ABILENE RED LIGHT RUNNING
ENGINEERING ANALYSIS

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Background and Introduction

The City of Abilene is considering the implementation of a photographic traffic signal enforcement system. Texas state law requires the City to conduct a traffic engineering study for each intersection approach that has been identified as a location for the placement of camera enforcement. The purpose of this engineering study was to determine if any countermeasures such as a design change to the intersection and/or a change in the signalization were likely to reduce the number of red light running violations.

Lee Engineering was contracted by the City of Abilene to perform the required traffic engineering study for six (6) intersections throughout the city. Twelve (12) approaches to the study intersections were the subject of this engineering analysis. The project approaches are listed in Table 1.

Table 1: Project Intersections and Approaches

Intersection	Study Approach
Buffalo Gap (FM 89) & Danville/Industrial (US 83 Frontage Road)	Westbound Danville/Industrial
South 14th (US 277) & Clack (US 83 frontage road)	Westbound S 14th
	Southbound Clack
South 1st (BI-20) & Sayles	Eastbound S 1st
	Southbound Sayles
Treadaway (BUS 83) & S 11th (SH 36)	Northbound Treadaway
	Southbound Treadaway
	Westbound S 11th
Buffalo Gap (FM 89) & Clack (US 83 Frontage Road)	Eastbound Clack
South 1st (BI-20) & Pioneer	Eastbound S 1st
	Westbound S 1st
	Southbound Pioneer

TxDOT Engineering Analysis Template

The Texas Department of Transportation, TxDOT, has prepared a template form for the required analysis. This template, "Red Light Running Cameras Engineering Analysis Template" has been completed for each study intersection. The TxDOT template provides the basic framework for the engineering analysis as well as a tool for documenting the presence of many of the countermeasures available for reducing red light running.

The analysis template was created by TxDOT for use as a tool to assist in the completion of the required engineering studies. Every intersection evaluated in this study involved at least one state roadway and TxDOT must approve of the installation of any red light camera within their right-of-way. It is expected that the completion of the analysis templates for each intersection will facilitate TxDOT review and approval.

The TxDOT engineering analysis template includes the following three major components:

A. Intersection and Signal Data
B. Signal Timing and Traffic Data
C. Crash and Enforcement Data

Each component of the TxDOT template is further broken down into sub-items. Any opportunities for improvement related to these items at a study approach are documented in this analysis.

<u>A. Intersection and Signal Data</u>

The first component in the engineering study to evaluate an intersection approach is to perform a site visit and field evaluation of the intersection. During the field evaluation a variety of information pertaining to the intersection and the operation of the traffic signal is collected through a detailed inventory of the intersection. This component includes information such as:

- Intersection Diagram
- Signal Visibility
- Warning Signs
- Signal Head Information
- Pavement Markings
- Pavement Condition and Surface

<u>B. Signal Timing and Traffic Data</u>

Typically, all signal timing and traffic analysis related projects require collection and evaluation of signal timing and traffic data. The engineering analysis conducted for the study approaches evaluated all of the following:

- Clearance Intervals (Yellow + All Red)
- Controller Settings
- Traffic Volumes

C. Crash and Enforcement Data

Additional historical information about the intersection, including crash and violation history, officer experience/observations, and improvement history at an intersection is included in the analysis. This component includes the collection of the following:

- Crash Data
- Violation Data
- Enforcement Issues

The TxDOT analysis template forms for each of the study intersections are attached to this report as an appendix. This template formed the basis for the structure of this report.

Other Supporting Documents

In addition to the TxDOT template analysis, the following research reports and documents were utilized in conducting the review of the study approaches:

- *Texas Manual on Uniform Traffic Control Devices – 2006 Edition, Revision 1*, Texas Department of Transportation, 2008
- *Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running,* Institute of Transportation Engineers, 2003
- *Field Guide for Inspecting Signalized Intersections to Reduce Red Light-Running*, Institute of Transportation Engineers, 2005
- *Red-Light-Running Handbook: An Engineer's Guide to Reducing Red-Light-Related Crashes*, Texas Transportation Institute, 2004
- *Review and Evaluation of Enforcement Issues and Safety Statistics Related to Red-Light-Running*, Texas Transportation Institute, 2003
- *Development of Guidelines for Identifying and Treating locations with a Red-Light-Running Problem*, Texas Transportation Institute, 2004
- *Engineering Countermeasures to Reduce Red-Light-Running*, Texas Transportation Institute, 2002

These documents provided a variety of information that was used in evaluating the study intersections. The *Texas Manual on Uniform Traffic Control Devices* is designated by state law as the document that sets forth conditions for the uniform application of traffic control devices across the state.

The other documents listed provided a wide variety of background information and guidance used in evaluating the study intersection approaches. These references provided guidance related to the selection of countermeasures used to reduce red light running problems. Information on field inspection of signalized intersection to evaluate the need for countermeasures was reviewed and utilized during field visits to the study intersections. The Texas Transportation Institute research provided information used in assessing the red light running problems at the intersections with measures such as violations per 1,000 vehicles, as well as the effectiveness of engineering countermeasures. These documents represent existing and emerging engineering practice regarding the issue of red-light running and were used throughout the analysis process.

Intersection and Signal Data

The primary goal of this study was to identify if any countermeasures were likely to reduce red-light running at the study intersections. The analysis reviewed the intersection geometry and signal features. Included in this review of the intersection were such items as the:

- Signal Visibility
- Presence of Warning Signs
- Signal Head Information
- Pavement Markings
- Pavement Condition and Presence of Surface Treatments

Signal Visibility

The existing signal heads were determined to be positioned within the 20 degree cone of vision as specified in the Texas MUTCD. All of the signalized approaches investigated were controlled using mast arm mounted signals over the roadway approach in question. The signal housings were yellow in color and mounted horizontally. The signal indications were properly positioned and satisfied the requirements of the Texas MUTCD.

At 11 of the 12 study approaches, signal head visibility was not determined to be a significant factor that may contribute to red light running. At these 11 study approaches, the signals were typically detectable farther than 1,000 feet away, and in all cases were detectable at a satisfactory distance given the roadway geometry, or approach configuration and operating characteristics.

At the intersection of Buffalo Gap (FM 89) and westbound Danville/Industrial (US 83 westbound frontage road) the signal heads were only visible for approximately 540 feet. This restricted visibility was primarily due to curvature in the roadway, and trees planted in or near the northern right of way along the front of the Texas Department of Public Safety building property. The Texas MUTCD requires a minimum of 390 feet of visibility for a signal with a posted speed limit of 40 mph; however, the Institute of Transportation Engineers and the Federal Highway Administration recommended determining minimum sight distance to a signal using a speed value equal to the 85th percentile or 10 miles per hour over the posted limit[1]. By using a speed of 50 mph for the sight distance calculation, the minimum visibility required is 540 feet which was approximately equal to the measured available sight distance. As such, a "Signal Ahead" warning sign may be beneficial to the unfamiliar or inattentive motorist. Additionally, a near side signal head on the south side of the approach may also be beneficial.

[1] McGee, Hugh and Kimberly Eccles. *Field Guide for Inspecting Signalized Intersections to Reduce Red-Light Running.* Institute of Transportation Engineers. Washington, DC. 2005. pp 8.

The installation of additional optional signal heads to increase the number of signal heads per approach lane to at least one, or that provide additional near side or far side visibility provide some benefit in reducing red light running[2]. The benefits are especially pronounced on approaches with sight distance or visibility problems, but emerging engineering practice suggests the use of the optional signal heads to reduce red light running.

When a passenger car is approaching a signal behind either a large SUV or a commercial vehicle the car driver may not be able to see either of the two signal heads mounted over the roadway. In this situation, an additional optional signal head mounted on the far right side or far left of the intersection may provide additional information to the motorist. A far side left signal head is sometimes known as a pull through head. A motorist in a queue of vehicles, especially left turning vehicles, may not observe the signal head once the queue begins to move forward, instead focusing on the vehicle in front of them and their destination on the receiving side of the intersection. A pull through head mounted on the far left side of the intersection is more in line with the left turning motorist's line of sight and the change from yellow to red may be better observed by the driver, even in a queue. An optional near side signal head can also provide additional information to the motorist and may be beneficial under certain circumstances.

As part of the field observation process, four approaches were identified as candidates for optional additional signal heads in order to provide additional information to the motorist. These approaches are listed below:

- Westbound Danville/Industrial at Buffalo Gap
    - A near left side signal head on the south side of the approach may be beneficial due to curvature in the roadway.
    - A far left side signal head, a pull through head, may be beneficial due to the high left turn volumes and curvature in the roadway.
- Westbound South 14th at Clack
    - A near right side signal head may be beneficial by providing additional visibility and conspicuity to a motorist coming from under the US 83 overpass.
- Southbound Clack at South 14th
    - A far left side signal head, a pull through head, may be beneficial to left turning vehicles.
- Eastbound Clack at Buffalo Gap
    - A far left side signal head, a pull through head, may be beneficial due to the left turning vehicles and curvature in the roadway.
    - A near right side signal head may be beneficial in increasing the target conspicuity of the signal.

A backplate is a small black aluminum or polycarbonate border that is mounted outside a signal housing and extends outwards approximately six (6) inches. Signal backplates are

[2] McGee, Hugh. *Making Intersections Safer: A Toolbox of Engineering Countermeasures to Reduce Red-Light Running.* Institute of Transportation Engineers. Washington, DC. 2003. pp 18-21.

not required by the Texas MUTCD. The use of backplates is completely optional and varies from agency to agency across the state. A backplate increases the target size and conspicuity of the signal heads allowing them to be more visible against a bright sky[3]. None of the signals present at study intersections had backplates mounted on them. In some instances, signal backplates have been shown to reduce red light running violations by as much as 25 percent and red light running crashes by as much as 32 percent[4]. On approaches with a red-light running problem, the installation of backplates should be strongly considered, especially for approaches in the east-west direction where glare from the sun in the morning or evening may impair signal visibility. Hiring a contractor to furnish and install signal backplates would likely cost between $500 and $1000 per approach.

All signal indications on the study approaches had 12 inch lenses already in place. During the field work for this study, the majority of intersections had incandescent bulbs in place for the signal indications. Only the intersection of Treadaway (Bus. 83) and South 11th (SH 36) had LED indications in place for the red indications; however, the yellow indications were incandescent bulbs during the field phase of this study. Red and yellow LED signal indications have been mentioned as countermeasures to reduce red light running[5]. Yellow LED indications have been shown to reduce violations up to 13 percent. Since the completion of the field phase of this study, the City of Abilene has installed LED signal indications in every signal citywide.

Pavement and Markings Data

In outlining the requirements for a motorist when presented with a red light, the Texas Transportation Code Section 544.007(d) states:

> "an operator of a vehicle facing only a steady red signal shall stop at a clearly marked stop line. In the absence of a stop line, the operator shall stop before entering the crosswalk on the near side of the intersection."

While stop lines are referenced in state law, neither the statute nor the Texas MUTCD require stop lines to be present at an intersection. Well marked and highly conspicuous stop lines give the motorist a more obvious stopping target, and provide law enforcement officers with a well delineated threshold for determining if a motorist violated a red signal.

The stop lines observed at the study approaches were generally in poor condition. The climate in the area combined with the oil present in asphalt lead to poor performance of pavement marking materials. Due to the significant maintenance requirements for stop

[3] Kell, James and Fullerton, Iris. *Manual of Traffic Signal Design, 2nd Edition.* Intitute of Transportation Engineers, Washington, D.C. 1998. pp 59

[4] Bonneson, James and Zimmerman, Karl. *Red Light Running Handbook: An Engineer's Guide to Reducing Red Light Related Crashes.* Report 0-4196-P1. Texas Transportation Institute, College Station, Texas, 2004. pp 22

[5] Bonneson, James and Zimmerman, Karl. *Red Light Running Handbook: An Engineer's Guide to Reducing Red Light Related Crashes.* Report 0-4196-P1. Texas Transportation Institute, College Station, Texas, 2004. pp 22

lines in this area, the condition of stop lines at the study approaches was understandable. Additionally, 10 of the 12 study approaches were on state maintained roadways. Within the City of Abilene, TxDOT is responsible for the maintenance of pavement markings on state roadways.

Moving forward, if an approach is identified as having a red light running safety concern, care should be taken to insure that stop lines remain highly conspicuous and useful to both motorists and law enforcement on that problem approach. Under these circumstances, and depending on the materials used, it is possible that a stop lines would need to be remarked every 1-3 years on a problem approach.

Signal Timing and Traffic Data

Lee Engineering visited each of the study intersections and observed traffic operations at the subject approaches. Lee Engineering staff also reviewed signal timing data provided by the City of Abilene, as well as available traffic volume data. No new traffic counts were performed as part of this study.

Traffic Signal Change Periods (Yellow + Red Clearance Intervals)

The traffic signal change period is usually composed of two elements, the yellow change interval and the red clearance interval. A yellow change interval is required at the end of each green phase. However, a red clearance interval is not required.

The MUTCD and Texas Transportation Code do not mandate a particular method for calculating the change period of a traffic signal, only that it be determined by engineering practices. As a result of the lack of a required method of calculating the change period, there are numerous acceptable methods of determining the yellow change and red clearance intervals. Due to the lack of a standard method, an engineer may use engineering judgment to choose any method of calculating the change period.

