
08:15		14	3			20	2				
08:30		4	9			10	3				
08:45		8	5	38	21	9	1	45	6	83	27
09:00		5	3			8	0				
09:15		2	4			9	2				
09:30		6	3			10	1				
09:45		4	2	17	12	6	0	33	3	50	15
10:00		3	0			2	1				
10:15		4	4			2	2				
10:30		5	0			3	1				
10:45		9	0	21	4	4	0	11	4	32	8
11:00		1	0			7	0				
11:15		6	1			4	1				
11:30		6	0			5	1				
11:45		5	1	18	2	5	0	21	2	39	4
Total		136	263			179	263			315	526
Percent		34.1%	65.9%			40.5%	59.5%			37.5%	62.5%
Grand Total			136	263			179	263			315	526
Percent			34.1%	65.9%			40.5%	59.5%			37.5%	62.5%
ADT			ADT 841		AADT 841							

MDM Transportation Consultants, Inc.

28 Lord Road, Suite 280
Marlborough, MA 01752

N: Sugar Road
S: Golden Run Road
W: Sugar Road

File Name : 509 TMC Sugar at Golden Run AM
Site Code : 50900001
Start Date : 10/8/2009
Page No : 2

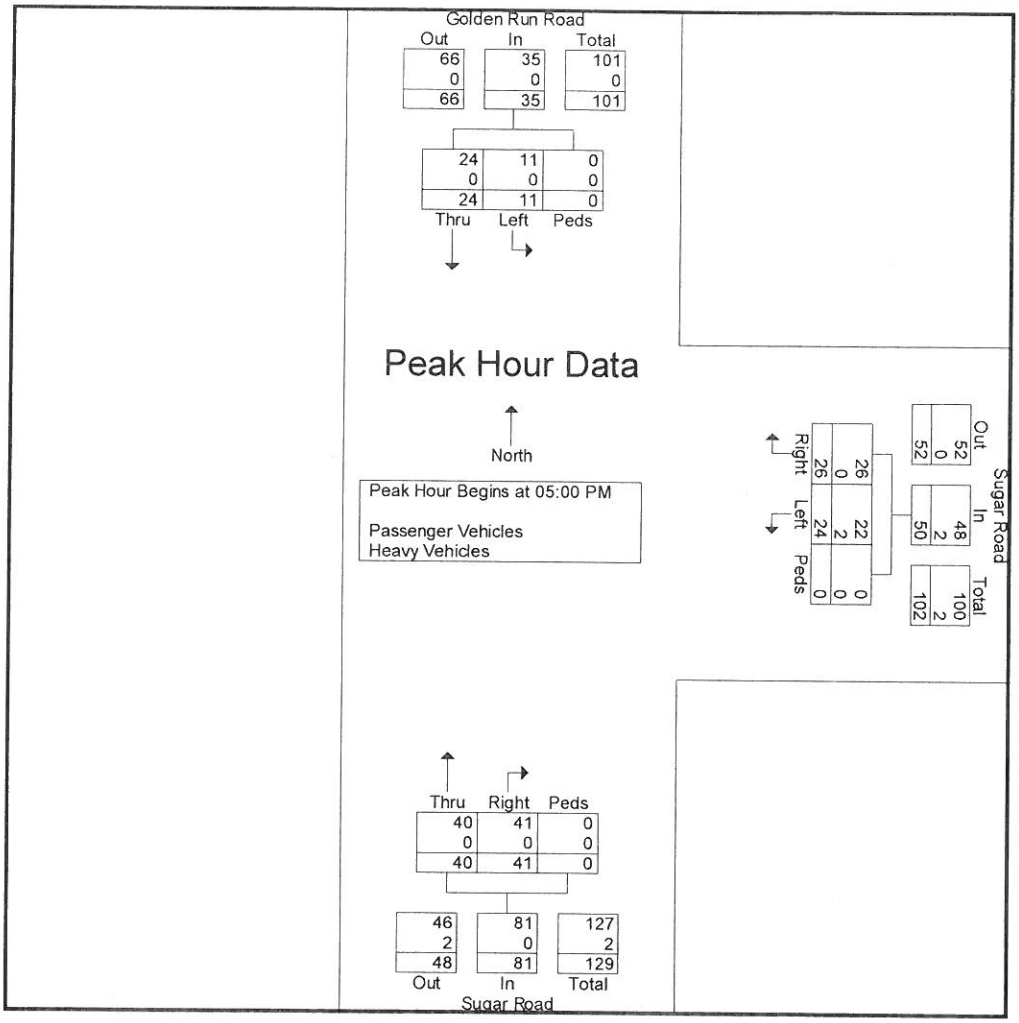


MDM Transportation Consultants, Inc.

