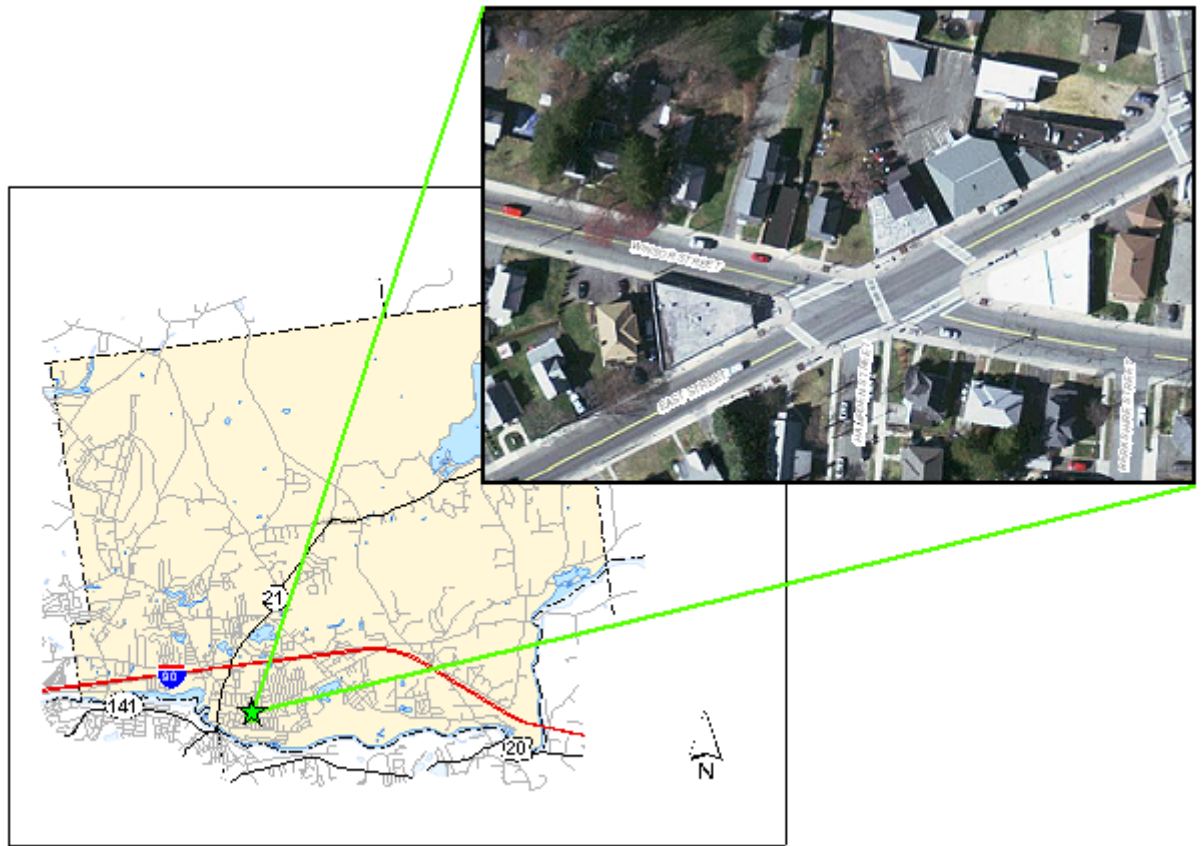


## TRANSPORTATION AND SAFETY STUDY

### LUDLOW

#### EAST STREET/WINSOR STREET/HAMPDEN STREET INTERSECTION



SEPTEMBER 2010

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Prepared in cooperation with the Town of Ludlow, Massachusetts Department of Transportation and the U.S. Department of Transportation - Federal Highway Administration and the Federal Transit Administration.

The views and opinions of the Pioneer Valley Planning Commission expressed herein do not necessarily state or reflect those of the U.S. Department of Transportation.

## TABLE OF CONTENTS

<b>I. Introduction .....</b>	<b>2</b>
A. Study Area.....	2
<b>II. Existing Transportation Conditions .....</b>	<b>6</b>
A. Peak Hour Volume and Turning Movement Counts.....	6
B. Safety.....	9
1. <i>Crash Rate Analysis</i> .....	9
2. <i>Collision Diagram</i> .....	10
C. Level of Service Analysis.....	13
D. Signal Warrant Analysis.....	14
E. Multi – Way ‘STOP’ Warrant Analysis .....	15
<b>III. Recommendations .....</b>	<b>17</b>
A. Pedestrian Safety .....	17
B. Pavement Markings and Signs.....	17
C. Parking Lanes and Sight Distance Consideration.....	18
D. Congestion and Level of Service .....	18
E. Signal Warrant and Multi-Way ‘Stop’ Warrant Analysis.....	18

### List of Tables

Table 1: Crash History .....	10
Table 2: Crashes included in Collision Diagram .....	12
Table 3: Level of Service (LOS) Designations for Unsignalized Intersections.....	13
Table 4: Existing Level of Service .....	14
Table 5: Signal Warrant Analysis Results.....	15
Table 6: Multi-Way ‘STOP’ Warrant Analysis Results .....	16

### List of Figures

Figure 1: Study Area .....	4
Figure 2: Aerial Image of the Intersection .....	5
Figure 3: Turning Movement Counts .....	7
Figure 4: Collision Diagram .....	11