Although there is no national or State of Texas standard, a kinematic formula for calculating traffic signal change periods published by the Institute of Transportation Engineers (ITE) is widely used. It is included in several ITE publications, including the Traffic Engineering Handbook[6] and the Manual of Traffic Signal Design[7]. The ITE formula for the signal change period, shown below as Equation 1, is typically broken into two intervals with the first portion of the equation being used to calculate the yellow change interval and the final term of the equation being used for the red clearance interval. Ultimately the balance of the yellow change interval and red clearance interval is determined through engineering judgment based on site specific characteristics and operations.

Equation 1: Change Period Equation

$$CP = t + \frac{V}{2a + 2Gg} + \frac{W + L}{V}$$

The variables in Equation 1, as set forth in the ITE references, are as follows:

- CP = Change Period, seconds, (Yellow Change + Red Clearance Interval)
- t = Perception-reaction time,
- V = Approach Speed, feet/second, 85^{th} percentile speed if available, or speed limit
- a = Deceleration rate,
- G = Gravity, 32.2 feet/second^2

[6] *Traffic Engineering Handbook, 5th Edition.* Institute of Transportation Engineers. Washington, DC. 1999. pp 480-481
[7] Kell, James and Iris Fullerton. *Manual of Traffic Signal Design, 2nd Edition.* Institute of Transportation Engineers. Washington, DC. 1998. pp 142-144

- g = percent grade,
- W = Width of intersection in feet,
- L = Length of vehicle.

The value used for the perception-reaction time is 1.0 seconds in the current ITE references, but may vary from 1.0 to 1.5 seconds as some practitioners choose to use a longer reaction time.

The approach speed is best determined by the 85th percentile speed from a spot speed survey. If speed data is not available, then the design speed or posted speed is most often used. However, some entities recommend using the posted speed plus 10 mph for the yellow change calculations. For the calculation of the red clearance interval the speed limit of the roadway is typically used, though some of the literature supports the use of the 15th percentile speed from a spot speed survey on the approach. For a left turn movement, the approach speed may not be appropriate for the turning movement; as such, some practitioners have assumed a speed value between 20 mph and 30 mph.

The normal range of values used for the deceleration rate is between 10 feet per second squared (ft/sec^2) and 15 ft/sec^2. In the past, a value of 15 ft/sec^2 was commonly used. However, more recently there has been a shift to the use of a lower deceleration rate. The 10 ft/sec^2 deceleration rate is the value currently present in the ITE references. A lower deceleration rate results in a larger yellow interval[8]. While a value of 10 ft/sec^2 is more commonly used now, some practitioners prefer to use the stopping sight distance deceleration rate of 11.2 ft/sec^2 from the American Association of State Highway and Transportation Officials (AASHTO).

For a through movement the width of the intersection is, as a minimum, the distance between the curb lines of the intersecting street. However the width can also include the distance between the stop line and the curb on the approach side and/or the distance between the curb and the outside edge of the crosswalk on the departure side. For a left turn movement the width can be determined either straight line or along the vehicular turning arc.

The length of the vehicle is typically assumed to be 20 feet as listed in the ITE references. However a larger value can be used if trucks are a major component of the traffic stream. Some practitioners leave out the length of the vehicle when calculating a change interval.

The grade is sometimes used only if the approach is in a down grade. In areas of relatively flat terrain the effect of grade is sometimes not considered. The grade is usually obtained from construction plans or spot measurements in the field. The value for the grade can be the grade at the stop line, at the mid point of the stopping distance for the approach speed, the average or the maximum grade within the stopping distance, or some other parameter.

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[8] Eccles, Kimberly and Hugh McGee. *A History of the Yellow and All-Red Intervals for Traffic Signals.* Institute of Transportation Engineers. Washington, DC. 2001. pp. 33-34

According to the MUTCD[9], the yellow change interval's function "shall be to warn traffic of an impending change in the right-of-way assignment". Essentially the yellow change interval warns the motorist to prepare for the display of a red light. As such, it is important that the interval be timed appropriately. The yellow must be of sufficient duration to provide adequate time for motorists traveling at the prevailing speed of traffic to make a safe and controlled stop when the yellow indication is displayed. From the ITE formula, the length of the yellow interval is determined by the assumed perception-reaction time of the driver, the assumed speed of the vehicle, the assumed deceleration rate and the grade of the approach.

The red clearance interval is intended to provide a time period for a vehicle that has just crossed the stop line or just entered the intersection prior to the onset of red to clear the intersection without conflicting with side street approaches. From the ITE formula, the red clearance interval length is determined by the assumed speed of the vehicle, the assumed length of the vehicle, and the width of the intersection.

At intersections with low speed traffic but wide clearance paths, a short red clearance interval will sometimes result in motorists being in the intersection when the conflicting movements are released. This occurrence may give the cross street motorists the impression that red lights are being violated, even though they are not.

Lee Engineering calculated the total change period (yellow change + red clearance) for the study approaches using the ITE equation. The following values for the variables were used:

- Perception-reaction time: 1.0 second
- Approach speed: posted speed limit
- Deceleration rate: 10 ft/sec^2
- Width of intersection: Assumed stop line location to far curb of conflicting movement
- Length of vehicle: 20 ft
- Grade: as estimated by spot measurements in the field.

Lee Engineering personnel utilized a digital smart level to measure the grade on the approach to the intersection. On approaches that appear level to the naked eye, a series of measurements were taken at or near the stop bar. On approaches with obvious grades, such as the downgrade from a railroad crossing, measurements were taken 40 to 60 feet upstream of the stop bar in order to capture some of the grade affecting the vehicle during braking.

Lee Engineering compared the calculated total change period value, as well as the individual yellow change value and red clearance value for the study intersection approaches with the signal timing data provided by the City of Abilene at the beginning of the study.

[9] *Texas Manual on Uniform Traffic Control Devices.* Texas Department of Transportation. Austin, TX 2006.

Based on the data available, 11 of the 12 study approaches have a total change period shorter than the value calculated using the ITE formula and the variable values selected by Lee Engineering. The change period calculated is the sum of the yellow change plus the all red clearance interval. These 11 approaches ranged in value from 0.3 to 2.3 seconds shorter than the calculated values. The primary reason the total change period differed from the calculated value was that the existing signal timings had shorter red clearance times. Longer or shorter values for the change period, yellow change, and red clearance intervals may result from different variable values using the ITE equation, or through the use of an entirely different methodology for calculating the change period.

Of the 11 approaches that had total change period deficiencies, five (5) had yellow change intervals that were shorter than the calculated values. These ranged from 0.2 to 0.9 seconds short. Even though some of the values differed from Lee Engineering's calculations, all values fell within the three (3) second to six (6) second of yellow required by the Texas MUTCD. A value that differed from Lee Engineering's calculation does not indicate a deficiency in time; it more likely indicates a different methodology was utilized in developing the signal timings.

The red clearance interval was short at 11 of the 12 approaches, and ranged in value from 0.2 seconds short to 2.1 seconds short. The longer values were a result of long clearance paths for the motorists as measured by Lee Engineering. Many agencies choose to not use red clearance intervals of the duration resulting from the formula; however, because the calculation is for the entire change period, Lee Engineering typically recommends that some of the extra time afforded by not using the calculated red clearance length be allocated to the yellow change interval in order to maintain a total change period of a length equal to or greater than the equation calculated value.

An engineer must exercise judgment in the application of the formula in attempting to balance the total change period, the required yellow change interval, and the optional red clearance interval. The unused red clearance value can not always simply be added to the yellow change interval when it is not used. Many agencies prefer to not have any yellow change interval greater than five (5) seconds, and are prohibited by the MUTCD from having a value greater than six (6) seconds. If the formula calculation results in a 2.5 second red clearance value and a 4.5 second yellow change interval, then an agency that does not regularly use red clearance could not add all of the calculated red clearance time to the yellow change interval without exceeding the six (6) second maximum yellow change interval length. As such, engineering judgment would be used in determining the values actually programmed into a signal controller.

While a variety of methods may be used to determine the yellow change interval value at an intersection approach, research from the Texas Transportation Institute indicates that an increase in the yellow change interval duration of 0.5 seconds over the existing value was associated with reported reductions in violations of 40 percent and 20 to 25 percent reductions in crashes[10]. As such, a 0.5 second increase in yellow change interval duration should be considered at intersection approaches with a red-light running problem.

A summary showing the calculated values, as well as the values from the existing signal controllers is shown in Table 2.

[10] Bonneson, James and Zimmerman, Karl. *Development of Guidelines for Identifying and Treating Locations with a Red-Light-Running Problem.* Report 0-4196-2. Texas Transportation Institute, College Station, Texas, 2004. pp 5-9

Table 2: Change Period Comparison

Intersection	Study Approach	Yellow Change			Red Clearance			Total Change Period		
		Calculated	Existing	Difference	Calculated	Existing	Difference	Calculated	Existing	Difference
Buffalo Gap at Danville / Industrial	Westbound Danville/Industrial	3.9	4.0	0.1	1.8	1.8	0.0	5.7	5.8	0.1
South 14th Street at Clack	Westbound South 14th Street	4.3	4.0	(0.3)	1.2	1.0	(0.2)	5.5	5.0	(0.5)
	Southbound Clack	3.8	3.0	(0.8)	1.9	1.0	(0.9)	5.7	4.0	(1.7)
South 1st at Sayles	Eastbound South 1st Street	4.0	4.0	0.0	2.0	1.0	(1.0)	6.0	5.0	(1.0)
	Southbound Sayles	3.4	4.0	0.6	2.0	1.0	(1.0)	5.4	5.0	(0.4)
Treadaway at South 11th	Northbound Treadaway	4.3	4.5	0.2	1.6	0.0	(1.6)	5.9	4.5	(1.4)
	Southbound Treadaway	3.9	4.5	0.6	1.4	0.0	(1.4)	5.3	4.5	(0.8)
	Westbound South 11th Street	3.5	3.5	0.0	2.2	1.0	(1.2)	5.7	4.5	(1.3)
Buffalo Gap at Clack	Eastbound Clack	4.2	4.0	(0.2)	2.1	0.0	(2.1)	6.3	4.0	(2.3)
South 1st Street at Pioneer	Eastbound South 1st Street	4.2	4.0	(0.2)	1.4	1.0	(0.4)	5.6	5.0	(0.6)
	Westbound South 1st Street	4.3	4.0	(0.3)	1.4	1.0	(0.4)	5.7	5.0	(0.7)
	Southbound Pioneer	3.5	4.0	0.5	3.0	1.0	(2.0)	6.5	5.0	(1.5)

Controller Settings

Lee Engineering was provided with printouts of the traffic signal controller settings for the six (6) study intersections. The signals are currently being operated within industry norms and no obvious errors or problems were evident in the controller settings.

Based on field observations, the phase time assigned to the frontage road movements along US 83 may need some minor modifications. Lee Engineering personnel observed queues not clearing at the intersection approaches shown in Table 3. There may be opportunities to retime the phase slightly in order to provide additional green time to these movements and clear queues. It is important to note that the queues may not be clearing on the US 83 approaches due to signal timing that intentionally favors the arterial roadway progression. Signal timing that provides for good arterial traffic progression often results in longer side street delays.

Table 3: Queues Observed Not Clearing

Intersection	Study Approach	Comment
Buffalo Gap at Danville/Industrial	WB Danville/ Industrial	Westbound Danville observed not clearing on multiple cycles at various times of day. Queue gets spread out and may be gapping out.
South 14th at Clack	SB Clack	Left turn movement from southbound Clack observed not clearing on multiple cycles during mid-afternoon and PM peak periods.
Buffalo Gap at Clack	EB Clack	Left turn movement from eastbound Clack observed not clearing on multiple cycles during the mid-afternoon and PM peak periods.

Traffic Volumes

Prior to beginning this study, City of Abilene forces collected 48 hour approach volumes at each of the study approaches. Lee Engineering averaged the 48 hour data to obtain an average 24 hour approach volume for each of the study approaches. These volumes are shown in Table 4.

Table 4: Average Approach Volumes (2008)

Intersection	Study Approach	24 Hour Volume (Avg)	Dates Counted (2008)
Buffalo Gap at Danville/Industrial	WB Danville/Industrial	8,300	Sept 22-23
South 14th at Clack	WB South 14th	7,100	Sept 15-16
South 14th at Clack	SB Clack	5,900	Sept 22-23
South 1st at Sayles	EB South 1st	9,900	Sept 17-18
South 1st at Sayles	SB Sayles	2,500	Sept 17-18
Treadaway at South 11th	NB Treadaway	11,200	Sept 23-24
Treadaway at South 11th	SB Treadaway	11,000	Sept 23-24
Treadaway at South 11th	WB South 11th	8,500	Sept 23-24
Buffalo Gap at Clack	EB Clack	9,700	Sept 22-23
South 1st at Pioneer	EB South 1st	8,700	Sept 16-17
South 1st at Pioneer	WB South 1st	8,900	Sept 16-17
South 1st at Pioneer	SB Pioneer	4,500	Sept 16-17

These volumes are all within the range for the roadway types and lane configurations documented in field visits to the intersections. Because capacity does not appear to be a significant concern, it is unlikely that additional lanes or capacity at the intersections would significantly reduce red light crashes or violations.

