Transportation
Land Development
Environmental
Services

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Memorandum

To: Ms. Elizabeth DeMille Barnett
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Town of Carlisle
66 Westford Street
Carlisle, MA 01741

Date: March 13, 2014

Project No.: 12623.00

From: Vinod Kalikiri, P.E., P.T.O.E.

Re: **Banta-Davis Land**
Route 225, Carlisle, Massachusetts

Supplemental Traffic Analysis

Vanasse Hangen Brustlin, Inc. (VHB) has prepared this memorandum as a supplement to the draft traffic memorandum that was previously prepared on January 24, 2014 to document the existing traffic conditions on Bedford Road (Route 225) at the driveway to Banta-Davis Athletic Facility (the Site) and the projected trip generation characteristics associated with the existing and potential future expansion of the athletic facility and the construction of a 48-unit multi-family rental development on the Site. This supplemental memorandum has been prepared at the request of the Town of Carlisle Affordable Housing Trust (Client), and specifically addresses the following additional items raised by the Carlisle School Committee.

- Trip generation estimate for a 400-student elementary school on the Banta-Davis land.
- Traffic capacity analysis at the following locations, for the specified conditions.
  - Intersection of multi-family residential driveway and Banta Davis Drive during the peak hours, if both the residential and school uses are constructed in addition to the athletic uses;
  - Intersection of Banta Davis Drive and Bedford Road during the peak hours, if both the residential and school uses are constructed in addition to the athletic uses; and,
  - Intersection of Banta Davis Drive at Bedford Road during the peak hours, if only the school is constructed in addition to the athletic uses.
- Preliminary traffic signal warrant analysis for the intersection of Banta Davis Drive at Bedford Road.
- Qualitative evaluation of the existing driveway for 338 Bedford Road as the driveway for a 48-unit apartment development as well, in lieu of using Banta-Davis Drive.

Elementary School Trip Generation

The Carlisle School Department is contemplating the construction of a 400-student elementary school on the Site. Peak hour traffic projections for the school use were derived from trip generation rates published by the ITE Trip Generation Manual[1], using the number of students as an *independent variable* in the analysis.

[1] Trip Generation Manual – 9th Edition; Institute of Transportation Engineers; Washington, D.C.; 2012

A review of the ITE trip estimates indicates that the ITE data is based on an assumption that only a relatively small percentage (approximately 20-percent) of the students are dropped off by their parents during the school peak times and the remaining 80-percent of students take the bus or other modes of transportation. This could potentially occur if the ITE rates are based on data collected at elementary schools across the country that have a high reliance on bus transportation and/or some of the schools studied in the ITE database are located in more urban areas where walking, as a mode of travel, is more common.

Since it is not possible to narrow down the data points used in the ITE analysis to suburban schools that are comparable to schools in towns like Carlisle, and also to provide a sensitivity analysis, an alternate peak hour trip generation estimate was also prepared for the condition where approximately 50-percent of the students are dropped off/picked up by parents. A 50-percent automobile mode of travel was selected for the alternate analysis to demonstrate the traffic effect if more children are driven to/from school by automobiles, as is the general tendency in many suburban school systems. The estimates based on both methods are summarized in Table 1 below.

Table 1: Elementary School Trip Generation

Time period	ITE based estimate [a]	Alternate estimate based on heavier reliance on automobiles [b]
Morning Peak Hour [c]		
In	99	218
Out	81	200
Total	180	418
Evening Peak Hour [c]		
In	29	72
Out	31	74
Total	60	146
Saturday Peak Hour [c]		
In	Negligible	Negligible
Out	Negligible	Negligible
Total	Negligible	Negligible

a Based on a 400-student elementary school (ITE LUC 520)
b ITE estimates prorated to reflect the condition where 50% of the students are dropped off/picked up by parents
c Vehicles per hour

As shown in Table 1, heavy reliance on bus or alternate mode of transportation, consistent with the data that forms the basis of the ITE rates, would result in approximately 180 trips (enter + exit) during the weekday morning commute peak hour and approximately a third of those trips during the afternoon commuter peak hour. The estimate for the afternoon commuter peak hour is much lower than the morning commuter peak hour estimates because the afternoon peak hour for the school occurs much earlier than the afternoon commuter peak hour. The trips noted above are generally representative of trips associated with students being picked up at school after sports and other extracurricular activities in the afternoon. The last column of the table shows that if close to 50-percent of students rely on parent drop-off/pick-up, the corresponding roadway peak hour trips could increase substantially (by more than two times, based on the assumptions made for the alternate analysis presented in Table 1) when compared to the ITE based analysis.