## ABBREVIATIONS

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1	a.m.	Afore Meridian
2	AADT	Average Annual Daily Traffic
3	ADT	Average Daily Traffic
4	ATR	Automatic Traffic Recorders
5	Ave.	Avenue
6	FY	For Year
7	LOS	Level of Service
8	MassDOT	Massachusetts Department of Transportation
9	MPH	Miles per Hour
10	MUTCD	Manual on Uniform Traffic Control Devices
11	p.m.	Post Meridian
12	PVPC	Pioneer Valley Planning Commission
13	Rd.	Road
14	St.	Street
15	TMC	Turning Movement Counts
16	TRB	Transportation Research Board
17	VPH	Vehicles per Hour

## I. INTRODUCTION

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Ludlow Master Plan committee identified the intersection of East Street with Winsor Street and Hampden Street in the Town of Ludlow as a location with the potential for future development, changes in existing traffic patterns, and opportunities for increased vehicle conflict. The Pioneer Valley Planning Commission (PVPC) conducted a transportation and safety study at the intersection as part of the FY 2010 Unified Planning Work Program. PVPC also performed a traffic signal warrant analysis to examine the feasibility of installing a traffic signal at the intersection. This study examines the existing conditions at the intersection and provides a series of short-term recommendations to improve existing traffic operations and increase safety.

### A. STUDY AREA

The intersection of East Street with Winsor Street and Hampden Street is a five-leg, unsignalized intersection located in the southwestern part of the Town of Ludlow just north of the Ludlow Mills complex. East Street operates as the major street and Winsor Street as the minor street under 'STOP' sign control. No traffic enters the intersection from Hampden Street as it is designated as a One Way street in the southbound direction.

Land use in the immediate vicinity of the intersection is a mix of commercial and residential characterized by closely spaced buildings that abut the sidewalk along East Street. The intersection provides a number of pedestrian amenities with sidewalks on both sides of all streets and crosswalks highlighted by an interior crosshatch pattern. Street lights are also present in the immediate vicinity of the intersection.

On street parking is permitted along both sides of East Street to the northeast of the intersection and on the northern side of East Street southwest of the intersection. Parking areas on East Street are highlighted with a single white edge line but individual spaces are not designated within these areas. On street parking is also permitted on both sides of Winsor and Hampden Street although no parking areas are defined with pavement markings. In general, on street parking is very well utilized in this area. Vehicles parked in the immediate vicinity of the

intersection on East Street were observed to interfere with the sight distance of vehicles exiting Winsor Street.

East Street is classified as an urban major collector (U5). It is a two lane, undivided highway. Winsor Street is classified as urban minor collector (U6) on the western side of the intersection and a local street on the eastern side of the intersection. Overall the pavement of the intersection is in fair condition and granite curbing is provided on all approaches. Pavement markings in the vicinity of the intersection consist of double yellow center lines in fairly good condition.

A number of improvements were made to the East Street corridor as part of an urban renewal project. Prior to this work, Hampden Street operated as a two-way street. Based on conversations with the Ludlow Department of Public Works, a number of pole mounted traffic signs were removed as part of the urban renewal projects to reduce visual clutter and increase pedestrian safety.