28 Lord Road, Suite 280
Marlborough, MA 01752

N: Sugar Road
S: Golden Run Road
W: Sugar Road
Bolton, MA

File Name : 509 TMC Sugar at Golden Run PM
Site Code : 50900002
Start Date : 10/8/2009
Page No : 2



□ Spot Speed Data

MDM Transportation Consultants, Inc.

28 Lord Road, Suite 280
Marlborough, MA 01752

File Name : 509 Spot Speed Combined
Site Code : 05090001
Start Date : 10/8/2009

#	Eastbound	Westbound
1	27	35
2	27	32
3	25	23
4	25	24
5	29	32
6	32	30
7	33	25
8	29	28
9	28	23
10	26	31
11	30	27
12	19	22
13	26	33
14	29	27
15		25
16		22
17		26
18		26
19		

Class	Vehicle Count	Average Speed	True Median (50th Percentile)	85 Percentile	10 MPH Pace Speed	Number in Pace	Percent in Pace	Number of Vehicles Over 20 MPH	Percent of Vehicles Over 20 MPH
Eastbound	14	28	28	30	24 - 33	13	93	13	93
Westbound	18	27	26	32	22 - 31	14	78	18	100
Summary	32	27	27	32	23 - 32	26	81	31	97

□ Crash Data

MassHighway

CRASH RATE WORKSHEET

CITY/TOWN : Bolton, MA COUNT DATE : Oct-09 **MHD USE ONLY**

DISTRICT : 3 UNSIGNALIZED : x SIGNALIZED : Source #

~ INTERSECTION DATA ~

MAJOR STREET : Sugar Road ST #

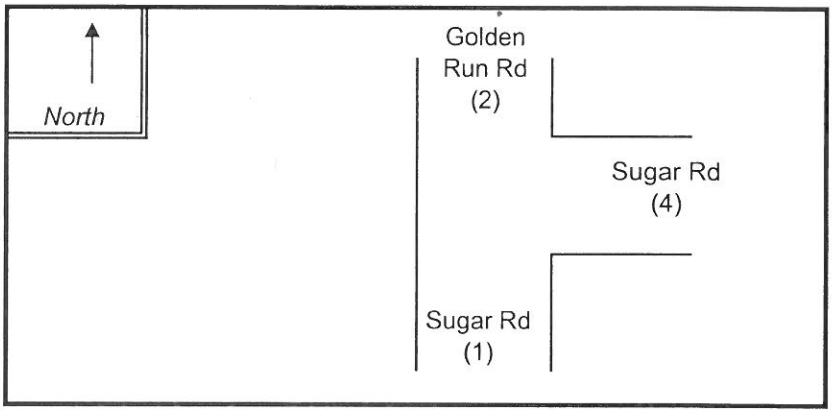
MINOR STREET(S) : Golden Run Road ST #

ST #

ST #

ST #

INTERSECTION DIAGRAM (Label Approaches)



INTERSECTION REF #

(1)

Peak Hour Volumes

APPROACH :	1	2	3	4	5	**Total Entering Vehicles**
DIRECTION :	NB	SB	EB	WB		
VOLUMES (**PM**) :	81	35		50		**166**

" K " FACTOR : **0.090** APPROACH ADT : **1,844** **ADT** = TOTAL VOL/"K" FACT.