Crash and Enforcement Data

City Wide Enforcement Data and Issues

The City of Abilene municipal court system was unable to provide citation data specific to the study intersections and approaches. The court system was queried to produce city wide citation totals for the 12 month period beginning September of 2007. This data is presented in Table 5 below.

Table 5: Citywide Red Light Citations

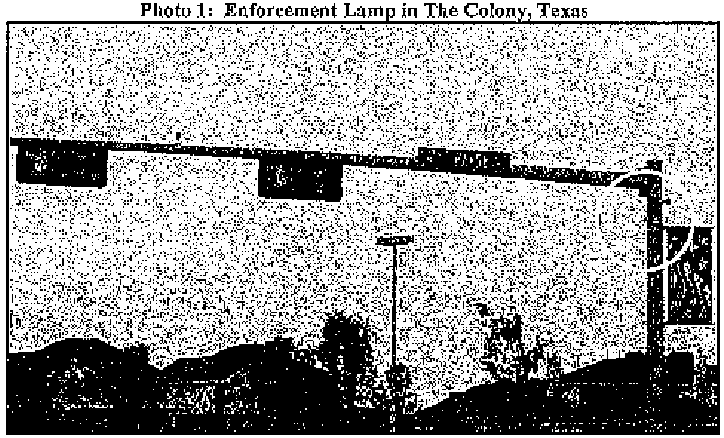
Month	Citations
September 2007	59
October 2007	84
November 2007	67
December 2007	48
January 2008	55
February 2008	86
March 2008	77
April 2008	79
May 2008	59
June 2008	73
July 2008	56
August 2008	55
September 2008	67

Discussions with the Abilene Police Department have revealed that there are limited traffic enforcement resources available within the department. Red light enforcement tends to be one of the least safe traffic enforcement activities that an individual officer can perform due to the requirement that the officer proceed through the same red light in order to pursue the violator.

One way to mitigate this safety concern is to utilize two officers, one as a spotter and one downstream of the intersection that can apprehend the violator. While safer for police personnel, this method of enforcement doubles the manpower demands that red light enforcement represents. Furthermore, unlike speeding enforcement, where typically more than 15% of motorists are exceeding the speed limit, the red light violation is a random event where only 1-2 motorists an hour may violate the red indication during an observation period.

A second way to mitigate the safety issues associated with red light enforcement is through the use of enforcement lamps at intersections with safety issues. An enforcement lamp is a small lamp attached to either the mast arm or signal pole that illuminates when the red indications illuminate. This allows a law enforcement officer to sit on the downstream side of the intersection yet still know when the red light has been displayed so the officer can determine when a motorist has violated the light. An enforcement lamp is shown in Photo 1.

Photo 1: Enforcement Lamp in The Colony, Texas



This relatively low cost improvement, installed costs could range from $300 to $700 dollars per installation, would allow police officers to enforce the signal by themselves and from the downstream side of an intersection, eliminating the need to use two officers or follow a violator thru an intersection. Enforcement lamps are available with white, red, and blue lenses. Based on Lee Engineering observations and signal design practice, white enforcement lamps seem to be the most common color utilized in Texas. Based on discussions with law enforcement officers in other areas of Texas, Lee Engineering recommends white as the preferred color and most easily observed indication for law enforcement. The most common mounting location is on the signal pole as shown in Photo 1 or above the mast arm adjacent to the signal pole connection.

Enforcement lamps are not currently installed at any location within the City of Abilene. They are not required for use by the Texas MUTCD or any legal statute and should be considered an optional improvement. Enforcement lamps are most beneficial when combined with a concerted high visibility traffic enforcement effort from the police department. Enforcement lamps should be added to the signal poles at intersections where the Abilene Police Department plans to expand their enforcement efforts. The lamps should be installed on the approach with the red light running problem. A public relations campaign should accompany the installation of the lamps and kickoff of any expanded efforts. This campaign would educate the public and reveal the purpose and use of the enforcement lamps.

Approach Specific Violation Data

Redflex, a red-light camera vendor collected violation data for eight (8) hours at nine (9) of the 12 study approaches. Additionally, Redflex collected violation data at three (3) other intersection approaches that were not part of this analysis. Lee Engineering personnel collected two (2) hours of violation data for the three (3) study approaches at the intersection of South 1st Street (BI-20) and Pioneer where Redflex did not collect dara. It is important to note that Redflex collected violation data using the detailed and deliberate review of recorded video of the intersection approach. Lee Engineering violation data was collected real time in the field and did not allow for the replay of a violation. Additionally, some split second violations that may be visible on video may not be perceived in the field by the observer in real time. The violation data is presented in Table 6.

Table 6: Violations Per Hour

Study Intersection	Approach Name	Violations Observed	Time Period	Violations Per Hour
Buffalo Gap & Danville/Industrial	Westbound Danville/Industrial	38	8 hr	4.8
South 14th & Clack	Westbound S 14th	7	8 hr	0.9
	Southbound Clack	14	8 hr	1.8
South 1st & Sayles	Eastbound S 1st	7	8 hr	0.9
	Southbound Sayles	0	8 hr	0.0
Treadaway & S 11th	Northbound Treadaway	4	8 hr	0.5
	Southbound Treadaway	5	8 hr	0.6
	Westbound S 11th	3	8 hr	0.4
Buffalo Gap & Clack	Eastbound Clack*	12	8 hr	1.5
South 1st & Pioneer**	Eastbound S 1st	8	2 hr	4.0
	Westbound S 1st	5	2 hr	2.5
	Southbound Pioneer	0	2 hr	0.0
Total		103	78 hr	1.3

* Data provided to City by Redflex identified Clack as a westbound approach.
** This intersection was collected by Lee Engineering personnel. All other data collected by Redflex and provided by City.

A total of 78 hours of violation data were collected across the 12 study approaches. The average violation rate across the 12 study approaches was 1.3 violations per hour. Only two approaches, westbound Danville/Industrial at Buffalo Gap and eastbound South 1st at Pioneer, had violation rates significantly higher than the study average.

Texas Transportation Institute research indicates that 3.0 to 5.0 violations per 1,000 vehicles may be considered a normal rate of violations for a typical intersection approach. In a study of 275 hours of signal operations across the state of Texas, the average number of violations was 3.5 violations per 1,000 vehicles [11].

Lee Engineering personnel counted the total number of approaching vehicles while observing red light violations at the intersection of South 1st and Pioneer. While Lee Engineering did not have the actual traffic volume data associated with the Redflex collected violation data, the 48-hour traffic counts collected by the City in September 2008 were available. City Staff informed Lee Engineering that Redflex violation data were collected between the hours of 11:00 AM and 7:00 PM. The 11:00 AM to 7:00 PM volume data were averaged over the two days of data available for each approach. Using these volume estimates Lee Engineering was able to calculate the number of violations per 1,000 vehicles for each study approach. The estimated eight hour volumes and calculated violations per 1,000 vehicles are shown in Table 7.

As shown in Table 7, the 12 study approaches have an average violation rate of 2.2 violations per 1,000 vehicles. This average value is lower than the typical range of 3.0 to 5.0 violations per 1,000 vehicles presented in the TTI research. Eight (8) of the 12 study approaches have violations per 1,000 vehicle rates that are lower than 3.0 violations per 1,000 vehicles. All eight of those approaches are also lower than the 2.2 violations per 1,000 vehicles rate calculated across the 12 study approaches. When compared to the statewide typical range of 3.0 to 5.0 violations per 1,000 vehicles, the eight (8) approaches below that typical range are unlikely to have a red light running violation problem.

As shown in Table 7, only four (4) intersection approaches had violation rates higher than the statewide average value of 3.5. Two (2) of these approaches, Southbound Clack at South 14th, and Westbound South 1st at Pioneer had rates slightly higher than the statewide average, yet were well within the typical range of values of 3.0 to 5.0 violations per 1,000 vehicles noted in the TTI research.

The westbound South 1st Street approach to Pioneer was one (1) of two (2) study approaches that had a violation rate higher than the typical range presented in the TTI research. With a violation rate of 5.2 violations per 1,000 vehicles, this approach fell just above the 5.0 violations per 1,000 range. The westbound Danville/Industrial approach to Buffalo Gap showed a violations per 1,000 vehicles rate (7.5) that was significantly higher than the statewide average or typical ranges presented in the previously referenced TTI research.

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[11] Bonneson, James and Zimmerman, Karl. *Development of Guidelines for Identifying and Treating Locations with a Red-Light Running Problem.* Report 0-4196-2. Texas Transportation Institute, College Station, Texas, 2004. pp 4-7 – 4-8.

Table 7: Violations per 1,000 Vehicles

Study Intersection	Approach Name	Violations observed	Estimated Approach Volume	Violations per 1,000 Vehicles
Buffalo Gap & Danville/Industrial*	Westbound Danville/Industrial	38	5,100	7.5
South 14th & Clack*	Westbound S 14th	7	4,100	1.7
	Southbound Clack	14	3,300	4.2
South 1st & Sayles*	Eastbound S 1st	7	5,500	1.3
	Southbound Sayles	0	1,600	0.0
Treadaway & S 11th*	Northbound Treadaway	4	6,200	0.6
	Southbound Treadaway	5	6,700	0.7
	Westbound S 11th	3	4,700	0.6
Buffalo Gap & Clack*	Eastbound Clack*	12	5,600	2.1
South 1st & Pioneer**	Eastbound S 1st	8	1,535	5.2
	Westbound S 1st	5	1,332	3.8
	Southbound Pioneer	0	580	0.0
Total		103	46,247	2.2

* Volume data estimated from City traffic count data.
** Volume data collected manually by Lee Engineering personnel.

As previously mentioned, the 12 study approaches have an average rate of 2.2 violations per 1,000 vehicles. Four (4) of the 12 intersection approaches had a violation rate higher than the study approach average value. These four (4) approaches are shown in Table 8. These four (4) approaches are also the only four (4) approaches with violation rates higher than the statewide average of 3.5 violations per 1,000 vehicles.

Table 8: Violation Rates Greater than City Study Average

Study Intersection	Approach Name and Number	Violations per 1,000 Vehicles
Study Average Rate Across all 12 Approaches		**2.2**
Buffalo Gap & Danville / Industrial	Westbound Danville/Industrial	**7.5***
South 1st & Pioneer	Eastbound S 1st	**5.2****
South 14th & Clack	Southbound Clack	4.2
South 1st & Pioneer	Westbound S 1st	3.8

* 3.4 times greater than study average; **2.4 times greater than study average

Intersection Specific Crash Data

The Abilene Police Department provided Lee Engineering with crash summaries for the most recent 18 months available. This crash data was summarized by approach into a variety of crash types including: rear-end, angle, head-on, pedestrian, and other. The direction of travel for the at-fault drive determined the approach that the crash was assigned to by the Abilene Police Department. The crash summaries that appear on the following pages contain only crash types with a documented crash. If there were zero (0) rear end crashes associated with a particular approach, then the rear end category row was not shown in the table. The crash data for the six study intersections is shown in the following tables. The actual study approaches are shaded in the data tables.

The aggregated crash data for all six (6) study intersections is shown in Table 9. The data in this table is aggregated by the 12 study approaches, the nine (9) non-study approaches, and the 21 total approaches at the six (6) study intersections. The data in Table 9 indicate that the non-study approaches have a higher percentage of angle crashes than the study approaches and a lower percentage in crashes associated with red light running. Overall, there was little difference between the study and non-study approaches in the types and percentage of crashes.

Table 9: Aggregate Crash Summary

	Total Crashes	Angle Crashes		Crashes associated with Red Light Running	
		Number	Percent of Total	Number	Percent of Total
Crashes on Study Approaches Only (12)	83	34	41 %	18	22 %
Crashes on Non-Study Approaches (9)	47	22	47 %	7	15 %
Crashes on All Approaches (21)	130	56	43 %	25	19 %

The data provided in Table 10 indicate that drivers in the westbound direction on Danville were at fault in 18 total crashes. Three (3) right angle crashes, two (2) of which were the result of red light running, were the fault of motorists in the westbound direction. The high number of "other" crashes was largely attributed to westbound motorists in the left-turn only lane disregarding lane assignment signage, attempting to proceed through the intersection, and striking a vehicle turning out of the shared through/left-turn lane. The data presented in Table 10 also indicated that the northbound Buffalo Gap approach to the intersection had higher numbers of angle and red light running crashes than the study approach.

Table 10: 18 Month Crash Summary - Buffalo Gap at Danville

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
Westbound Danville	Angle	3	1		2
	Other	15	1		
	Total	18	2	0	2
Northbound Buffalo Gap	Rear End	1	-	-	-
	Angle	6	-	-	3
	Other	1	-	-	-
	Total	8	0	0	3
Southbound Buffalo Gap	Other	1	-	-	-
	Total	1	0	0	0

Table 11 indicates that at the intersection of South 14^{th} Street and Clack there were a total of 14 crashes in the previous 18 months. Of those 14, six (6) were crashes associated with red light running. The westbound approach on South 14^{th} was the approach with the most crashes, experiencing 10 total crashes, five (5) of which were angle crashes. Westbound South 14^{th} also experienced the highest number, four (4), of red light running crashes than any other study approaches with the exception of eastbound Clack at Buffalo Gap, which also had four (4).