Figure 1: Study Area

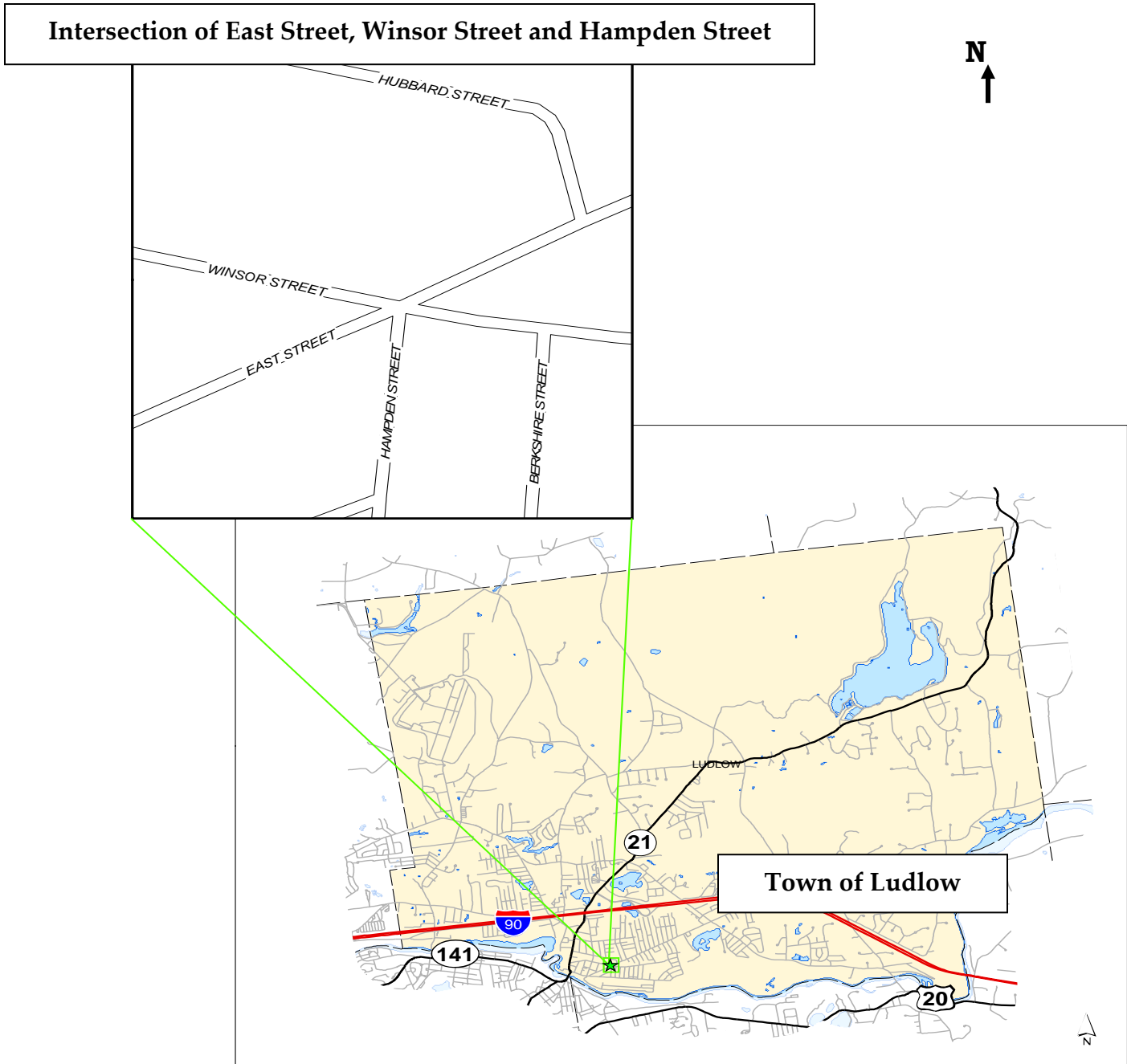




Figure 2: Aerial Image of the Intersection



## II. EXISTING TRANSPORTATION CONDITIONS

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This section provides a technical evaluation of the transportation components for the intersection. It includes a presentation of the data collected, analysis of traffic operations, and a series of observations and conclusions derived from the analysis.

### A. PEAK HOUR VOLUME AND TURNING MOVEMENT COUNTS

Turning Movement Counts (TMC's) were conducted for the intersection during the peak commuter periods. The weekday peak commuter period occurs during the morning hours of 7:00 AM to 9:00 AM and the afternoon hours of 2:00 PM to 6:00 PM for any intersection in the vicinity of a school. The TMC's were conducted to identify the peak four consecutive 15 minute periods of traffic through the intersection. These consecutive peak 15 minute periods constitute a location's Peak Hour Volume. The peak hour of traffic volume represents the most critical period for operations and will be the focus for some of the analysis conducted in this study.