TOTAL # OF ACCIDENTS : 1 # OF YEARS : 3 AVERAGE # OF ACCIDENTS (**A**) : **0.33**

CRASH RATE CALCULATION : **0.50** RATE = $\frac{(A * 1{,}000{,}000)}{(ADT * 365)}$

Comments :

Project Title & Date: 509 - Bolton (October 2009)

MASS HIGHWAY

MassHighway Crash Report for Bolton 2006

Crash Number	City/Town Name	Crash Date	Crash Time	Crash Severity	Number of Vehicles	Total Nonfatal Injuries	Total Fatal Injuries	Manner of Collision	Vehicles Travel Directions	Most Harmful Events	Road Surface Condition	Ambient Light	Weather Condition	At Roadway Intersection	Distance from Nearest Roadway Intersection	Distance from Nearest Milemarker	Distance from Nearest Exit	Distance from Nearest Landmark	Non Motorist Type	X Coordinate	Y Coordinate

□ Seasonal Data

SECTION I - CONTINUOUS COUNTING STATION MONTHLY AVERAGE DAILY TRAFFIC

STATION 9 - BOLTON - RTE.I-495 - NORTH OF RTE.62

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	October Adjustment to year	
02	82,222	86,945	83,851	93,720	97,882	100,741	108,519	111,011	*100,000*	92,992	85,888	86,224	94,166	1.01	
	-4%	-8%	1%	-2%	0%	0%	-3%	-5%	1%	6%	8%	-3%	-1%		
03	78,671	79,756	84,400	91,562	98,000	100,760	105,330	106,000	101,250	98,860	92,696	83,323	93,384	0.94	
												Growth	**-0.83%**	0.98	Sub Average

STATION 403 - CONCORD - RTE.2 - 0.2 km EAST OF CONCORD ROTARY

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
02	*44,954*	45,810	46,721	48,169	49,311	51,680	47,639	48,050	48,219	49,947	45,640	45,000	47,595	0.95	
	0%	-5%	-1%	-2%	-2%	0%	-7%	-3%	-2%	-2%	7%	7%	-1%		
03	44,737	43,740	46,023	47,402	48,225	51,537	44,070	46,781	47,154	49,000	48,980	*48,000*	47,137	0.96	
	1%	5%	2%	2%	0%	4%	5%	0%	1%	0%	-6%	-4%	1%		
04	45,000	46,000	46,867	48,260	48,136	53,710	46,206	46,905	47,793	49,000	46,023	*45,983*	47,490	0.97	
	-9%	-5%	-3%	-4%	-2%	-5%	-3%	-1%	-4%	0%	-2%	-6%	-4%		
05	41,051	43,677	45,426	46,370	46,939	51,129	44,632	46,318	46,004	49,000	45,178	*43,329*	45,754	0.93	
	8%	0%	2%	-2%	-1%	-3%	-3%	-2%	0%	0%	0%	0%	0%		
06	44,150	43,659	46,395	45,607	46,453	49,481	43,449	45,449	45,925	49,000	44,963	*43,417*	45,662	0.93	
												Growth	**-1.02%**	0.95	Sub Average

STATION 4089 - MARLBOROUGH - RTE.I-495 - NORTH OF RTE.I-290

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
02	77,668	*92,058*	87,824	96,397	103,604	107,137	111,880	116,046	103,409	102,673	93,211	93,000	98,742	0.96	
	0%	-2%	4%	-1%	-8%	-6%	0%	-1%	0%	-1%	4%	-1%	-1%		
03	77,926	*90,000*	*91,000*	*95,000*	95,435	100,796	111,611	115,416	102,927	101,626	96,652	*92,000*	97,532	0.96	
	10%	-2%	0%	-2%	7%	5%	3%	0%	-7%	-2%	-3%	4%	1%		
05	86,000	88,000	91,400	93,441	102,364	106,066	115,416	115,922	96,206	99,993	93,582	95,470	98,655	0.99	
	7%	7%	4%	4%	-2%	0%	-6%	-2%	9%	-1%	0%	-5%	1%		
06	91,632	93,896	94,654	97,548	99,848	106,518	107,960	113,530	104,483	99,380	93,184	90,801	99,453	1.00	
												Growth	**0.05%**	0.99	Sub Average