Table 11: 18 Month Crash Summary - South 14th at Clack

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
Southbound Clack	Angle	2			1
	Other	1			
	Total	3	0	0	1
Eastbound South 14^{th}	Angle	1	-	-	1
	Total	1	0	0	1
Westbound South 14th	Rear End	5	3		
	Angle	5	1		4
	Total	10	4	0	4

The South 1^{st} at Sayles intersection crash data is shown in Table 12. This intersection is unique in that some red light running crashes were head-on crashes. Based on comments from City Staff, these crashes were likely left-turn opposing crashes. The eastbound South 1st Street approach experienced five (5) angle crashes in the 18 month period.

Table 12: 18 Month Crash Summary - South 1st (BI-20) at Sayles

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
Northbound Sayles	Rear End	2	1	-	-
	Angle	4	1	-	-
	Head-On	1	-	-	1
	Other	2	-	-	-
	Total	9	2	0	1
Southbound Sayles	Angle	1	-	-	-
	Head-On	1	-	-	1
	Total	2	0	0	1
Eastbound South 1st	Angle	5	3	-	2
	Total	5	3	0	2
Westbound South 1st	Rear End	2	-	-	-
	Angle	2	-	-	-
	Head-On	2	-	-	1
	Other	3	3	-	-
	Total	9	3	0	1

The Treadaway at South 11th Street data is presented in Table 13. Both the northbound and southbound approaches have six (6) total crashes recorded in the 18 month period. The westbound South 11th Street approach had neither an angle crash nor a crash associated with red light running.

Table 13: 18 Month Crash Summary - Treadaway at South 11th

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
Northbound Treadaway	Rear End	3	-	-	-
	Angle	2	-	-	1
	Other	1	-	-	-
	Total	6	0	0	1
Southbound Treadaway	Rear End	1	-	-	-
	Angle	2	-	-	2
	Other	3	-	-	-
	Total	6	0	0	2
Eastbound South 11th	Other	1	-	-	-
	Total	1	0	0	0
Westbound South 11th	Rear End	1	-	-	-
	Other	1	-	-	-
	Total	2	0	0	0

Crash data for the intersection of Buffalo Gap at Clack is presented in Table 14. This intersection has a higher number of angle crashes than any other intersection. The eastbound Clack approach experienced nine (9) angle crashes; four (4) of which were associated with red light running.

Table 14: 18 Month Crash Summary - Buffalo Gap at Clack

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
Eastbound Clack	Rear End	5	1		
	Angle	9	2		4
	Other	3			
	Total	17	3	0	4
Northbound Buffalo Gap	Rear End	2	2	-	-
	Angle	2	-	-	-
	Other	2	-	-	-
	Total	6	2	0	0
Southbound Buffalo Gap	Rear End	4	-	-	
	Angle	5	1	-	
	Total	9	1	0	0

The final intersection is South 1st Street at Pioneer. The crash data is provided in Table 15. Both the westbound and southbound approaches to this intersection did not have a crash associated with red light running.

Table 15: 18 Month Crash Summary - South 1st (BI-20) at Pioneer

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
Northbound Pioneer	Rear End	1	-	-	-
	Angle	2	-	-	1
	Total	3	0	0	1
Southbound Pioneer	Rear End	1			
	Angle	1			
	Total	2	0	0	0
Eastbound South 1st	Rear End	2	1		
	Angle	3	2		1
	Other	2			
	Total	7	3	0	1
Westbound South 1st	Rear End	3	1		
	Angle	1			
	Other	1	1		
	Total	5	2	0	0

Crash data is sometimes represented by a statistical Poisson distribution. The standard deviation of a Poisson distribution is the square root of the mean. In order to better compare the study approaches, the 18 month crash frequency was converted to an annual rate, crashes per year. Using the number of crashes per year per approach the angle and red light crashes at the various approaches can be compared to each other and to the average of all 21 approaches. Typical comparison points are one and two standard deviations from the mean.

Table 16: Statistical Values for Crash Comparisons

Statistic	Angle Crash Frequency Per Year	Red Light Running Crash Frequency Per Year
Mean (Average)	1.8	0.8
Standard Deviation ($\sqrt{mean}$)	1.3	0.9
Mean + 1 Standard Deviation	3.1	1.7
Mean + 2 Standard Deviations	4.4	2.6

While no crash is acceptable for the motorists involved in the crash, a certain amount of crashes must be tolerated in order to prioritize limited engineering and enforcement resources. Zero crashes is the goal any agency strives for; however, crashes are random and rare events that occur as the result of numerous factors and can never be fully eliminated.

Any intersection approach that has fewer angle or red light running crashes than the mean frequency shown in Table 16 should not be considered for improvements prior to any intersection that has more crashes than the mean. Similarly, any intersection approach with a crash frequency that is at least two standard deviations above the mean value would typically be a better candidate for improvement than an approach with crashes equal to or only slightly greater than the mean.

The twelve study approaches were analyzed using this method and grouped in Table 17 and Table 18. Table 17 groups the crashes based on their angle crash frequency. Seven (7) of the twelve (12) intersection approaches are below the mean angle crash frequency. The eastbound Clack at Buffalo Gap is two standard deviations above the mean. Two (2) other approaches were at least one standard deviation above the mean. The westbound Danville approach to Buffalo Gap was above the mean, but not more than one standard deviation above. This is interesting because this approach had the highest rate of violations per hour and violations per 1,000 vehicles in the study. This illustrates that the violations do not necessarily translate directly to crashes.

Limitations are present in the applicability of this statistical comparison due to the low number of angle and red light running crashes on each approach. One or two additional crashes per year on an approach will result in that approach being ranked one or more standard deviations above the mean because the number of crashes on each approach were low initially.

Table 17: Study Approaches Angle Crash Groupings

Intersection	Study Approach	Angle Crash Frequency*	Group (1 is highest)
Buffalo Gap at Clack	EB Clack	> M + 2	1
South 14th at Clack	WB South 14th	> M + 1	2
South 1st at Sayles	EB South 1st	> M + 1	2
Buffalo Gap at Danville/Industrial	WB Danville/Industrial	> M	3
South 1st at Pioneer	EB South 1st	> M	3
South 14th at Clack	SB Clack	< M	4
South 1st at Pioneer	SB Pioneer	< M	4
South 1st at Pioneer	WB South 1st	< M	4
South 1st at Sayles	SB Sayles	< M	4
Treadaway at South 11th	NB Treadaway	< M	4
Treadaway at South 11th	SB Treadaway	< M	4
Treadaway at South 11th	WB South 11th	< M	4

* M= Mean value; M+1=Mean + 1 Standard Deviation; M+2 = Mean + 2 Standard Deviations

The twelve (12) study approaches were also grouped by red light running crash frequency. These groupings are presented in Table 18. Only five (5) intersection approaches were above the mean crash frequency. Eastbound Clack at Buffalo Gap, and Westbound South 14th at Clack were both at least two standard deviations above the mean, indicating a potential crash problem at these intersection.

Table 18: Study Approaches Red Light Running Crash Groupings

Intersection	Study Approach	Red Light Crash Frequency*	Group (1 is highest)
Buffalo Gap at Clack	EB Clack	> M + 2	1
South 14th at Clack	WB South 14th	> M + 2	1
Buffalo Gap at Danville/Industrial	WB Danville/Industrial	> M	3
South 1st at Sayles	EB South 1st	> M	3
Treadaway at South 11th	SB Treadaway	> M	3
South 14th at Clack	SB Clack	< M	4
South 1st at Pioneer	EB South 1st	< M	4
South 1st at Pioneer	SB Pioneer	< M	4
South 1st at Pioneer	WB South 1st	< M	4
South 1st at Sayles	SB Sayles	< M	4
Treadaway at South 11th	NB Treadaway	< M	4
Treadaway at South 11th	WB South 11th	< M	4

* M= Mean value; M+1=Mean + 1 Standard Deviation; M+2 = Mean + 2 Standard Deviations

Summary of Violation and Enforcement Data

Lee Engineering reviewed the data provided by the City of Abilene regarding red light running citations, crashes, and violations in an effort to better understand the nature of the red light running problem on the 12 study approaches.

The violation data collected by Redflex and Lee Engineering indicated an average of 2.2 violations per 1,000 vehicles at the study approaches. This is much lower than the average rate of 3.5 violations per 1,000 vehicles in a TTI study of approaches across the state. The majority of the 12 Abilene study approaches reviewed had average rates per 1,000 vehicles below the 3.0 to 5.0 range cited in TTI literature as typical. Four study approaches had violation rates that exceeded both the city (2.2 per 1,000 vehicles) and state wide (3.5 per 1,000 vehicles) average rates. Those approaches were the following four:

- Westbound Danville/Industrial at Buffalo Gap;
- Eastbound South 1st at Pioneer;
- Southbound Clack at South 14th; and
- Westbound South 1st at Pioneer.

The crash data provided by the City of Abilene indicated an average of 1.8 angle crashes per year per study approach. The average number of red light running crashes per year per approach was 0.8. Only the eastbound Clack approach to Buffalo Gap had an average number of angle crashes per year that was two standard deviations above the mean number of angle crashes per year. Two study approaches had annual average numbers of red light running crashes two standard deviations greater than the mean number of red light crashes per year. These were the eastbound Clack approach to Buffalo Gap and the westbound South 14th approach to Clack. The eastbound Clack approach to Buffalo Gap was the intersection approach with the largest difference between Lee Engineering calculated change period and change period currently in the controller. Seven (7) of the 12 study approaches had annual rates of both angle crashes and red light crashes that were below the mean values.

Conclusions

Intersection and Signal Data

- Signal visibility was not determined to be a significant factor in red light running at the study intersections. However, there was some concern surrounding sight distance at the westbound Danville/Industrial approach to Buffalo Gap due to roadway curvature and tree growth on the approach.
- Stop lines are not required but would be helpful at those approaches with red light running problems or concentrated police enforcement efforts. Pavement marking maintenance is a significant challenge due to asphalt mixes and climate conditions. Stop lines at the majority of intersection approaches were coated with oil or dirt and therefore were difficult to see.
- No black signal backplates were present on any signals. Backplates are not required but should be considered for certain conditions.
- Signal indications were not found to be an issue. All lenses were 12" in size and LED signal indications are now in place citywide. LED signal indications and 12 inch lenses are common countermeasures used for reducing red-light running.

Signal Timing and Traffic Data

- There is no required or standard method of calculating signal change periods. All methods require exercising engineering judgment in the application of yellow change and red clearance interval lengths. Lee Engineering's preferred method of calculating change periods resulted in values longer than those present at the study intersections. Eleven of the 12 intersection approaches had change periods shorter than calculated; ranging from 0.3 seconds short to 2.3 seconds short. Five of the 12 approaches had yellow change intervals shorter than the calculated values; ranging from 0.2 to 0.9 seconds short. Eleven of the 12 approaches had red clearance intervals shorter than the calculated values; ranging from 0.2 to 2.1 seconds short.
- Signal timing was not found to be a significant factor in red light running at the majority of study approaches. Three (3) approaches had minor street queues that did not always clear during the allocated green time.
- Based on traffic observation and count data collected, there was no indication of capacity problems at the study intersections.

Violations

- The City study average violation rate of 2.2 violations per 1,000 is lower than the statewide typical range of 3.0 to 5.0 violations per 1,000 vehicles.
- Based on the violation data analyzed, there appears to be a significant red-light violation problem on the westbound Danville/Industrial approach to Buffalo Gap and on the eastbound South 1st Street approach to Pioneer. These two approaches were significantly higher than the city study average rate of 2.2 violations per 1,000 vehicles based on data at the 12 city study approaches. These were the only

two approaches with violation rates higher than the statewide typical range of 3.0 to 5.0 violations per 1,000 vehicles.

- Two other intersection approaches had violation rates greater than the average rate – westbound South 1st Street at Pioneer and Southbound Clack at South 14th Street. While higher than the city study average rate, these approaches were within the typical statewide range of 3.0 to 5.0 violations per 1,000 vehicles.
- The other eight study approaches do not appear to have red-light violation problems based on having a violation rate lower than the City study average violation rate of 2.2 violations per 1,000 vehicles.

18 Month Crash Data

- Three study approaches had an annual rate of angle crashes per year that were one or more standard deviations above the average for the study approaches.
- Two study approaches had annual rates of red light running crashes that were one or more standard deviations above the average for the study approaches.
- A comparison to the other intersection approaches for which data were provided, the angle and red light running crash annual rates at the eastbound Clack approach to Buffalo Gap and the westbound South 14th approach to Clack were significantly higher than other study approaches. Eastbound South 1st at Sayles also was higher than the study approach average in both angle and red light running crash frequencies.
- Other intersection approaches that had either annual angle or annual red light running crash rates higher than the study average, but not significantly higher, were westbound Danville/Industrial at Buffalo Gap, eastbound South 1st at Pioneer, and southbound Treadaway at South 11th Street.
- The eastbound Clack approach to Buffalo Gap was the only approach two standard deviations greater than the average study annual rate for both angle and red light running crashes.

Enforcement

- Based on data provided by the City of Abilene Police Department, significant officer directed red-light enforcement efforts are difficult to accomplish. Additionally, officer safety is put at significant risk through traditional means of enforcing red light compliance by requiring an officer to follow a violator through an already red light.
- No enforcement or confirmation light assemblies are currently used.
- Based on a review of the crash and violation data, only two (2) of the twelve (12) study approaches warrant consideration for red light camera enforcement. These two (2) approaches – westbound Danville/Industrial at Buffalo Gap and eastbound South 1st at Pioneer – experienced violation rates significantly higher than other study approaches and significantly higher than statewide data. Camera enforcement on these two (2) approaches should be considered after the other remedial efforts outlined in the recommendations have been implemented and proven unsuccessful in reducing red-light violations and angle crashes.