For comparison and reference, the peak hour trip estimates for the residential and athletic uses that were documented in the January 24, 2014 memorandum are repeated below in Table 2. Scenario 1 athletic uses in Table 2 represent the athletic facility expansion that could occur within the next

seven years. Scenario 2 athletic expansion would likely occur after seven years. The footnotes for Table 2 outline the development program assumed for the corresponding trip estimates.

Table 2: Athletic Facility Trip Generation

Time Period	Residential Trips [a]	Scenario 1 Athletic Trips [b]	Scenario 2 Athletic Trips [c]
Morning Peak Hour [d]			
In	6	11	15
Out	22	0	0
Total	28	11	15
Evening Peak Hour [d]			
In	29	73	104
Out	16	47	74
Total	45	120	178
Saturday Peak Hour [d]			
In	13	85	124
Out	13	87	124
Total	26	172	248

a Based on 50 apartment units (ITE LUC 220)
b 1 Little League field, 1 softball field, 2 multi-purpose field fields, 4 tennis courts
c 2 Little League fields, 1 softball field, 2 multi-purpose field fields, 6 tennis courts
d Vehicles per hour

Traffic Capacity Analysis

Measuring existing traffic volumes and projecting future traffic volumes quantifies traffic flow within the study area. To assess quality of flow, roadway capacity analyses were conducted for the existing and projected future traffic volume conditions. Capacity analyses provide an indication of how well the roadway facilities serve the traffic demands placed upon them. Roadway operating conditions are classified by calculated levels of service.

Level-of-service (LOS) is the term used to denote the different operating conditions which occur on a given roadway segment under various traffic volume loads. It is a qualitative measure of a number of factors including roadway geometrics, speed, travel delay and freedom to maneuver. Level-of-service provides an index to the operational qualities of a roadway segment or an intersection. Level-of-service designations range from A to F, with LOS A representing the best operating conditions and LOS F representing congested operating conditions.

For this evaluation, capacity analyses were completed for the unsignalized intersections of Banta-Davis Drive/Bedford Road and Banta-Davis Drive/future residential driveway using SYNCHRO traffic analysis software. Level-of-service designation is reported differently for signalized and unsignalized intersections. For unsignalized intersections, the LOS is only determined for left-turns from the main street and all movements from the minor street. The evaluation criteria used to analyze intersections is based on the HCM[2].

As requested by the Client, peak hour capacity analyses were conducted for the following conditions.

[2] Highway Capacity Manual; Transportation Research Board; Washington D.C.

a. Existing conditions athletic facility

b. Scenario 1 and Scenario 2 athletic facility expansion accompanied by the school project only (no residential)

c. Scenario 1 and Scenario 2 athletic facility expansion accompanied by the school and residential uses.

Tables 3 and 4 present a summary of the capacity analyses for the existing and future conditions with various combinations of athletic facility expansions and the school and residential uses. **Future conditions analysis results in Tables 3 and 4 are based on the lower, ITE school trip generation estimates.**

Table 3: Capacity Analysis Summary for STOP Controlled Movements (Existing Vs. Scenario 1 Results)