STATION 4164 - MARLBOROUGH - RTE.I-495 - SOUTH OF RTE.I-290

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
02	77,707	80,439	81,100	86,449	89,762	92,496	92,846	*92,419*	90,162	90,587	85,227	84,000	86,933	0.96	
	-1%	-1%	0%	-5%	-1%	-4%	-1%	0%	-4%	2%	-5%	-8%	-2%		
03	*77,000*	*80,000*	*81,000*	81,845	89,106	89,000	*92,313*	*92,139*	86,275	92,284	81,115	77,674	84,979	0.92	
	-1%	-1%	5%	4%	-1%	8%	5%	1%	11%	2%	6%	5%	4%		
04	75,960	79,210	*84,900*	*85,000*	*88,000*	96,485	97,307	93,364	95,515	93,682	86,306	81,816	88,129	0.94	
	4%	3%	0%	9%	9%	4%	-2%	8%	-2%	-1%	8%	10%	4%		
05	79,000	81,755	84,587	92,269	96,161	100,110	95,264	100,510	93,379	92,615	93,638	90,255	91,629	0.99	
	3%	1%	2%	-7%	-6%	-4%	-2%	-1%	2%	1%	-5%	-7%	-2%		
06	81,709	82,413	86,405	86,233	90,449	96,153	92,889	99,498	94,991	93,287	89,334	84,009	89,781	0.96	
												Growth	**0.85%**	0.95	Sub Average

STATION 4172 - ACTON - RTE.2 - 1.6 km WEST OF RTE.27

YR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR		
02	36,353	37,058	38,281	39,159	40,388	39,770	36,773	39,939	37,226	40,848	37,179	37,000	38,331	0.94	
	-6%	-4%	-5%	-1%	-2%	1%	5%	-4%	7%	2%	2%	-3%	-1%		
03	34,042	35,512	36,375	38,809	39,678	40,000	38,757	38,417	39,804	41,741	38,098	35,900	38,094	0.91	
	5%	5%	7%	3%	1%	5%	0%	3%	9%	4%	3%	4%	4%		
04	35,765	37,276	38,911	40,010	40,194	42,010	38,646	39,710	43,483	43,584	39,252	37,476	39,693	0.91	
												Growth	**1.79%**	0.92	Sub Average

Average Adjusment Factor (October) 0.96

Average Yearly Growth Calculated 0.17%

MADT

ITALICS = ESTIMATED DATA

□ Trip Generation Calculations

Institute of Transportation Engineers (ITE)
Land Use Code (LUC) 210 - Single-Family Detached Housing

Average Vehicle Trips Ends vs: Dwelling Units
Independent Variable (X): 15

AVERAGE WEEKDAY DAILY

T = 9.57* (X)
T = 9.57* 15
T = 143.55
T = 144 vehicle trips
with 50% (72 vpd) entering and 50% (72 vpd) exiting.

WEEKDAY MORNING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.75* (X)
T = 0.700 * 15
T = 11.25
T = 11 vehicle trips
with 25% (3 vph) entering and 75% (8 vph) exiting.

WEEKDAY EVENING PEAK HOUR OF ADJACENT STREET TRAFFIC

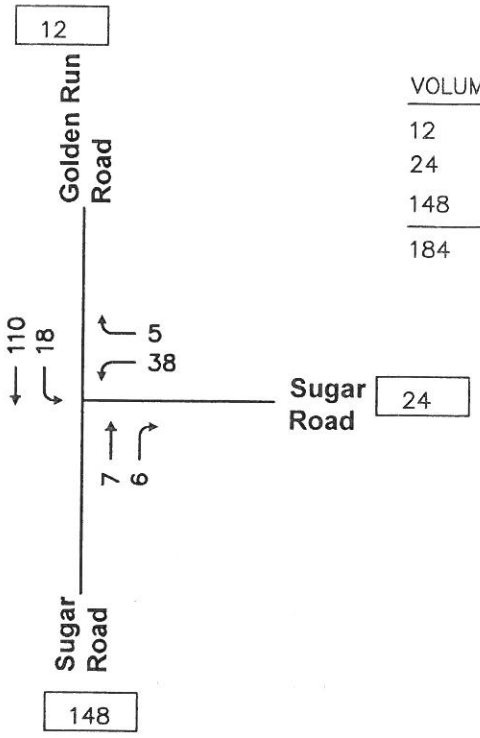
T = 1.01* (X)
T = 1.01* 15
T = 15.15
T = 15 vehicle trips
with 63% (9 vph) entering and 37% (6 vph) exiting.