The TMC data also identifies the number of heavy vehicles and pedestrians on the roadway. Heavy vehicles include trucks, recreational vehicles and buses. The percentage of heavy vehicles in the traffic flow is an important component in calculating the serviceability of a corridor or intersection. Trucks impact traffic flow because they occupy more roadway space than passenger cars and have poorer operating capabilities with respect to acceleration, deceleration and maneuverability.

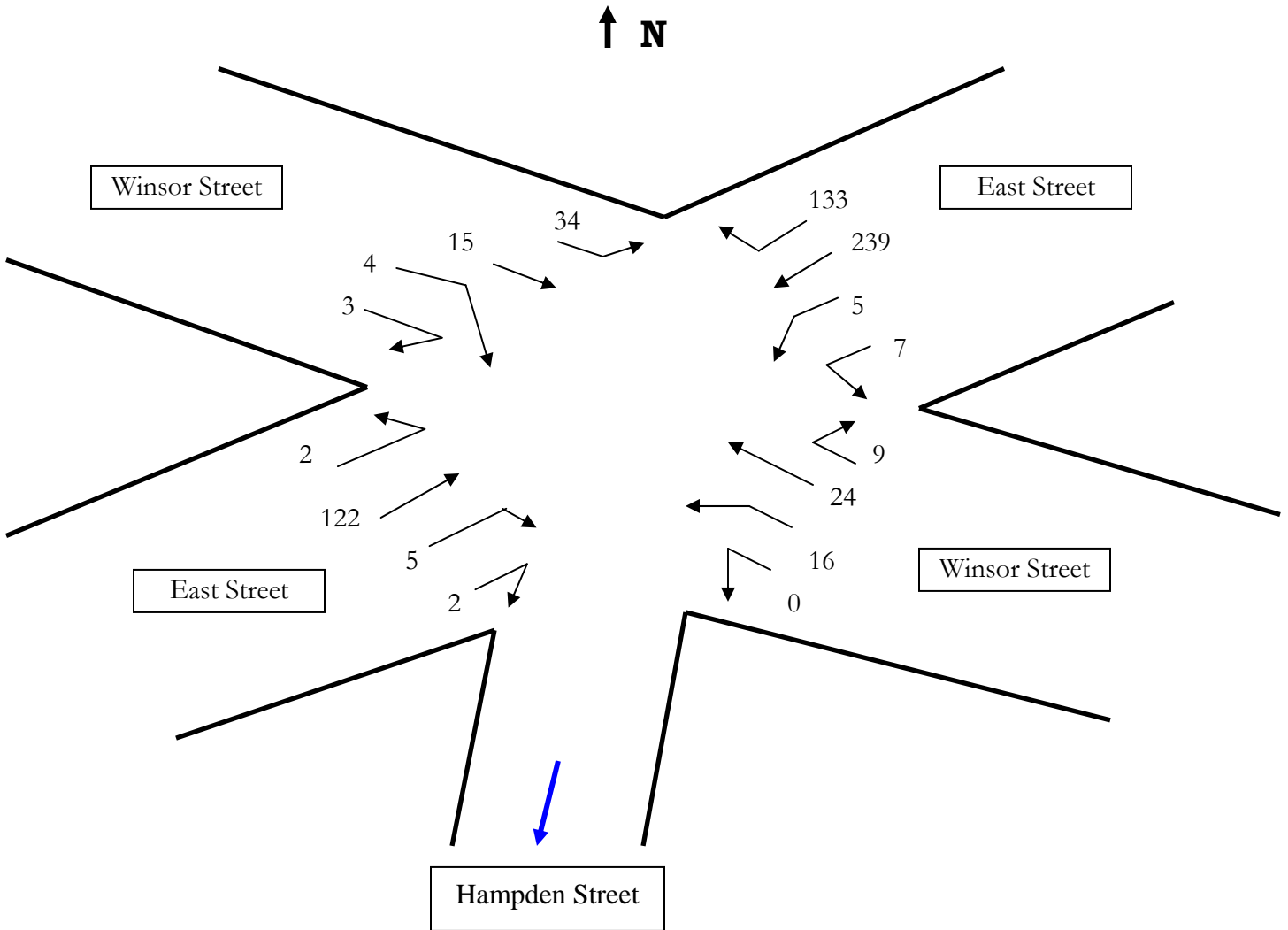
The TMC data was obtained during weekday peak periods. As traffic volumes tend to fluctuate over the course of the year, the Massachusetts Department of Transportation (MassDOT) develops traffic volume adjustment factors to reflect monthly variations. These factors were examined to determine the traffic conditions at the intersection of East Street with Winsor Street and Hampden Street.