Recommendations

Based on Lee Engineering's review of the data provided by the City of Abilene, field visits, and observation data collected, Lee Engineering offers the following recommendations for consideration by the City of Abilene. General recommendations were made for all study approaches. Additionally, specific recommendations were made for some of the individual study approaches. Specific recommendations were not made for each individual approach.

<u>All Study Approaches</u>

- Black signal backplates should be installed on all signal heads controlling intersection approaches with either a perceived or documented red-light running problem. Priority in programming signal backplate upgrades should be given to signal heads on east/west approaches first and then to north/south ones.
- Twenty-four inch thermoplastic stop lines should be installed across all signalized intersection approaches with either a perceived or documented red-light running problem. Stop lines are not required by statute or the Texas MUTCD and are only recommended for the problem approaches to an intersection, not all approaches.
- Where the Abilene Police Department plans to concentrate red light running enforcement efforts, white enforcement lamps should be installed on signal poles in order to maximize the safety and efficiency of officer enforcement efforts. If enforcement lamps are implemented, a public information campaign should inform motorists about the functionality of the lamps and should be combined with an initial high level of visible enforcement by APD to attempt to change driver behavior.
- Consider lengthening the yellow change intervals to at least the Lee Engineering calculated minimums.
- Consider lengthening the red clearance interval to at least the Lee Engineering calculated minimums.
- Consider lengthening the total change periods (yellow + red clearance) using Lee Engineering's change period methodology.
- Based on information presented in TTI's research on countermeasures to reduce red light running, consideration should be given to adding an additional 0.5 seconds of yellow to the calculated yellow time on approaches with a red-light running problem.

<u>Buffalo Gap at Danville/Industrial (Westbound Danville/Industrial Approach)</u>

- A "Signal Ahead" sign should be added approximately 600' feet from stop line.
- A new thermoplastic stop line should be installed on this approach.
- New signal backplates should be installed on this approach.
- A near side left vertical three section signal head should be considered for installation on the existing pedestal pole on the southeast corner. This signal head would provide additional visibility due to curvature of the road.

- A far side left vertical three section signal head should be considered for installation on the southwest corner of the intersection on an existing signal pole. This signal head would provide additional information for left turning motorists.
- Based on the violation rate being 3.4 times greater than the 12 study approach average the Abilene Police Department should concentrate red light enforcement efforts at this approach. A white enforcement lamp should be added to the signal pole to maximize the safety and efficiency of APD efforts.
- Based on the violation rate being 3.4 times greater than the 12 study approach average, a red light camera should be considered for installation on this approach if after an adequate trial of other measures proves unsuccessful in reducing red-light running.

South 14th At Clack (Westbound South 14th Approach)

- Based on Lee Engineering's change period calculations, the yellow change interval should be lengthened to at least 4.3 seconds. Consider lengthening the red clearance interval to at least 1.2 seconds.
- New signal backplates should be installed on this approach.
- A vertical three section head should be considered for installation on a new pedestal pole on the NE corner. This would provide a near side right signal head.
- Due to an average annual rate of crashes involving red-light running significantly higher than the other study approaches the Abilene Police Department should concentrate red light enforcement efforts on the westbound South 14th approach. A white enforcement lamp should be added to the signal pole to maximize the safety and efficiency of APD efforts.

South 14th At Clack (Southbound Clack Approach)

- Based on Lee Engineering's change period calculations, the yellow change interval should be lengthened to at least 3.8 seconds. Consider lengthening the red clearance interval to at least 2 seconds.
- A new thermoplastic stop line should be installed on this approach.
- New signal backplates should be installed on this approach.
- A far side left vertical three section head should be considered for installation on the existing signal pole to function as a pull through head and provide better information for left turning motorists.
- Based on the violation rate being higher than the 12 study approach average the Abilene Police Department should concentrate red light enforcement efforts on the eastbound approach. A white enforcement lamp should be added to the signal pole to maximize the safety and efficiency of APD efforts

South 1st Street at Sayles (Eastbound Approach)

- Based on Lee Engineering's change period calculations, consider lengthening the red clearance interval to at least 2 seconds.
- A new thermoplastic stop line should be installed on this approach.
- New signal backplates should be installed on this approach.

Buffalo Gap At Clack (Eastbound Clack Approach)

- Based on Lee Engineering's change period calculations, the yellow change interval should be lengthened to at least 4.2 seconds. Consider lengthening the red clearance interval to at least 2.1 seconds.
- A new thermoplastic stop line should be installed on this approach
- New signal back plates should be installed on this approach.
- A far side left vertical three section head should be considered for installation if possible on the existing signal pole in the northeast corner of the intersection to provide better information for the left turning motorists.
- A near side right vertical three section head should be considered for installation high on the existing signal pole in the southwest corner of the intersection if possible to provide better visibility for approaching motorists.
- Turning movement counts should be conducted and signal phases optimized so that queue clears regularly.
- Due to an average annual rate of crashes involving red-light running significantly higher than the other study approaches the Abilene Police Department should concentrate red light enforcement efforts on the eastbound Clack approach. A white enforcement lamp should be added to the signal pole to maximize the safety and efficiency of APD efforts.

South 1st Street at Pioneer (Eastbound Approaches)

- Based on Lee Engineering's change period calculations, the yellow change interval should be lengthened to at least 4.2 seconds. Consider lengthening the red clearance interval to at least 1.4 seconds.
- New signal backplates should be installed on the eastbound approach.
- Verify that left-turn lane detection functions as intended. If possible, modify detector settings to ensure better queue clearance.
- Based on the violation rate being 2.4 times greater than the 12 study approach average the Abilene Police Department should concentrate red light enforcement efforts on the eastbound approach. A white enforcement lamp should be added to the signal pole to maximize the safety and efficiency of APD efforts.
- Based on the violation rate being 2.4 times greater than the 12 study approach average, a red light camera should be considered for installation on this approach if after an adequate trial of other measures proves unsuccessful in reducing red-light running.

South 1st Street at Pioneer (Westbound Approach)

- Based on Lee Engineering's change period calculations, the yellow change interval should be lengthened to at least 4.3 seconds. Consider lengthening the red clearance interval to at least 1.4 seconds.
- New signal backplates should be installed on the westbound approach.
- Verify that left-turn lane detection functions as intended. If possible, modify detector settings to ensure better queue clearance.
- Based on the violation rate being higher than the 12 study approach average the Abilene Police Department should concentrate red light enforcement efforts on the eastbound approach. A white enforcement lamp should be added to the signal pole to maximize the safety and efficiency of APD efforts.

APPENDIX
Texas Department of Transportation Template Analysis

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: Buffalo Gap (FM 89) & Danville/Industrial (US 83 Frontage Road)
Westbound Danville/Industrial approach only

A. Intersection and Signal Data

1. Signal Visibility
   a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
WB	+0.9%	40	540	390

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
Are "SIGNAL AHEAD" warning signs needed? ☒ Yes ☐ No
Are other warning signs present in the vicinity of the intersection?
☐ Yes ☒ No
Explain: Visibility restricted by curvature and landscaping

c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
WB	12"	LED	N	N

2. Pavement and Markings Data
   a. Are stop bars in "good" condition? ☐ Yes ☒ No
   Explain: Poor visibility of stop lines due to faded markings with asphalt and oil tracked over them.

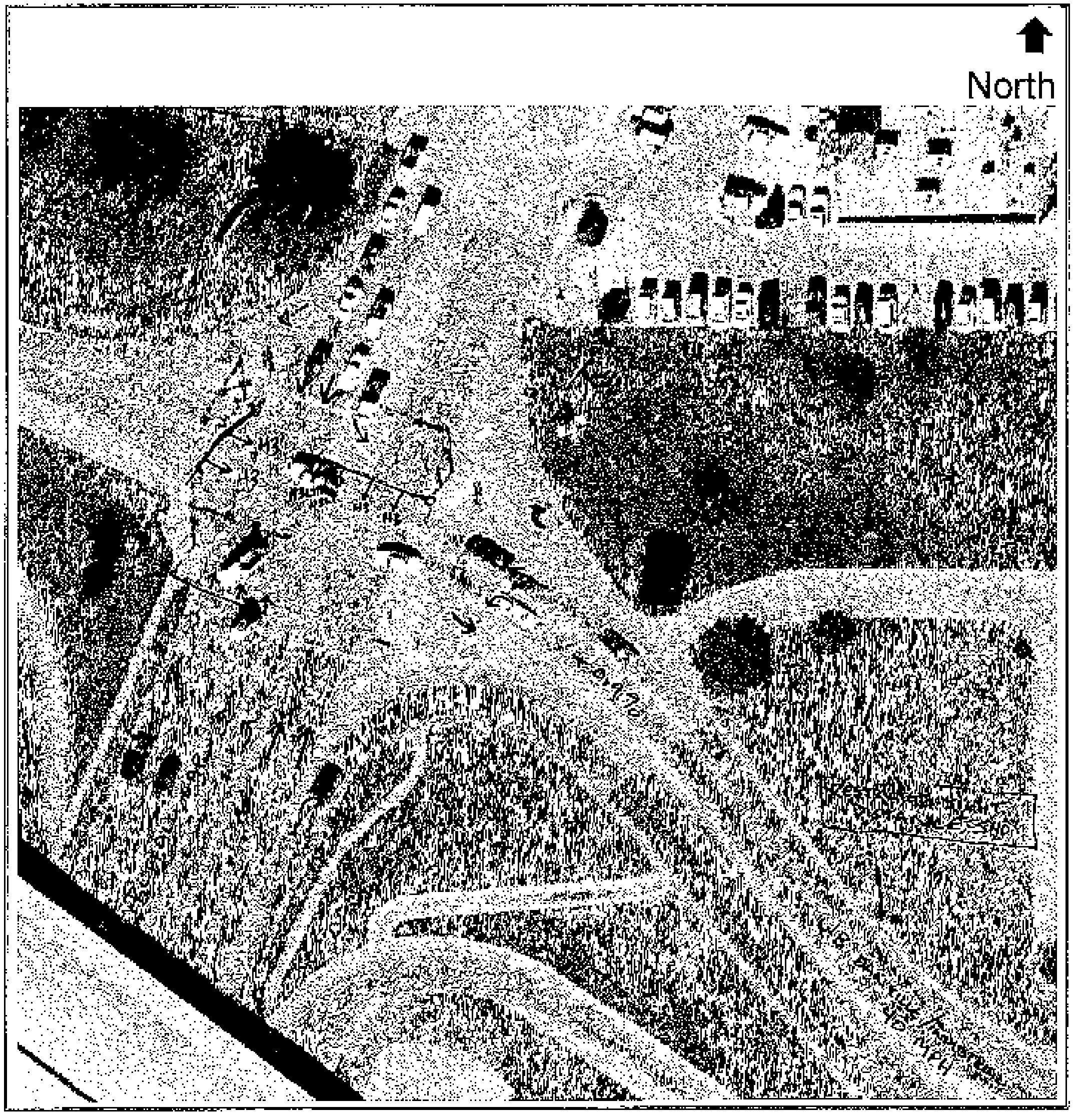
   b. Are lane lines "clearly" visible? ☒ Yes ☐ No
   Explain:

   c. Are crosswalks "clearly" marked? ☐ Yes ☒ No
   Explain: Not Present

d. What is the pavement condition (ruts, potholes, cracking, etc.)?
- ☐ Good Explain: ______
- ☒ Fair Explain: Concrete approach in satisfactory condition
- ☐ Poor Explain: ______

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?
- ☒ Yes Explain: Transverse grooving for friction is present
- ☐ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
WB	40	+0.9%	87'	4.0	3.9	1.8	1.8

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?

   ☒ Yes ☐ No

   Explain: Signal was observed not always clearing WB queues at various times. Congestion is sometimes cited as a cause of red light running.

   b. List comments or recommendations on potential signal timing or phasing changes: Consider adding a few seconds to westbound split to extend signal longer, or increasing gap time on detection so phase does not gap out as quickly.