SATURDAY DAILY

T = 10.08* (X)
T = 10.08* 15
T = 151.20
T = 151 vehicle trips
with 50% (76 vph) entering and 50% (75 vph) exiting.

SATURDAY MIDDAY PEAK HOUR OF GENERATOR

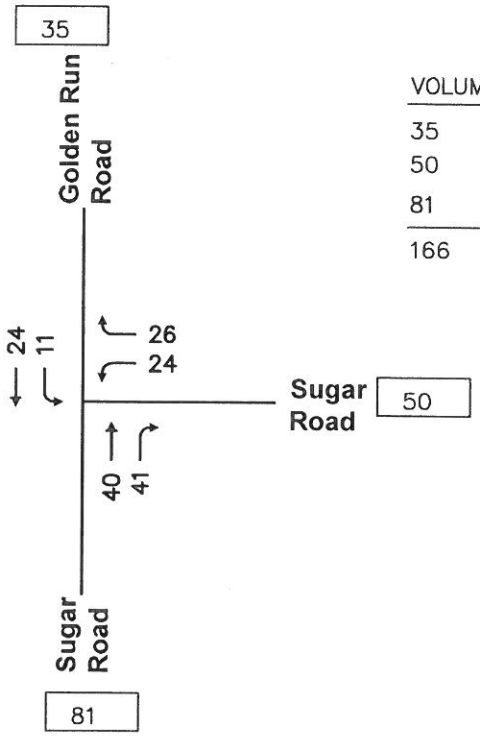
T = 0.93* (X)
T = 0.93* 15
T = 13.95
T = 14 vehicle trips
with 53% (7 vph) entering and 47% (7 vph) exiting.



VOLUME	%
12	7%
24	13%
148	80%
184	100%

TO WORK

Weekday Morning Peak Hour



VOLUME	%
35	21%
50	30%
81	49%
166	100%

AVG. AM & PM	
VOLUME	%
Golden Run	15%
Sugar E/W	20%
Sugar N/S	65%
	100%

North

Scale: Not to Scale

FROM WORK

Weekday Evening Peak Hour

MDM TRANSPORTATION CONSULTANTS, INC.
Planners & Engineers

Appendix

Trip Distribution Calculations
Peak Hour Traffic Volumes

Date: October 2009
Dwg No. 509 TIAS.dwg
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Residence State-County-MCD Name	Workplace State-County-MCD Name	Count	%
Bolton town Worcester Co. MA	Hopkinton town Middlesex Co. MA	25	1.1%
Bolton town Worcester Co. MA	Newton city Middlesex Co. MA	25	1.1%
Bolton town Worcester Co. MA	Woburn city Middlesex Co. MA	25	1.1%
Bolton town Worcester Co. MA	Maynard town Middlesex Co. MA	29	1.3%
Bolton town Worcester Co. MA	Fitchburg city Worcester Co. MA	30	1.4%
Bolton town Worcester Co. MA	Littleton town Middlesex Co. MA	30	1.4%
Bolton town Worcester Co. MA	Lancaster town Worcester Co. MA	33	1.5%
Bolton town Worcester Co. MA	Sudbury town Middlesex Co. MA	33	1.5%
Bolton town Worcester Co. MA	Leominster city Worcester Co. MA	36	1.6%
Bolton town Worcester Co. MA	Bedford town Middlesex Co. MA	37	1.7%
Bolton town Worcester Co. MA	Acton town Middlesex Co. MA	40	1.8%
Bolton town Worcester Co. MA	Framingham town Middlesex Co. MA	41	1.9%
Bolton town Worcester Co. MA	Chelmsford town Middlesex Co. MA	43	1.9%
Bolton town Worcester Co. MA	Lexington town Middlesex Co. MA	46	2.1%
Bolton town Worcester Co. MA	Concord town Middlesex Co. MA	48	2.2%
Bolton town Worcester Co. MA	Natick town Middlesex Co. MA	48	2.2%
Bolton town Worcester Co. MA	Stow town Middlesex Co. MA	50	2.3%
Bolton town Worcester Co. MA	Burlington town Middlesex Co. MA	55	2.5%
Bolton town Worcester Co. MA	Cambridge city Middlesex Co. MA	56	2.5%
Bolton town Worcester Co. MA	Waltham city Middlesex Co. MA	65	2.9%
Bolton town Worcester Co. MA	Boston city Suffolk Co. MA	78	3.5%
Bolton town Worcester Co. MA	Westbor. town Worcester Co. MA	91	4.1%
Bolton town Worcester Co. MA	Worcester city Worcester Co. MA	101	4.6%
Bolton town Worcester Co. MA	Marlbor. city Middlesex Co. MA	119	5.4%
Bolton town Worcester Co. MA	Hudson town Middlesex Co. MA	123	5.6%
Bolton town Worcester Co. MA	Bolton town Worcester Co. MA	399	18.0%
	Total	**2,212**	**100.0%**