The morning peak hour occurred between 8:00 am to 9:00 am and the afternoon peak hour traffic occurred between 2:45 pm to 3:45 pm.

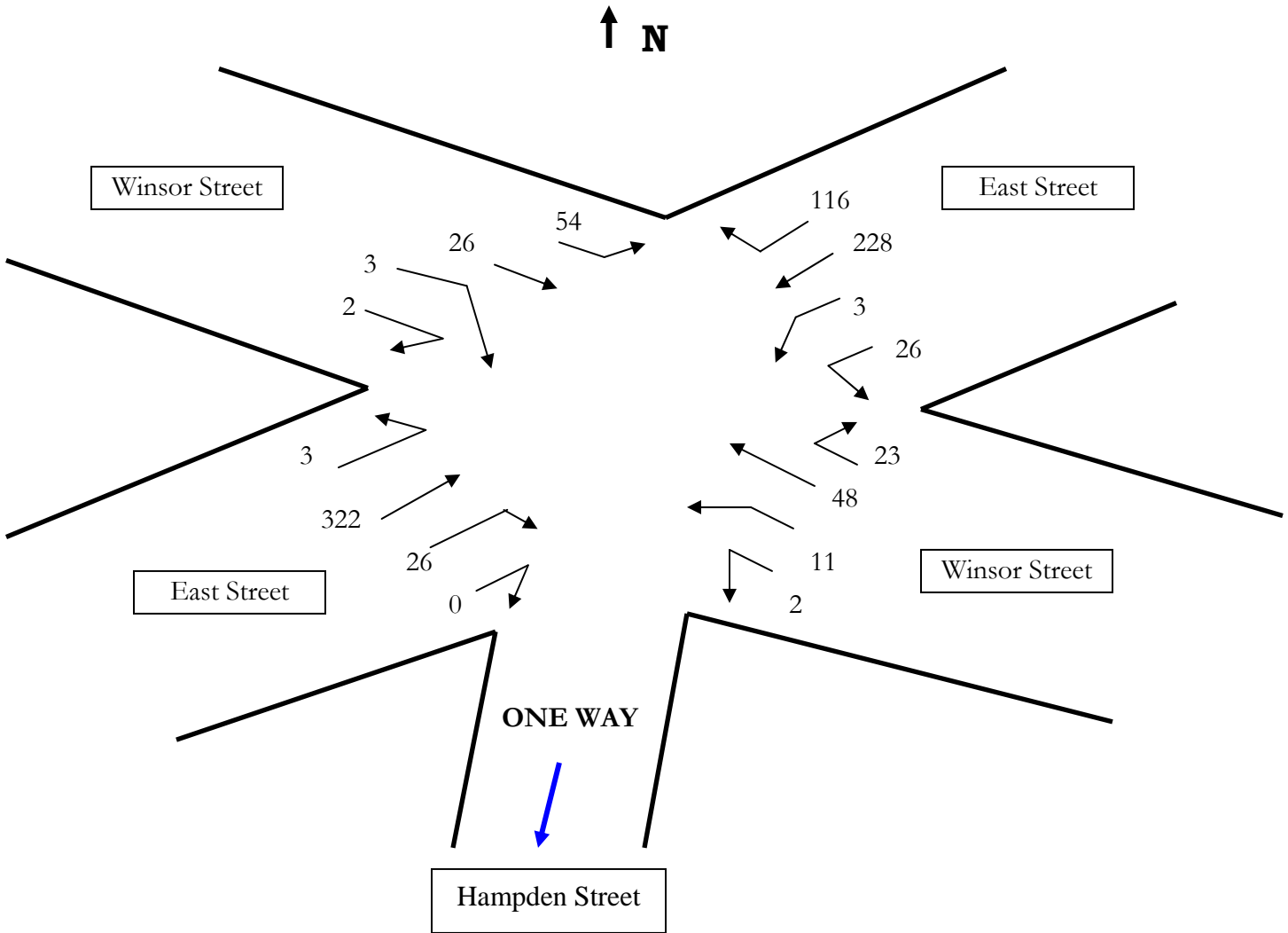


Figure 3: Turning Movement Counts

Morning Peak Hour 8:00 am to 9:00 am



Afternoon Peak Hour 2:45 pm to 3:45 pm



## **B. SAFETY**

To study safety, PVPC obtained the crash history of the intersection from the MassDOT and the Ludlow Police Department. Actual crash reports were studied and analyzed to form a collision diagram of the intersection and identify patterns that could contribute to the crashes in this area.

### **1. Crash Rate Analysis**

A crash rate analysis was performed to compare the value at the intersection to the average value for MassDOT District 2 intersections. The crash rate per million entering vehicles was calculated. In theory, crash rates can increase as the traffic volume along the roadway increases or as the potential for conflict is increased. The crash rate per million entering vehicles takes into consideration the number of crashes at an intersection and the number of vehicles that enter the intersection over the course of an average day. Based on MassDOT data, the average crash rate for unsignalized intersections in District 2 is 0.67.

As shown in Table 1, the crash rate at the intersection of East Street with Winsor Street and Hampden Street is 1.31. Although the number of crashes at this location is on an average about 4 crashes per year, the crash rate is high because of low traffic volumes in this area. This value indicates that there are more crashes occurring at this intersection compared to other similar intersections in the region. A total of 19 crashes were recorded from 2006 to 2009. The intersection averaged just over five crashes per year from 2006 – 2008. This number reduced to three crashes in 2009. One crash resulted in a non fatal injury and all other crashes resulted in property damage. A mix of angle, rear end and side swipe crashes was observed. A total of 5 crashes occurred during rain and wet road conditions.

**Table 1: Crash History**

Year	Total # of Crashes	Type	Severity	Weather Condition	Road Condition	Crash Rate
2006	5	Angle Rear End Single Vehicle	2 Property Damage 1 Non fatal Injury 2	2 Clear 3 Cloudy Rain	2 Dry 1 Wet 2	2 3
2007	5	Angle Rear End	3 Property Damage 2 Non fatal Injury	4 Clear 1 Cloudy	4 Dry 1 Wet	4 1
2008	6	Angle Rear End	5 Property Damage 1	6 Clear Rain Not Known	2 Dry 3 Wet 1 Not Known	2 3 1
2009	3	Side Swipe Rear End	2 Property Damage 1	3 Clear	3 Dry	3
Total	19		19	19	19	<b>1.31</b>