Location	Peak Period	Existing Conditions			Future Conditions (Scenario 1 Athletic + School) [d]			Future Conditions (Scenario 1 Athletic + School + Residential) [d]		
		v/c [a]	Del [b]	LOS [c]	v/c	Del	LOS	v/c	Del	LOS
Bedford Road at Banta-Davis Drive	Weekday Morning	0.01	16	C	0.27	21	C	0.35	22	C
	Weekday Afternoon	0.14	20	C	0.35	28	D	0.42	31	D
	Saturday Midday	0.13	13	B	0.18	14	B	0.21	14	B
Banta-Davis Drive at Residential Driveway	Weekday Morning							0.03	9	A
	Weekday Evening							0.02	9	A
	Saturday Midday							0.02	9	A

a volume-to-capacity ratio for the critical side street movements
b delay of critical approach only, in seconds per vehicle
c level of service of the side street movements
d Trip generation for the school use based on ITE estimates presented in Table 1

Table 4: Capacity Analysis Summary for STOP Controlled Movements (Existing Vs. Scenario 2 Results)

Location	Peak Period	Existing Conditions			Future Conditions (Scenario 2 Athletic + School) [a]			Future Conditions (Scenario 2 Athletic + School + Residential) [a]		
		v/c	Del	LOS	v/c	Del	LOS	v/c	Del	LOS
Bedford Road at Banta-Davis Drive	Weekday Morning	0.01	16	C	0.27	21	C	0.35	22	C
	Weekday Afternoon	0.14	20	C	0.49	35	D	0.58	41	E
	Saturday Midday	0.13	13	B	0.27	15	B	0.30	16	C
Banta-Davis Drive at Residential Driveway	Weekday Morning							0.03	9	A
	Weekday Evening							0.02	9	A
	Saturday Midday							0.02	9	A

a Trip generation for the school use based on ITE estimates presented in Table 1

In addition performing future conditions analysis with ITE school trip generation estimates as shown in Tables 3 and 4 above, capacity analyses were also conducted for the alternate school trip generation estimates shown in Table 1 for 50-percent student drop off/pick up by automobiles. **Tables 5 and 6 present a summary of the future conditions capacity analyses that include the alternate trip generation estimates for the school use (50-percent automobile mode share).**

Table 5: Capacity Analysis Summary for STOP Controlled Movements (Higher Auto Mode School Trip Estimates)

Location	Peak Period	Future Conditions (Scenario 1 Athletic + School) [d]			Future Conditions (Scenario 1 Athletic + School + Residential) [d]		
		v/c [a]	Del [b]	LOS [c]	v/c	Del	LOS
Bedford Road at Banta-Davis Drive	Weekday Morning	0.73	44	E	0.82	55	F
	Weekday Afternoon	0.63	48	E	0.73	60	F
	Saturday Midday	0.18	14	B	0.21	14	B
Banta-Davis Drive at Residential Driveway	Weekday Morning				0.03	9	A
	Weekday Evening				0.02	9	A
	Saturday Midday				0.02	9	A

a volume-to-capacity ratio for the critical side street movements
b delay of critical approach only, in seconds per vehicle
c level of service of the side street movements
d Trip generation for the school use based on the alternate estimate in Table 1 that involves 50-percent reliance on personal automobiles for drop-off/pick-up

Table 6: Capacity Analysis Summary for STOP Controlled Movements (Higher Auto Mode School Trip Estimates)

Location	Peak Period	Future Conditions (Scenario 2 Athletic + School)			Future Conditions (Scenario 2 Athletic + School + Residential) [a]		
		v/c	Del	LOS	v/c	Del	LOS
Bedford Road at Banta-Davis Drive	Weekday Morning	0.73	45	E	0.82	55	F
	Weekday Afternoon	0.80	70	F	0.92	95	F
	Saturday Midday	0.27	15	B	0.30	16	C
Banta-Davis Drive at Residential Driveway	Weekday Morning				0.03	9	A
	Weekday Evening				0.02	9	A
	Saturday Midday				0.02	9	A

a Trip generation for the school use based on the alternate estimate in Table 1 that involves 50-percent reliance on personal automobiles for drop-off/pick-up

A review of the capacity analysis presented in Tables 3 through 6 lead to the following inferences.

1. Weekday peak hour traffic operations for Banta-Davis Drive, at its intersection with Bedford Road, are projected to Fail (LOS F) if the elementary school traffic is even comprised of approximately 50-percent personal automobile travel. To ensure that the impacts to Bedford Road traffic as well as on-site traffic are better managed, aggressive monitoring and controlling of automobile mode of travel to/from the school should be implemented.