FIPS State Code of Residence

FIPS County Code of Residence

FIPS County Subdivision Code of Residence

FIPS Metropolitan Statistical Area (MSA) or Consolidated Metropolitan Statistical Area (CMSA) Code of Residence
This field contains the 4-digit code for the MSAs and CMSAs designated June 30, 1999.
9999 Appears for nonmetropolitan areas

FIPS Primary Metropolitan Statistical Area (PMSA) Code of Residence
This field contains the 4-digit code for the PMSAs designated June 30, 1999.
9999 Not in a PMSA

Residence County Subdivision and County names and State abbreviation

Modified FIPS State Code or Foreign Country/Area Code of Workplace
FIPS State codes have been extended to three characters by adding a leading zero.

FIPS County Code of Workplace
000 Appears in conjunction with codes for workplaces in a Foreign Country/Area.

FIPS County Subdivision Code of Workplace

FIPS Metropolitan Statistical Area (MSA) or Consolidated Metropolitan Statistical Area (CMSA) Code of Residence
This field contains the 4-digit code for the MSAs and CMSAs designated June 30, 1999.
9999 Appears for nonmetropolitan areas
bbbb This field is blank for workplaces outside the U.S. such as Puerto Rico or a foreign country.

FIPS Primary Metropolitan Statistical Area (PMSA) Code of Residence
This field contains the 4-digit code for the PMSAs designated June 30, 1999.
9999 Not in a PMSA
bbbb This field is blank for workplaces in U.S. Island Areas or foreign countries.

Workplace County Subdivision and County names and State abbreviation

Number of Workers 16 years old and over in the commuter flow

□ Capacity Analyses

LEVEL OF SERVICE METHODOLOGY

Capacity analysis of intersections is developed using the Synchro® computer software, which implements the methods of the 2000 Highway Capacity Manual (HCM). The resulting analysis presents a level-of-service (LOS) designation for individual intersection movements and (for signalized intersections) for the entire intersection. The LOS is a letter designation that provides a qualitative measure of operating conditions based on several factors including roadway geometry, speeds, ambient traffic volumes, traffic controls, and driver characteristics. Since the LOS of a traffic facility is a function of the traffic flows placed upon it, such a facility may operate at a wide range of LOS, depending on the time of day, day of week, or period of year. A range of six levels of service are defined on the basis of average delay, ranging from LOS A (the least delay) to LOS F (delays greater than 50 seconds for unsignalized movements, and greater than 80 seconds for signalized movements).

Signalized Intersection Performance Measures

The six LOS designations for signalized intersections may be described as follows:

- *LOS A* describes operations with low control delay; most vehicles do not stop at all.
- *LOS B* describes operations with relatively low control delay. However, more vehicles stop than LOS A.
- *LOS C* describes operations with higher control delays. Individual cycle failures may begin to appear. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.
- *LOS D* describes operations with control delay in the range where the influence of congestion becomes more noticeable. Many vehicles stop and individual cycle failures are noticeable.
- *LOS E* describes operations with high control delay values. Individual cycle failures are frequent occurrences.
- *LOS F* describes operations with high control delay values that often occur with over-saturation. Poor progression and long cycle lengths may also be major contributing causes to such delay levels.