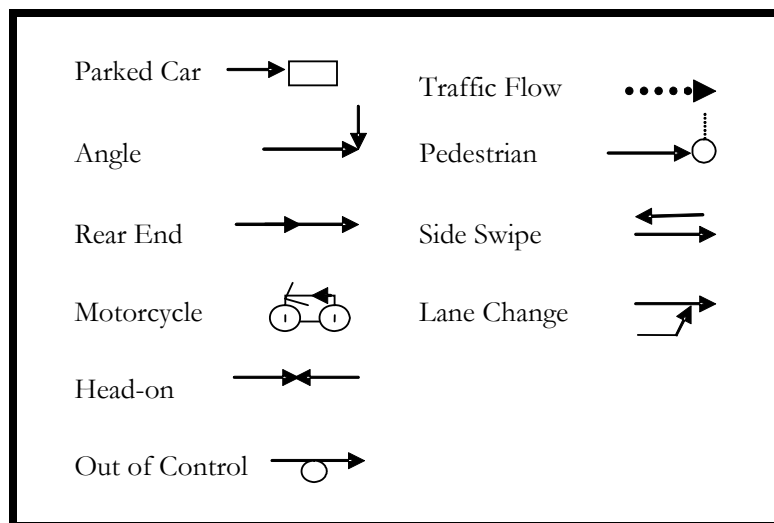
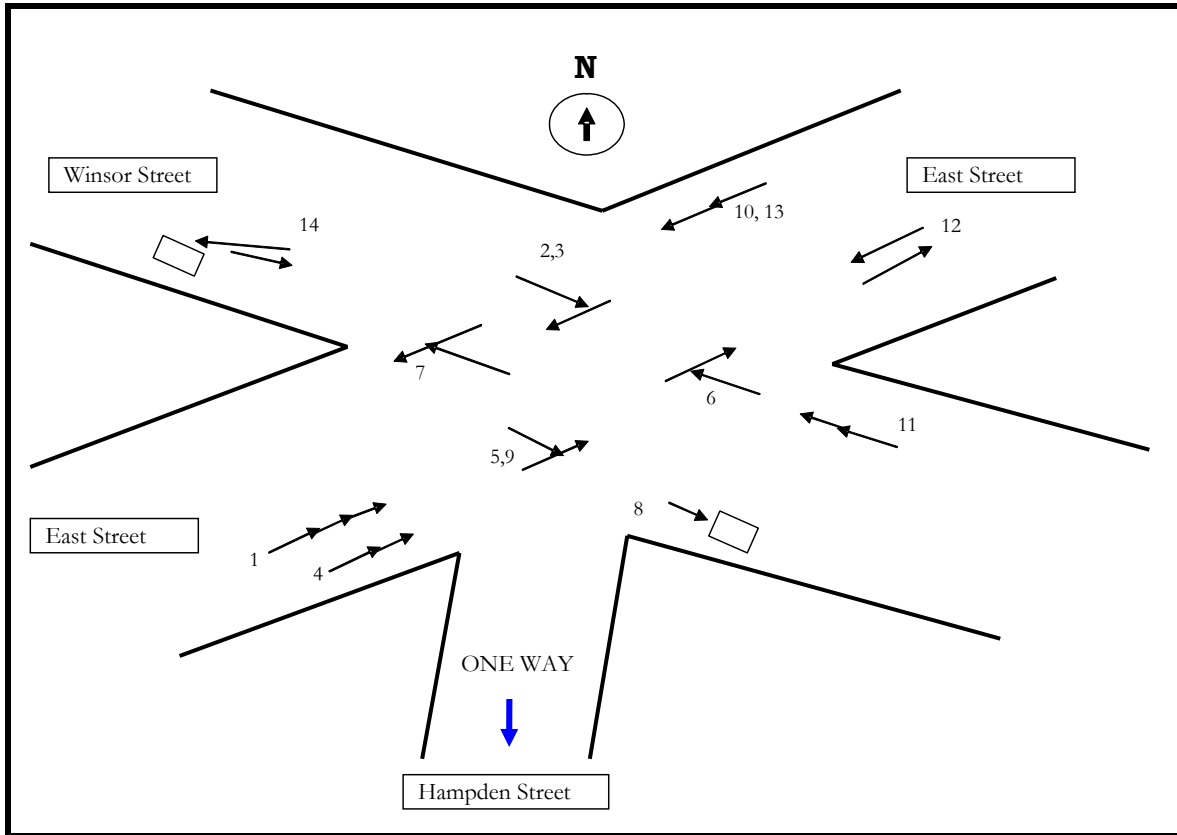
Source: MassDOT, Ludlow Police Department

## 2. Collision Diagram

Based upon the data in the crash reports, each crash has been depicted graphically in the collision diagram and crash patterns have been identified. Figure 4 shows the collision diagram for the intersection. The details of the crashes shown in the figure are summarized in Table 2.

A total of 14 crash reports were obtained for the calendar years of 2007 to 2009. These crashes have been graphically presented in Figure 4.

Figure 4: Collision Diagram



**Table 2: Crashes included in Collision Diagram**

	DATE	TIME	DAY	SEV.	L	R	P
1	01/26/07	12:20 PM	FRI	I	1	1	5
2	02/06/07	9:52 AM	TUE	PD	1	1	13
3	05/13/07	12:31 AM	SUN	PD	3	2	13
4	10/05/07	7:37 PM	FRI	PD	2	1	5
5	12/21/07	5:18 PM	FRI	PD	3	1	13
6	02/05/08	12:07 AM	TUE	PD	3	2	13
7	02/14/08	6:34 PM	THU	PD	3	2	13
8	02/21/08	11:51 AM	THU	PD	4	4	2
9	07/28/08	6:50 AM	MON	PD	1	1	13
10	10/28/08	12:48 PM	TUE	PD	1	2	5
11	11/01/08	5:01 PM	SAT	PD	1	1	5
12	01/14/09	9:39 AM	WED	PD	1	1	10
13	01/23/09	11:36 PM	FRI	PD	1	1	5
14	10/14/09	6:53 PM	WED	PD	3	1	2,10

Source: Ludlow Police Department

SEVERITY (SEV)	
Fatality	F
Personal Injury	I
Property Damage	PD

<u>Light Condition (L)</u>		
1. Daylight		
2. Dawn/Dusk		
3. Darkness		
4. Unknown		
<u>Road Condition (R)</u>		
1. Dry		
2. Wet		
3. Snow/Ice		
4. Not Known		
		<u>Pattern (P)</u>
	0. Not Known	7. Wrong side of road
	1. Speed too fast	8. Improper turning
	2. Parked Car	9. Improper backing
	3. Ran Stop Sign	10. Sideswipe
	4. Ran Traffic Signal	11. Pedestrian violation
	5. Rear End	12. Human Error
	6. Improper Passing	13. Angle



Crash numbers 1, 4, 10, 11, and 13 were rear end collisions. One of these rear end collisions occurred when the driver attempted to back up from the intersection. Crash numbers 2, 3, 5, 7, and 9 were angled collisions, some of which were result of drivers not being able to observe the vehicles approaching on East Street due to sight distance restrictions. The vehicles involved in these angle type collisions were also reported to have stopped before proceeding into the intersection. Two crashes were the result of vehicles colliding with other vehicles parked on Winsor Street. Collision number 12 was a side swipe crash between two vehicles moving in opposite direction on East Street. Collision 14 was a side swipe crash between two vehicles which also collided with the third vehicle parked on the street.