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
WB	Loop 6' x 40'	4' in front of stop bar

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
WB	8,300	5%	750	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
WB	Rear End	0			
	Angle	3	1		2
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	15	1		
	Total	18	2	0	2
NB	Rear End	1			
	Angle	6			3
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	8	0	0	3
SB	Rear End				
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	1	0	0	0
	Rear End				
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total				

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a   Year: ____________

   b. Observed Violations:
      Date: July 2008   Time Period: 8 hours

Approach	Traffic Volume	Number of Violations
WB	5,100	38

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is heavily developed with numerous turning conflicts that may hamper apprehension. Also left turners would be stopped in interior of diamond creating congestion. Officer must pursue violator through red indication.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Low pedestrian volumes

      Number of pedestrians per hour: n/a
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: South 14th Street (US 277) & South Clack Street (US 83 Frontage Road)
Westbound South 14th Street approach only

A. Intersection and Signal Data

1. Signal Visibility
   a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
WB	+0.3%	45	> 600'	460

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

   b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
   Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
   Are other warning signs present in the vicinity of the intersection? ☐ Yes ☒ No
   Explain: ______________________________

   c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
WB	12"	LED	N	N

2. Pavement and Markings Data
   a. Are stop bars in "good" condition? ☐ Yes ☒ No
   Explain: WB – Faded / Dirty

   b. Are lane lines "clearly" visible?
   WB - ☒ Yes ☐ No
   Explain: ______________

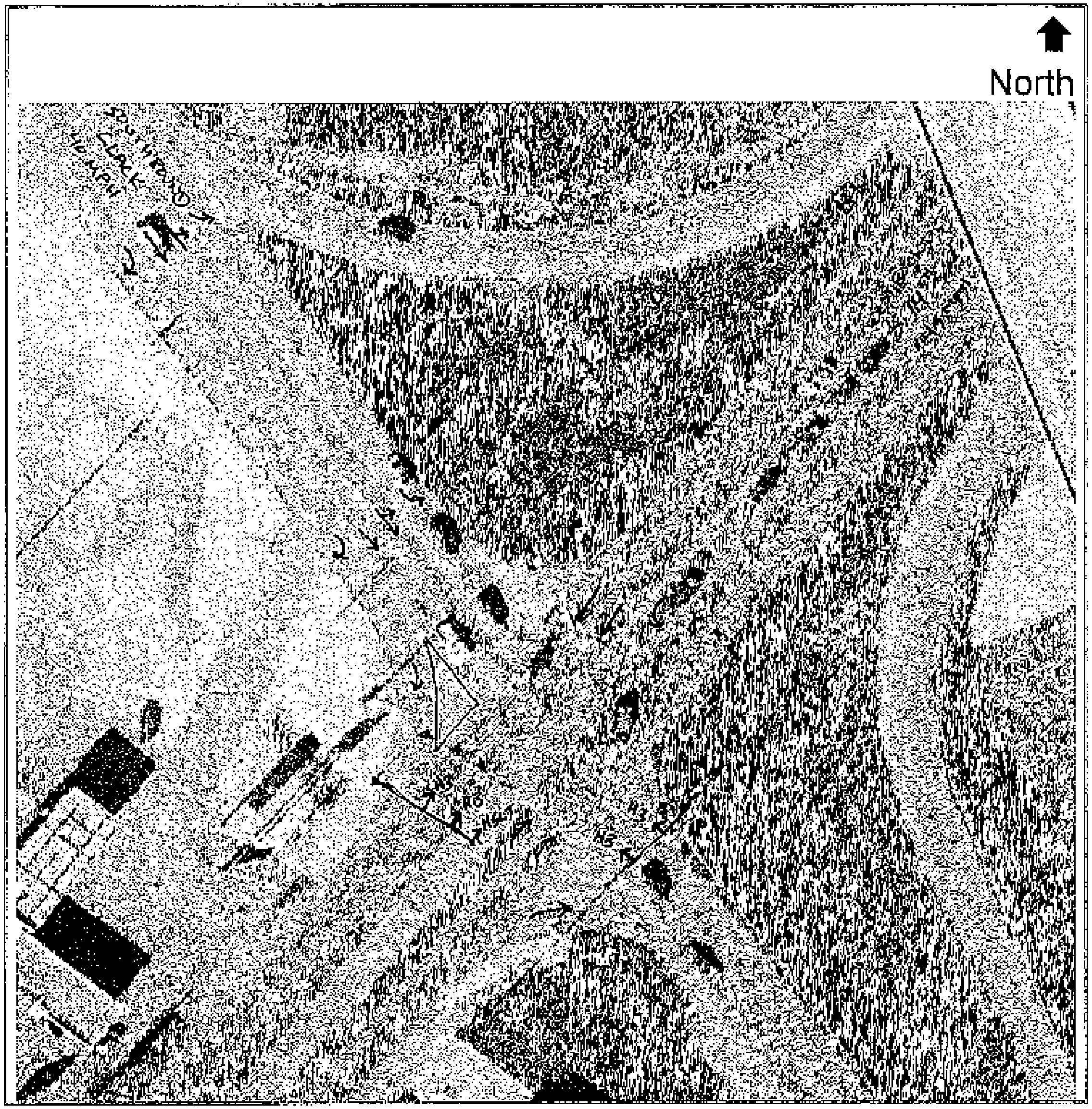
c. Are crosswalks "clearly" marked?
WB - ☐ Yes ☒ No

Explain: None Present

d. What is the pavement condition (ruts, potholes, cracking, etc.)?
WB
☐ Good Explain:
☐ Fair Explain:
☒ Poor Explain: WB – sleek and appears slippery

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?
☐ Yes Explain: Neither direction
☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
WB	45	+0.3%	58'	4.0	4.3	1.0	1.2

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?
   ☐ Yes Explain:
   ☒ No

   b. List comments or recommendations on potential signal timing or phasing changes:

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
WB	Loop	Left turn detection

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
WB	7,100	5%	670	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
WB	Rear End				
	Angle	2			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	3	0	0	1
NB	Rear End				
	Angle	1			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	1	0	0	1
SB	Rear End	5	3		
	Angle	5	1		4
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	10	4	0	4
	Rear End				
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	0	0	0	0

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a Year:____________

   b. Observed Violations:
      Date: July 2008 Time Period: 8 hours

Approach	Traffic Volume	Number of Violations
WB	4,100	7

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red. Difficult to observe WB traffic from inside diamond.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is heavily developed with numerous turning conflicts that may hamper apprehension. Officer must pursue violator through red indication and runs risk of stopping violator in interior of diamond.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Low pedestrian volumes

      Number of pedestrians per hour: n/a
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:____________________

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: South 14th Street (US 277) & South Clack Street (US 83 Frontage Road)
Southbound South Clack Street approach only

A. Intersection and Signal Data

1. Signal Visibility

   a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
SB	+1.0%	40	> 1000'	390

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

   b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
   Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
   Are other warning signs present in the vicinity of the intersection? ☐ Yes ☒ No
   Explain:______________________________

   c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
SB	12"	LED	N	N

2. Pavement and Markings Data

   a. Are stop bars in "good" condition? ☒ Yes ☐ No
   Explain:

   b. Are lane lines "clearly" visible?
   SB - ☒ Yes ☐ No

   Explain:

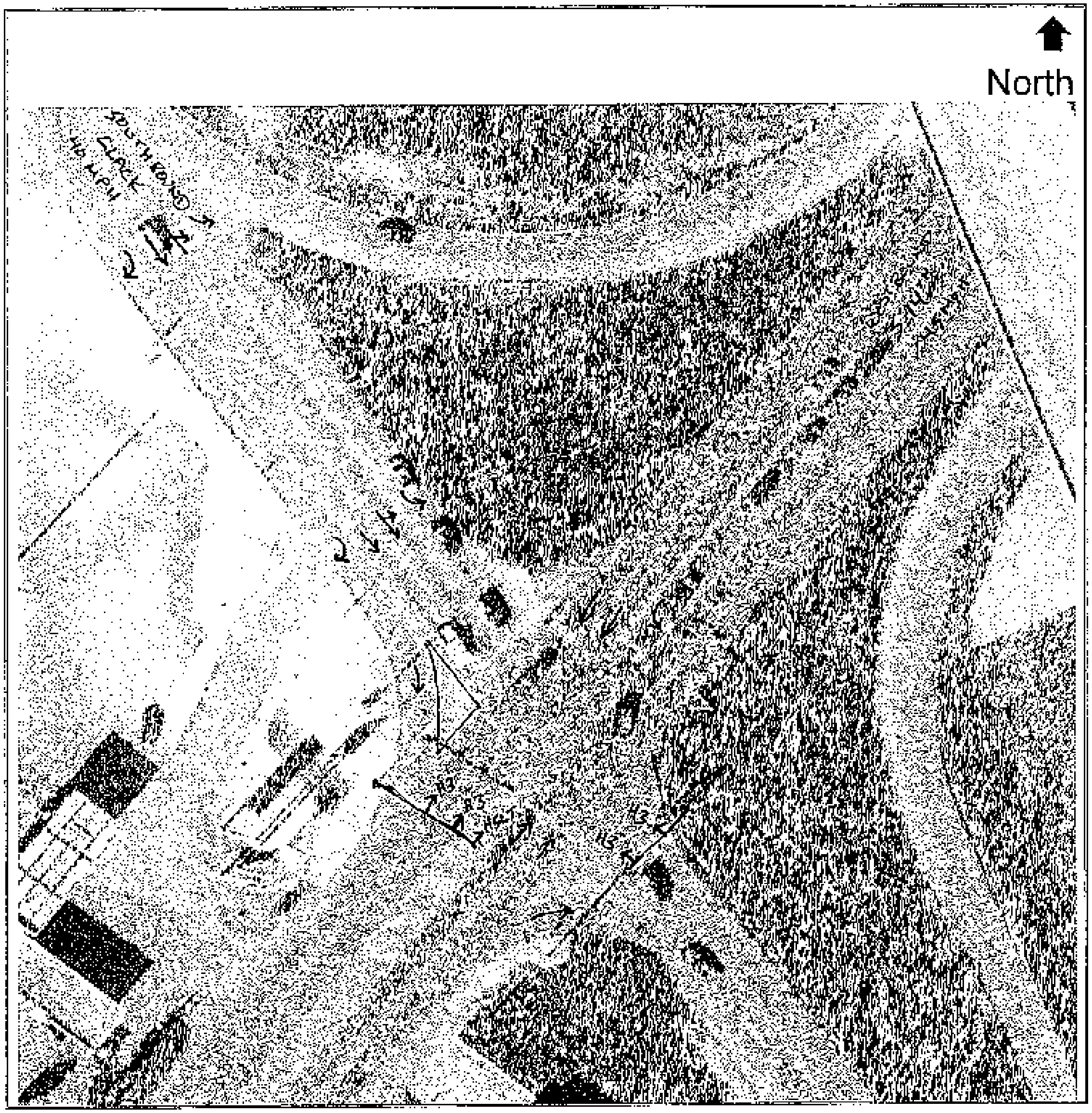
   c. Are crosswalks "clearly" marked?
   SB - ☐ Yes ☒ No

   Explain: None present

d. What is the pavement condition (ruts, potholes, cracking, etc.)?
SB
- ☒ Good Explain: SB – Good, recent overlay
- ☐ Fair Explain:
- ☐ Poor Explain:

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?
- ☐ Yes Explain: Neither direction
- ☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
SB	40	+1.0%	67'	3.0	3.8	1.0	1.9

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?

      ☒ Yes Explain: Left turn movement from southbound Clack observed not clearing on multiple cycles during mid-afternoon and PM peak periods.

      ☐ No

   b. List comments or recommendations on potential signal timing or phasing changes: Evaluate phase time

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
SB	5,900	5%	630	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
WB	Rear End				
	Angle	2			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	3	0	0	1
NB	Rear End				
	Angle	1			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	1	0	0	1
SB	Rear End	5	3		
	Angle	5	1		4
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	10	4	0	4
	Rear End				
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	0	0	0	0

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a   Year: ______

   b. Observed Violations:
      Date: July 2008   Time Period: 8 hours

Approach	Traffic Volume	Number of Violations
SB	3,300	14

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red. Difficult to observe WB traffic from inside diamond.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is heavily developed with numerous turning conflicts that may hamper apprehension. Officer must pursue violator through red indication and runs risk of stopping violator in interior of diamond.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Low pedestrian volumes

      Number of pedestrians per hour: n/a
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information: ______

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: South 1st Street (BI-20) at Sayles Boulevard
Eastbound South 1st Street approach only