2. The above noted failing operations are expected as a result of the school generated traffic, and as such, the need for at least a police detail at the Banta-Davis Drive/Bedford Road intersection should be anticipated for school use on the Site, *independent* of the 48-unit housing development.

3. Under all analysis scenarios, the effect of the traffic generated by the residential use is nominal.

4. Weekday traffic operations for vehicles exiting Banta-Davis driveway can be expected to be in the range of LOS B/D under most analysis scenarios when automobile travel to the school is reduced and bus transportation is promoted (i.e., with ITE school trip rates). The LOS is estimated to drop to E during the afternoon commuter peak hour under the *Future Conditions - Scenario 2 Athletic + School + Residential*. The addition of the residential use in this scenario contributes to an additional six seconds of wait time per vehicle, when compared to

the *Future Conditions - Scenario 2 Athletic + School* scenario (i.e., 41 seconds of wait time instead of 35 seconds of wait time).

5. Saturday midday peak hour traffic operations are expected to be generally better than weekday peak hour operations. A review of the analytical data indicates that this is primarily because of the substantially lower traffic volume on Bedford Road on Saturdays when compared to weekdays.

6. Under all analysis scenarios, the intersection of Banta-Davis Drive/future residential driveway is projected to operate at LOS A with minimal delays.

Based on the foregoing analysis, widening Banta-Davis Drive, as needed, to a minimum paved width of 20 to 22 feet to accommodate two lanes of traffic (one entering and one exiting the Site, with no on-street parking) can adequately serve the projected traffic volumes under all analysis scenarios. The analysis indicates that the intersection of Banta-Davis Drive/future residential driveway would operate adequately with stop-sign control on the driveway and with shared through/turn lanes on Banta-Davis Drive. When the elementary school is constructed, and if the primary mode of travel for students is personal automobiles, instead of bus transportation, a more thorough review of lane needs on Banta-Davis Drive may need to be performed, including evaluating the need to widen all approaches of the intersection of Banta-Davis Drive/Bedford Road to accommodate separate turn lanes.

Signal Warrant Analysis

Traffic signal Warrant analyses were prepared to determine if the projected traffic volumes at the intersection of Banta-Davis Drive/Bedford Road exceed the thresholds for the installation of a traffic signal at the location. The Manual on Uniform Traffic Control Devices[3] (MUTCD) is the established standard for Warrant analyses. The Warrants consider the roadway geometry, traffic volume entering the intersection, and speeds.

Overall, the warrant analysis indicates that the estimated weekday morning peak hour traffic volume exceeds the Peak Hour Volume Warrant threshold if an elementary school is constructed and even 50-percent of the students travel by personal automobiles. If the majority of student transportation will occur by bus (i.e., lower vehicle trips on Banta-Davis Drive), then the Warrant analysis indicates that the traffic volume on Bedford Road would need to be 35 to 40 percent higher than its current levels to require traffic signal control at the intersection. It should be noted that installation of traffic signal control solely based on traffic volume justification for one hour of the day, is not common practice.

A more detailed analysis of actual hourly school operations post-construction, in conjunction with the future athletic uses on the Site and future traffic growth on Bedford Road (which can be expected to grow over time) will be needed to determine whether police details or traffic signal control is more appropriate when the school is in operation.

Driveway for 338 Bedford Road

As requested by the Client, a qualitative review of the driveway for 338 Bedford Road was performed to determine its ability to serve as the access/egress for the potential 48 apartment units on the Banta-Davis Site.