### C. LEVEL OF SERVICE ANALYSIS

The intersection was examined with regard to capacity and delay characteristics to determine the existing Level of Service (LOS). LOS is an indicator of the operating conditions which occur on a roadway under different volumes of traffic and is defined in the 2000 Highway Capacity Manual by six levels, 'A' through 'F'. A number of operational factors can influence the LOS including geometry, travel speeds, delay, and the number of pedestrians. Table 3 presents the LOS designations for an unsignalized intersection.

**Table 3: Level of Service (LOS) Designations for Unsignalized Intersections**

LOS	Expected Delay To Minor Street	Average Control Delay (s/veh)
A	Little or no delay	0.0 to 10.0
B	Short traffic delays	>10.0 to 15.0
C	Average traffic delays	>15.0 to 25.0
D	Long traffic delays	>25.0 to 35.0
E	Very long delays	>35.0 to 50.0
F	Extreme delays	>50.0

Source: Highway Capacity Manual

Depending on the time of day and year, a roadway may operate at varying levels. Level of Service 'A' represents the best operating conditions and is an indicator of ideal travel conditions with vehicles operating at or above posted speed limits with little or no delays. Conversely, LOS 'F', or failure, generally indicates forced flow conditions illustrated by long delays and vehicle queues. Level of Service 'C' indicates a condition of stable flow and is generally considered satisfactory in rural areas. Under LOS 'D' conditions, delays are considerably longer than under LOS 'C', but are considered acceptable in urban areas. At LOS 'E' the roadway begins

to operate at unstable flow conditions as the facility is operating at or near its capacity. The actual LOS for the intersection of East Street with Winsor Street and Hampden Street is shown in Table 4.

It can be seen from Table 4 that the eastbound approach of Winsor Street operates at LOS 'E' during the afternoon peak hour. One of the reasons for this increase in delay is the higher pedestrian volumes experienced at the intersection in the afternoon compared to the morning. On an average about 17 pedestrians per hour were observed to cross the street during the afternoon peak hours.

**Table 4: Existing Level of Service**

Approach	Movement	AM Peak Hour		PM Peak Hour	
		Delay*	LOS**	Delay*	LOS**
East Street Northeast Bound	Left/Through/Right	0.2	A	0.2	A
East Street Southwest Bound	Left/Through/Right	0.5	A	0.8	A
Winsor Street Westbound	Left/Through/Right	14.4	B	23.9	C
Winsor Street Eastbound	Left/Through/Right	16.0	C	37.2	E

Source: PVPC

\* Delay in seconds

\*\* Level of Service

#### D. SIGNAL WARRANT ANALYSIS

The intersection of East Street with Winsor Street and Hampden Street was analyzed to determine whether a traffic signal is required. The Manual on Uniform Traffic Control Devices (MUTCD) identifies eight different warrants to evaluate if an intersection meets the minimum requirements for signalization. One or more warrants must be satisfied to justify a traffic signal however engineering judgment dictates if an intersection warrants the installation of a signal. The installation of a traffic signal must improve the safety and operation of the location under study. Table 5 presents the results of the signal warrant analysis.

Of the eight total warrants for the installation of a traffic signal, Warrant 1 – Eight Hour Vehicular Volume is generally considered the most important as it requires minimum volumes to be met on both the major and minor streets for at least eight hours. Warrant 2 – Four Hour Vehicular Volume and Warrant 3 – Peak Hour Volume, also require minimum volumes to be met but over shorter timeframes.

Warrant 7 – Crash Experience requires 80% of the volume requirements of Warrant 1 to be satisfied and at least 5 crashes of a type correctable through traffic signalization to have occurred over the last year. This warrant also requires that less restrictive remedies such as improved signage and pavement markings be tried and have failed to reduce crashes before a signal can be installed.

**Table 5: Signal Warrant Analysis Results**

<b>Warrant</b>	<b>Description</b>	<b>Status</b>
1	Eight Hour Volume	Not Satisfied
2	Four Hour Volume	Not Satisfied
3	Peak Hour	Not Applicable
4	Pedestrian Volume	Not Considered
5	School Crossing	Not Applicable
6	Coordinated Signal System	Not Applicable
7	Crash Experience	Not Satisfied
8	Roadway Network	Not Required

Source: PVPC

The above table shows that the intersection does not meet the requirements of any of the eight warrants. Traffic volumes warrants for Warrants 1 and 2 are not satisfied at either 100% or 80% requirements. Warrant 3 is only applicable to special conditions which create high volume of vehicles for specific peak hours and therefore is not completely applicable. The required volume of 100 pedestrians per hour to satisfy the pedestrian warrant was not observed during TMCs therefore a separate pedestrian warrant was not considered. The Town of Ludlow can request a separate pedestrian volume warrant if they believe that conditions at the intersection deem it necessary. A total of 19 crashes were observed from calendar year 2006 to 2009 which means fewer than 5 crashes occurred per year. Other corrective measures to improve safety can still be considered therefore all conditions for the satisfaction of Warrant 7 have not been met.