A. Intersection and Signal Data

1. Signal Visibility

a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
EB	-0.3%	40	> 1000'	390

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
Are other warning signs present in the vicinity of the intersection? ☐ Yes ☒ No
Explain: __________

c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
EB	12"	LED	N	N

2. Pavement and Markings Data

a. Are stop bars in "good" condition?
EB - ☐ Yes ☒ No Explain: Visible, but oily

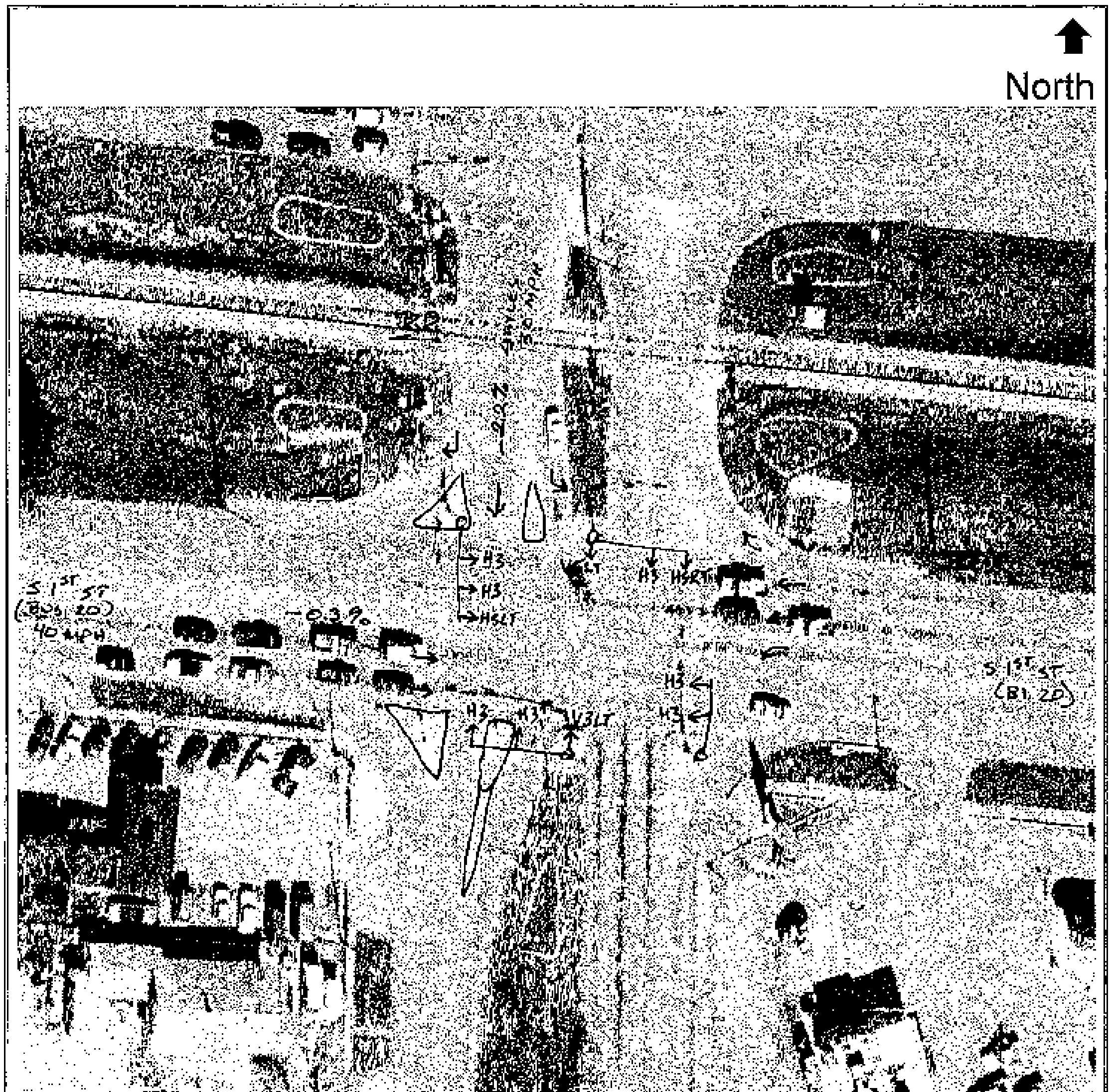
b. Are lane lines "clearly" visible?
EB - ☐ Yes ☒ No Explain: Visible, thermo

c. Are crosswalks "clearly" marked?
EB - ☐ Yes ☒ No Explain: Marked but not readily visible

d. What is the pavement condition (ruts, potholes, cracking, etc.)?
EB
- ☐ Good Explain: ______
- ☐ Fair Explain: ______
- ☒ Poor Explain: Asphalt - pavement has rutting and potholes

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?
- ☐ Yes Explain: ______
- ☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



H3* - CENTER HEAD ON SB MAST ARM HAS OPTICALLY PROGRAMMED LOUVER

B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
EB	40	-0.3%	97.0	4.0	4.0	1.0	2.0

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?
      EB - ☐ Yes ☒ No Explain: ____________

   b. List comments or recommendations on potential signal timing or phasing changes:

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
EB	9,900	5%	910	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
NB	Rear End	2	1		
	Angle	4	1		
	Head-On	1			1
	Pedestrian				
	Pedalcyclist				
	Other	2			
	Total	9	2	0	1
SB	Rear End				
	Angle	1			
	Head-On	1			1
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	2	0	0	1
EB	Rear End				
	Angle	5	3		2
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	5	3	0	2
WB	Rear End	2			
	Angle	2			
	Head-On	2			1
	Pedestrian				
	Pedalcyclist				
	Other	3	3		
	Total	9	3	0	1

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
   Number: n/a Year:____________

   b. Observed Violations:
   Date: July 2008 Time Period: 8 Hours

Approach	Traffic Volume	Number of Violations
EB	5,500	7

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but difficult due to rail road crossing proximity and fact that officer must pursue violator through red indication.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Low pedestrian volumes

      Number of pedestrians per hour: n/a
      Pedestrian crosswalk provided? ☒ Yes ☐ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: South 1st Street (BI-20) at Sayles Boulevard
Southbound Sayles Boulevard approach only

A. Intersection and Signal Data

1. Signal Visibility
   a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
SB	-2.2%	30	> 400'	270

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

   b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
   Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
   Are other warning signs present in the vicinity of the intersection? ☐ Yes ☒ No
   Explain: ______

   c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
SB	12"	LED	N	N

2. Pavement and Markings Data
   a. Are stop bars in "good" condition?
   SB - ☐ Yes ☒ No Explain: Visible for left turn movement, through movement largely obscured by oily residue

   b. Are lane lines "clearly" visible?
   SB - ☒ Yes ☐ No Explain: Visible, marked with buttons

   c. Are crosswalks "clearly" marked?
   SB - ☐ Yes ☒ No Explain: Not present

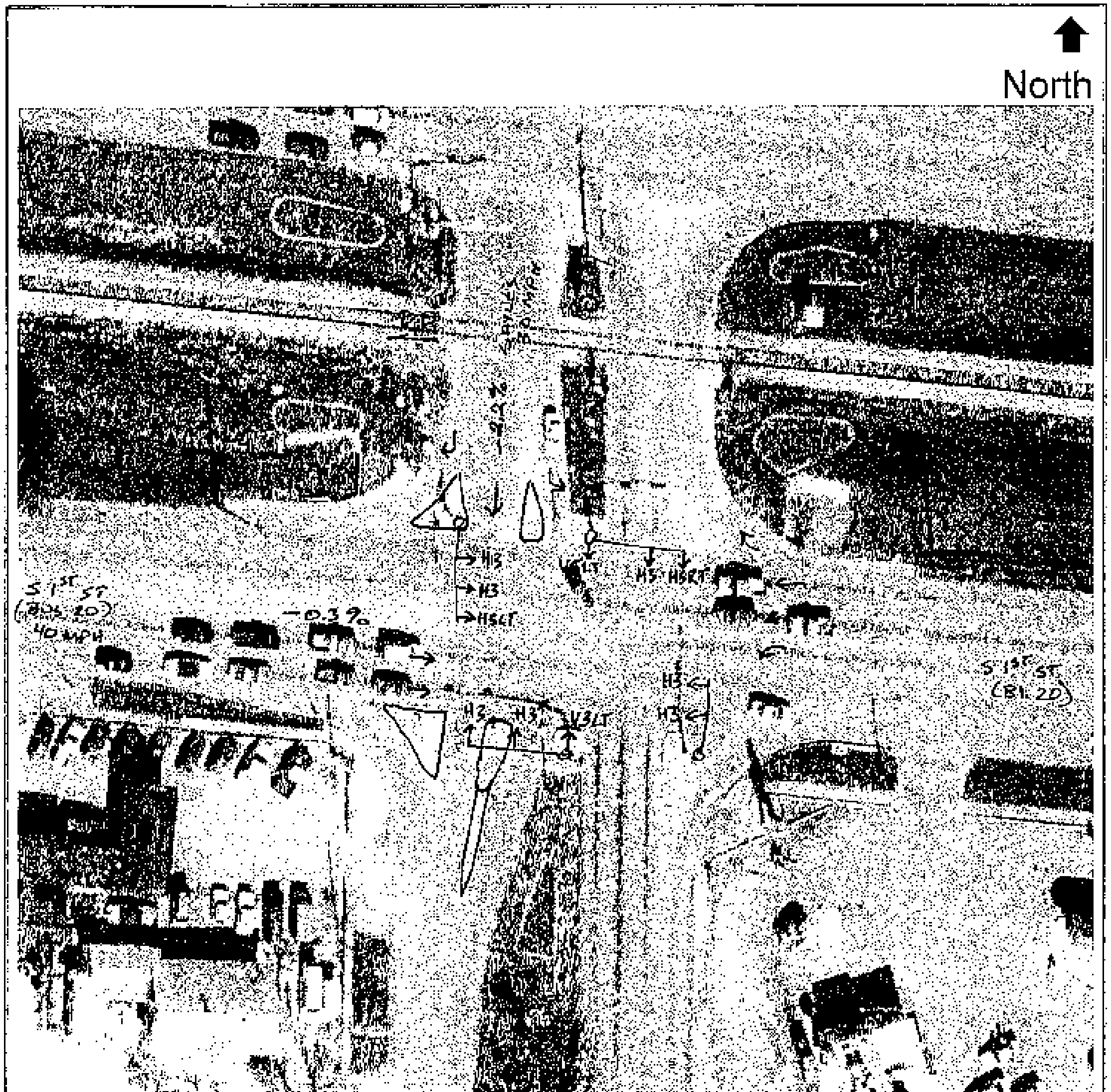
d. What is the pavement condition (ruts, potholes, cracking, etc.)?
SB

- ☐ Good Explain: ____________
- ☐ Fair Explain: ____________
- ☒ Poor Explain: Asphalt – cracked, unsmooth transition to railroad

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?

- ☐ Yes Explain: ____________
- ☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



H3* - CENTER HEAD ON SB MAST ARM HAS OPTICALLY PROGRAMMED LOUVER

B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
SB	30	-2.2%	67.0	4.0	3.4	1.0	2.0

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?
      SB - ☐ Yes ☒ No Explain: ____________

   b. List comments or recommendations on potential signal timing or phasing changes:

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
SB	Loop	Left turn detection

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
SB	2,500	5%	280	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
NB	Rear End	2	1		
	Angle	4	1		
	Head-On	1			1
	Pedestrian				
	Pedalcyclist				
	Other	2			
	Total	9	2	0	1
SB	Rear End				
	Angle	1			
	Head-On	1			1
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	2	0	0	1
EB	Rear End				
	Angle	5	3		2
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	5	3	0	2
WB	Rear End	2			
	Angle	2			
	Head-On	2			1
	Pedestrian				
	Pedalcyclist				
	Other	3	3		
	Total	9	3	0	1

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a Year:____________

   b. Observed Violations:
      Date: July 2008 Time Period: 8 Hours

Approach	Traffic Volume	Number of Violations
SB	1,600	0

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but difficult due to rail road crossing proximity and fact that officer must pursue violator through red indication.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Low pedestrian volumes

      Number of pedestrians per hour: n/a
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: Treadaway (BUS 83) & South 11th St (SH 36)
Northbound Treadaway approach only

A. Intersection and Signal Data

1. Signal Visibility

a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
NB	-0.2%	45	> 1000'	460

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
Are other warning signs present in the vicinity of the intersection? ☐ Yes ☒ No
Explain: ____________________

c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
NB	12"	LED	N	N

2. Pavement and Markings Data

a. Are stop bars in "good" condition?
NB - ☐ Yes ☒ No Explain: Faded/dirty – asphalt/oil residue

b. Are lane lines "clearly" visible?
NB - ☐ Yes ☒ No Explain: Faded/dirty

c. Are crosswalks "clearly" marked?
NB - ☐ Yes ☒ No Explain: Not Present

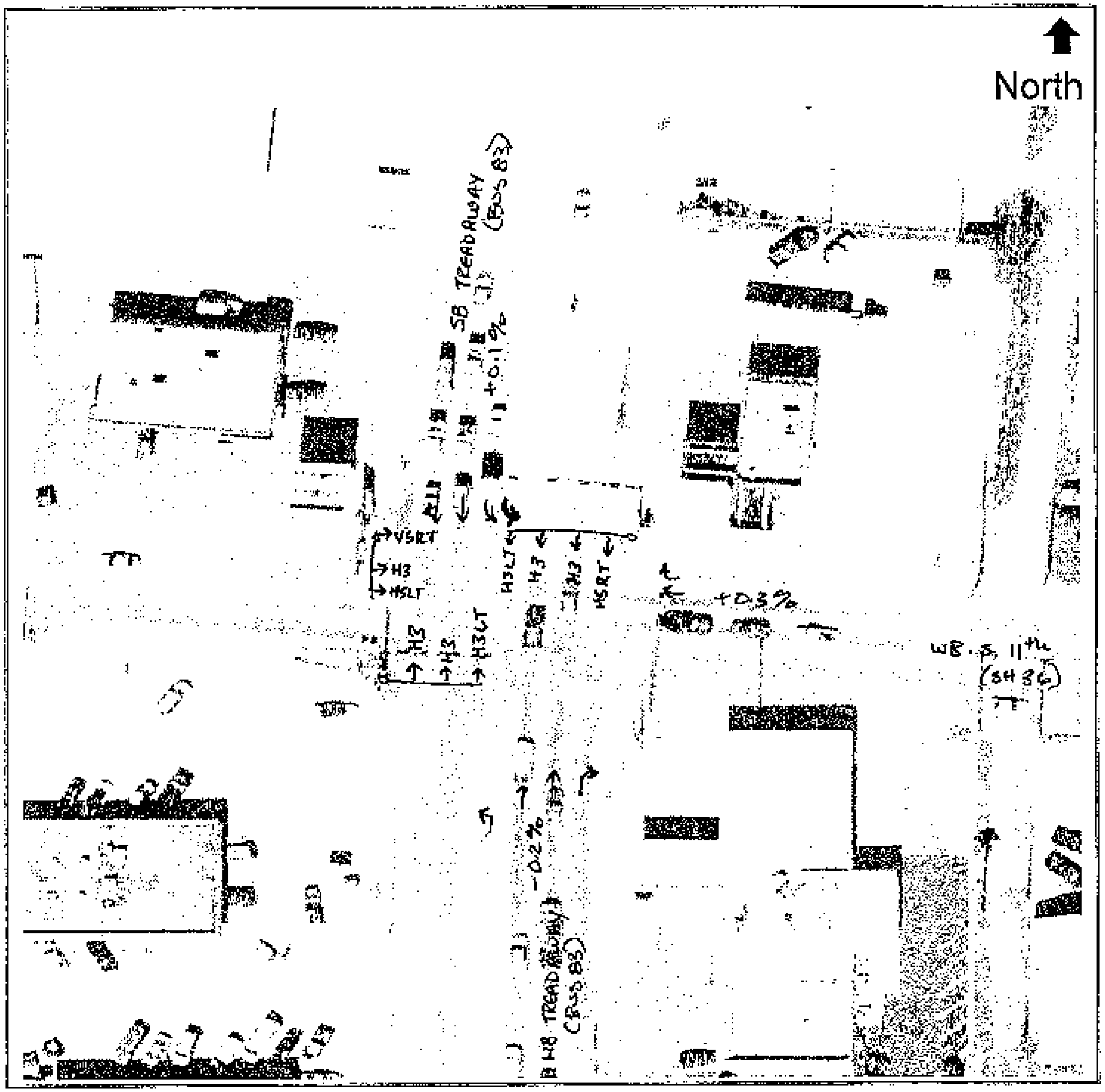
d. What is the pavement condition (ruts, potholes, cracking, etc.)?
NB

- ☐ Good Explain: ______
- ☒ Fair Explain: Asphalt – cracking, but has been sealed
- ☐ Poor Explain: ______

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?