Unsignalized Intersection Performance Measures

The six LOS designations for unsignalized intersections may be described as follows:

- *LOS A* represents a condition with little or no control delay to minor street traffic.
- *LOS B* represents a condition with short control delays to minor street traffic.
- *LOS C* represents a condition with average control delays to minor street traffic.
- *LOS D* represents a condition with long control delays to minor street traffic.
- *LOS E* represents operating conditions at or near capacity level, with very long control delays to minor street traffic.
- *LOS F* represents a condition where minor street demand volume exceeds capacity of an approach lane, with extreme control delays resulting.

The LOS designations of unsignalized intersections are determined by application of a procedure described in the 2000 *Highway Capacity Manual.*[2] LOS is measured in terms of average control delay. Mathematically, control delay is a function of the capacity and degree of saturation of the lane group and/or approach under study and is a quantification of motorist delay associated with traffic control devices such as traffic signals and STOP signs. Control delay includes the effects of initial deceleration delay approaching a STOP sign, stopped delay, queue move-up time, and final acceleration delay from a stopped condition. Definitions for LOS at unsignalized intersections are also given in the *Highway Capacity Manual 2000.* **Table A2** summarizes the relationship between LOS and average control delay.

Table A2
LEVEL-OF-SERVICE CRITERIA FOR UNSIGNALIZED INTERSECTIONS[1]

Level of Service	Average Control Delay (seconds per vehicle)
A	≤ 10.0
B	10.1 to 15.0
C	15.1 to 25.0
D	25.1 to 35.0
E	35.1 to 50.0
F	>50.0

[1]Source: *Highway Capacity Manual 2000,* Transportation Research Board; Washington, DC; 2000.

[2] ibid

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Yield			Stop
Volume (vph)	38	5	7	6	18	110
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	42	6	8	7	20	122

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	48	14	142
Volume Left (vph)	42	0	20
Volume Right (vph)	6	7	0
Hadj (s)	0.15	-0.15	0.05
Departure Headway (s)	4.4	4.0	4.1
Degree Utilization, x	0.06	0.02	0.16
Capacity (veh/h)	789	871	868
Control Delay (s)	7.7	7.1	7.9
Approach Delay (s)	7.7	7.1	7.9
Approach LOS	A	A	A

Intersection Summary			
Delay	7.8		
HCM Level of Service	A		
Intersection Capacity Utilization	23.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Yield			Stop
Volume (vph)	43	6	7	8	18	110
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90
Hourly flow rate (vph)	48	7	8	9	20	122

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	54	17	142
Volume Left (vph)	48	0	20
Volume Right (vph)	7	9	0
Hadj (s)	0.15	-0.21	0.05
Departure Headway (s)	4.4	4.0	4.1
Degree Utilization, x	0.07	0.02	0.16
Capacity (veh/h)	789	879	863
Control Delay (s)	7.7	7.0	7.9
Approach Delay (s)	7.7	7.0	7.9
Approach LOS	A	A	A

Intersection Summary			
Delay	7.8		
HCM Level of Service	A		
Intersection Capacity Utilization	23.5%	ICU Level of Service	A
Analysis Period (min)	15		

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Sign Control	Stop		Yield			Stop
Volume (vph)	28	27	40	47	12	24
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	30	29	43	51	13	26

Direction, Lane #	WB 1	NB 1	SB 1
Volume Total (vph)	60	95	39
Volume Left (vph)	30	0	13
Volume Right (vph)	29	51	0
Hadj (s)	-0.12	-0.32	0.07
Departure Headway (s)	4.0	3.7	4.2
Degree Utilization, x	0.07	0.10	0.05
Capacity (veh/h)	858	934	841
Control Delay (s)	7.3	7.2	7.4
Approach Delay (s)	7.3	7.2	7.4
Approach LOS	A	A	A

Intersection Summary			
Delay	7.3		
HCM Level of Service	A		
Intersection Capacity Utilization	18.6%	ICU Level of Service	A
Analysis Period (min)	15		