#### **E. MULTI – WAY ‘STOP’ WARRANT ANALYSIS**

The intersection was also examined to determine whether a multi - way ‘STOP’ sign control is warranted to improve safety and congestion at the intersection. The Manual on Uniform Traffic Control Devices (MUTCD) identifies four distinct criteria to evaluate if an intersection meets the minimum requirements for a multi

– way ‘STOP’ sign installation. The first criterion permits a multi – way ‘STOP’ installation as an interim measure at intersections where traffic control signals are warranted. Criterion two, is similar to Warrant 7 for crashes in signal warrant analysis, permits a multi – way ‘STOP’ installation if the intersection has five or more reported crashes in 12 month period that are susceptible to correction by the multi – way ‘STOP’. The third criterion consists of the minimum volume requirements for major street and minor street approaches. Criteria four is satisfied if the requirements in both criteria two and three are satisfied to 80% of minimum requirement values. Table 6 shows the results of the multi – way ‘STOP’ warrant analysis for the intersection of East Street with Winsor Street and Hampden Street.

**Table 6: Multi-Way ‘STOP’ Warrant Analysis Results**

Criterion	Description	Status
1	Interim Measure	Not Satisfied
2	Crash Warrant	Not Satisfied
3	Condition 1: Major Street Volume	<i>MET</i>
	Condition 2: Minor Street Combined Volume	Not Met
	Higher Speed on Major Street Approaches	Not Met
4	80% of Minimum Requirements	Not Satisfied

Source: PVPC

As can be seen from the above table, the intersection does not meet the criteria required to warrant the installation of a multi – way ‘STOP’ sign with ‘All Way’ plaque. In addition, use of multi – way ‘Stop’ at this intersection could be difficult due to the non standard intersection layout.

### **III. RECOMMENDATIONS**

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The intersection of East Street with Winsor Street and Hampden Street experiences a crash rate per million entering vehicles which is almost double the average value for unsignalized intersections in MassDOT District 2. Some of the collisions indicate sight distance issues and poor judgment by drivers on both approaches of Winsor Street. Collisions of moving vehicles with vehicles parked on-street have also been reported for this area. Winsor Street experiences longer delays in the afternoon peak hour which could lead to driver frustration and a willingness to risk accepting shorter gaps in traffic on East Street. The following short term recommendations have been made to improve transportation conditions at the intersection.

#### **A. PEDESTRIAN SAFETY**

At the time of the field inventory 67 pedestrians and 13 bikes were observed crossing the street during the afternoon from 2:00 pm to 6:00 pm. The intersection is located in an area with a mix of residential and commercial land use and therefore has a potential for generating high pedestrian volumes. Ludlow ECC elementary school is located along Winsor Street in the west of the intersection. There are a number of crosswalks in the vicinity of the intersection. It is recommended that the Town of Ludlow consider installing pedestrian warning signs in the neighborhood of the intersection in compliance with the Manual on Uniform Traffic Control Devices (MUTCD). The Town and school district can also consider participating in the Safe Routes to School Program, which will provide a resource for improving the pedestrian and bicycling conditions in the area.

#### **B. PAVEMENT MARKINGS AND SIGNS**

Winsor Street does not have any pavement edge lines or marked parking spaces. Therefore, some vehicles were observed to be parked away from the curb on both sides of street narrowing down the travel lanes. Two of the fourteen crashes observed in the collision diagram were side swipe crashes between vehicles moving in opposite directions. These may have occurred because of the reduction in available travel lane width. Other vehicles have also crashed with vehicles parked on Winsor Street. It is recommended that the Town of Ludlow consider painting marked parking spaces on the pavement to well define the parking lanes and to increase the capacity and efficiency of the available on street parking.

As mentioned previously, a number of traffic signs in the vicinity of the intersection were removed as a part of the East Street streetscape project to reduce visual clutter. Presently there are no warning signs for through traffic on East Street to alert the drivers of the upcoming five-way intersection. The Town of Ludlow should consider installing 'Intersection Ahead' warning signs for both approaches of East Street.

### **C. PARKING LANES AND SIGHT DISTANCE CONSIDERATION**

On - street parking in the immediate vicinity of the intersection on East Street obstructs the sight distance for the vehicles attempting to exit from Winsor Street. It is recommended that the Town of Ludlow define parking along East Street with painted parking spaces. This will maximize on-street parking spaces and assist in improving sight distance in the vicinity of intersection.

### **D. CONGESTION AND LEVEL OF SERVICE**

Winsor Street eastbound approach has nearly 40 seconds of delay during the afternoon peak hour and operates at the LOS E. Currently both approaches of East Street operate at LOS A during both morning and afternoon peak hours. Center Street/East Street corridor appears as one of the moderately congested routes of the Pioneer Valley region according to PVPC's Congestion Management Process report 2010. Any short or long term improvement measures at this intersection will have a direct impact on the travel time delay and congestion along the entire corridor. It is recommended that for any future study or project, the Town should consider examining the impact of the considered improvement measure, on the congestion and level of service at the intersection and the corridor.

### **E. SIGNAL WARRANT AND MULTI-WAY 'STOP' WARRANT ANALYSIS**

The analysis shows that the intersection does not meet the minimum volume requirements for the installation of a traffic signal or a multi-way 'STOP' sign. However, the intersection may satisfy a warrant in the future if the number of crashes per year increases. It is recommended that this intersection be reexamined in the future to include the impacts of the proposed Ludlow Mills redevelopment project and monitor any changes in traffic volume. In addition, the feasibility of installing a traffic signal should be revisited at this time.