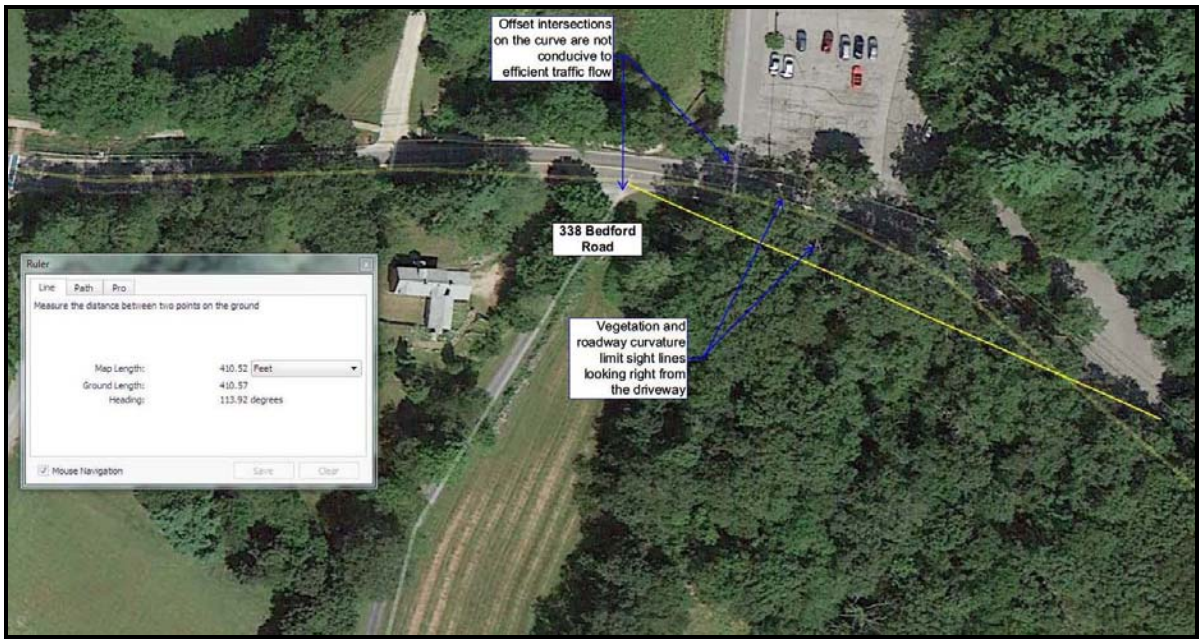
Based on a review of on-line aerial mapping, the driveway for 338 Bedford Road appears to be approximately 10 to 12 feet wide, which is not adequate for two-way travel for a 48-unit apartment

[3] Manual on Uniform Traffic Control Devices, Federal Highway Administration, Washington DC, 2003.

development. It is VHB's understanding that the section of the driveway for # 338 that is closest to Bedford Road cannot be readily widened due to its proximity to wetlands. The driveway is also located on the inside of a curve in the roadway, which, combined with the dense vegetation growth close to the edge of the roadway, significantly limits the sight lines to on-coming traffic. Sight distance analyses presented in the January 24, 2014 draft traffic evaluation indicated that, for the recorded 85th percentile speed of 37 mph on Bedford Road, approximately 410 feet of Intersection Sight Distance (ISD) is required for vehicular traffic exiting any driveway in that area of Bedford Road.

As shown in Figure 1, all vegetation and any other vertical sight line obstructions between the yellow sight line and the edge of the travel way on Bedford Road would need to be cleared to achieve the calculated ISD per the guidelines of the American Association of State Highway and Transportation Officials (AASHTO)[4]. It is VHB's understanding that most the affected vegetation is either in wetlands or on conservation land which renders clearing infeasible.

Figure 1: Required ISD Looking East from the Driveway for 338 Bedford Road



Finally, as indicated in Figure 1, the driveway for 338 Bedford Road forms an offset intersection with the Kimball Ice-cream parking lot driveway. A driveway that would serve as many as 48 residential units on a horizontal curve, with limited sight distances and forming an offset intersection with a significant traffic generator like Kimball Ice-cream, is not desirable.

For the above reasons, the driveway for 338 Bedford Road would not be a viable alternative for providing primary access to the 48-unit residential development in addition to the two group homes. Detailed capacity analysis summarized in the prior section indicates that the multi-family residential traffic can be adequately accommodated by the Banta-Davis Drive, obviating the need for an alternate driveway location.

[4] A Policy on the Geometric Design of Highways and Streets; American Association of State Highway and Transportation Officials; Washington, D.C.; 2004.