- ☐ Yes Explain: ______
- ☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
NB	45	-0.2%	88'	4.5	4.3	0.0	1.6

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?
      - ☐ Yes
      - ☒ No

      Explain:

   b. List comments or recommendations on potential signal timing or phasing changes:

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
NB	Loop	Left turn @ stop bar

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
NB	11,200	5%	1,140	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
NB	Rear End	3			
	Angle	2			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	6	0	0	1
SB	Rear End	1			
	Angle	2			2
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	3			
	Total	6	0	0	2
EB	Rear End				
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	1	0	0	0
WB	Rear End	1			
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	2	0	0	0

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a Year: ____________

   b. Observed Violations:
      Date: July 2008 Time Period: 8 Hours

Approach	Traffic Volume	Number of Violations
NB	6,200	4

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is heavily developed with numerous turning conflicts that may hamper apprehension. Officer must pursue violator through red indication.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Low pedestrian volumes

      Number of pedestrians per hour: N/A
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: Treadaway (BUS 83) & South 11th St (SH 36)
Southbound Treadaway approach only

A. Intersection and Signal Data

1. Signal Visibility
   a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
SB	+0.1%	40	> 1000'	390

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

   b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
   Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
   Are other warning signs present in the vicinity of the intersection? ☐ Yes ☒ No
   Explain: ______

   c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
SB	12"	LED	N	N

2. Pavement and Markings Data
   a. Are stop bars in "good" condition?
   SB - ☐ Yes ☒ No Explain: Faded/dirty – asphalt/oil residue

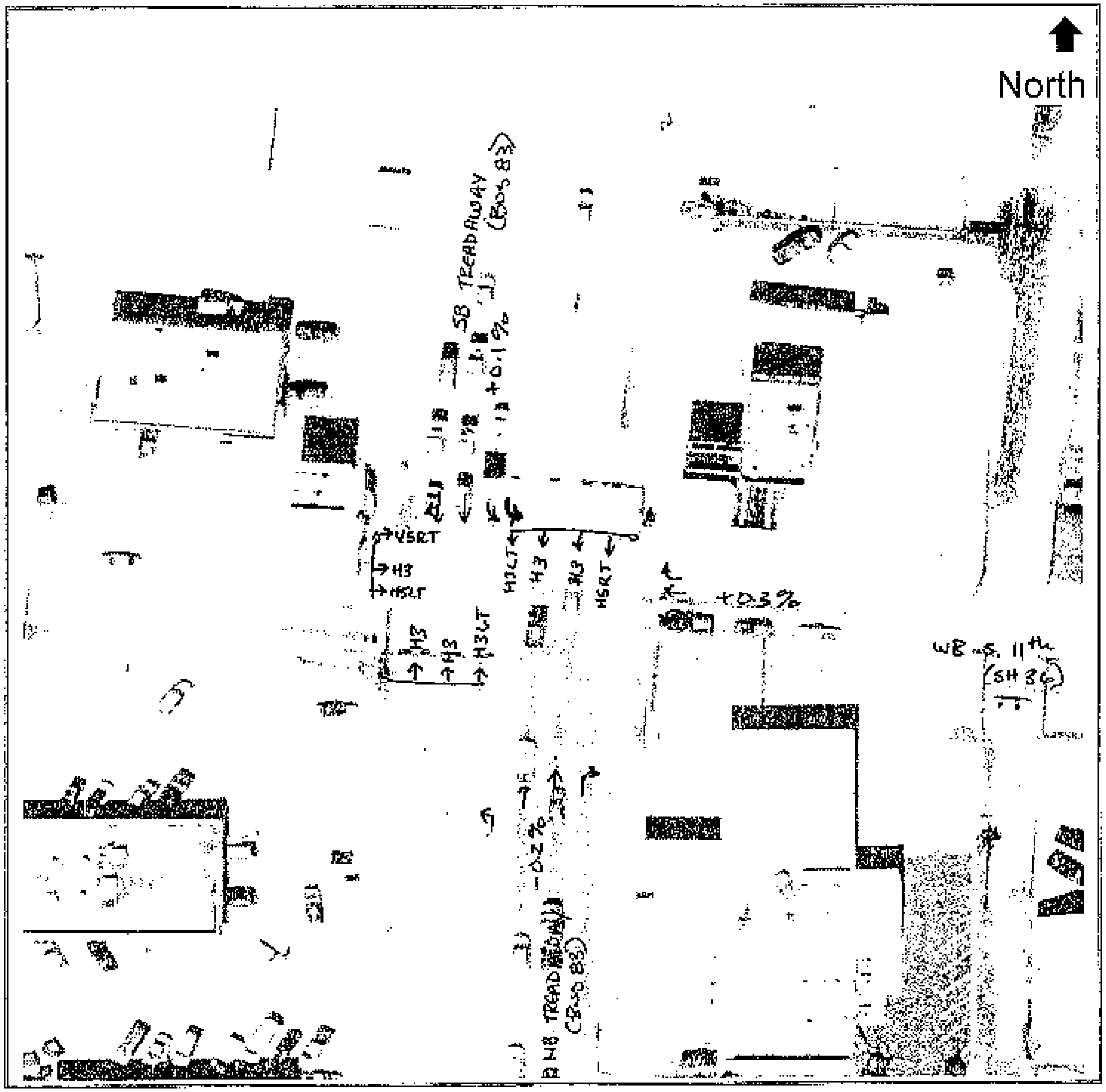
   b. Are lane lines "clearly" visible?
   SB - ☐ Yes ☒ No Explain: Faded/dirty

   c. Are crosswalks "clearly" marked?
   SB - ☐ Yes ☒ No Explain: Not present

d. What is the pavement condition (ruts, potholes, cracking, etc.)?
SB
- ☐ Good Explain: ______
- ☒ Fair Explain: Asphalt – cracking, but has been sealed
- ☐ Poor Explain: ______

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?
- ☐ Yes Explain: ______
- ☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
SB	40	+0.1%	63'	4.5	3.9	0.0	1.4

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?
      - ☐ Yes
      - ☒ No

      Explain:

   b. List comments or recommendations on potential signal timing or phasing changes:

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
SB	Loop	Left turn @ stop bar

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
SB	11,000	5%	1,250	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
NB	Rear End	3			
	Angle	2			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	6	0	0	1
SB	Rear End	1			
	Angle	2			2
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	3			
	Total	6	0	0	2
EB	Rear End				
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	1	0	0	0
WB	Rear End	1			
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	2	0	0	0

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a Year:____________

   b. Observed Violations:
      Date: July 2008 Time Period: 8 Hours

Approach	Traffic Volume	Number of Violations
SB	6,700	5

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is heavily developed with numerous turning conflicts that may hamper apprehension. Officer must pursue violator through red indication.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Low pedestrian volumes

      Number of pedestrians per hour: N/A
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE   County: TAYLOR

Intersection: Treadaway (BUS 83) & S 11th St (SH 36)
Westbound South 11th St approach only

A. Intersection and Signal Data

1. Signal Visibility
   a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
WB	+0.3%	35	> 1000'	325

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

   b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
   Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
   Are other warning signs present in the vicinity of the intersection?
   ☐ Yes ☒ No
   Explain: ______________________

   c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
WB	12"	LED	N	N

2. Pavement and Markings Data
   a. Are stop bars in "good" condition?
   WB - ☐ Yes ☒ No Explain: Faded/dirty – asphalt/oil residue

   b. Are lane lines "clearly" visible?
   WB - ☒ Yes ☐ No Explain: Faded/dirty

   c. Are crosswalks "clearly" marked?
   WB - ☐ Yes ☒ No Explain: Not present

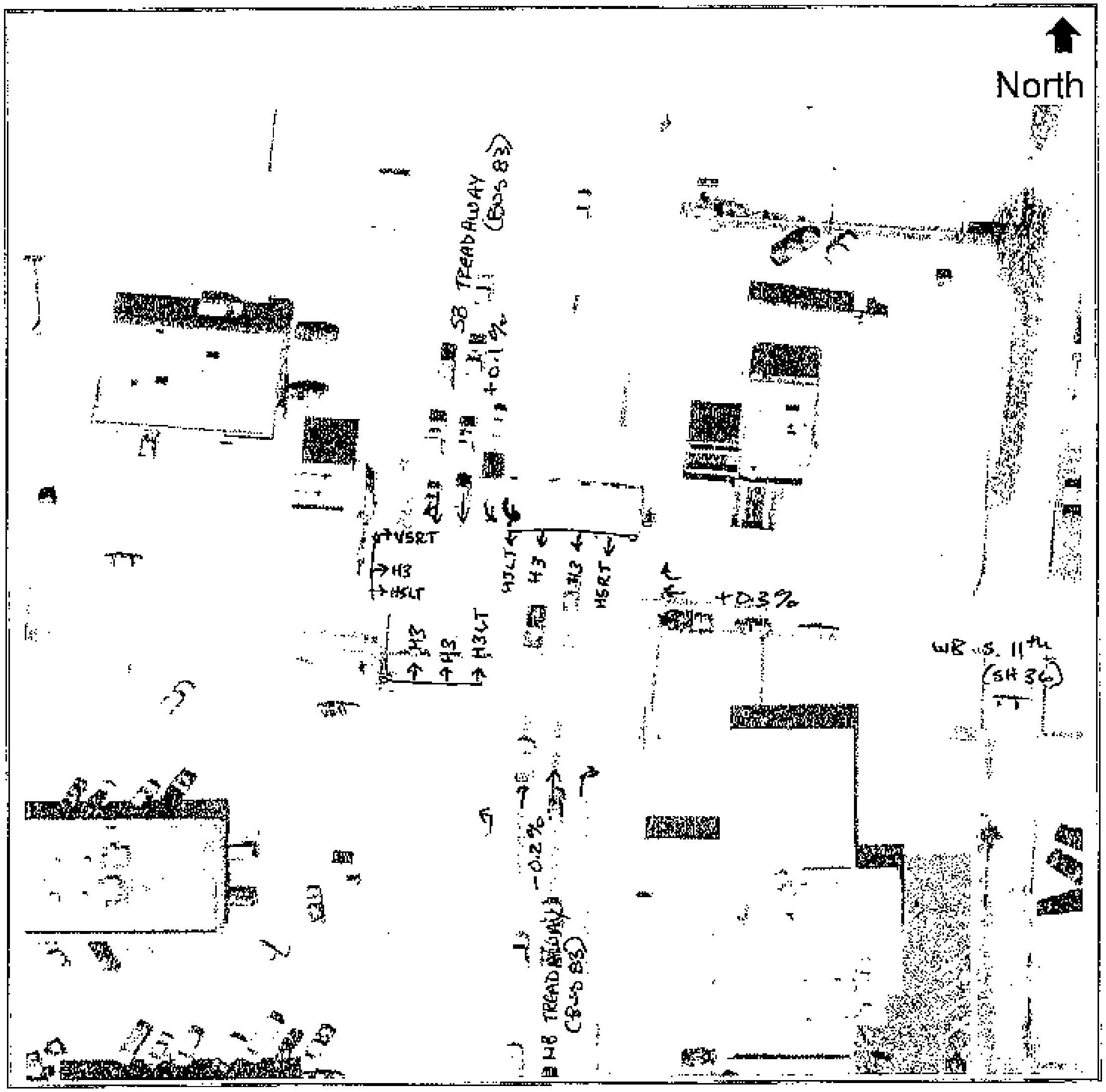
   d. What is the pavement condition (ruts, potholes, cracking, etc.)?

WB

- ☐ Good Explain: ____________
- ☒ Fair Explain: Asphalt – cracking, but has been sealed
- ☐ Poor Explain: ____________

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?
- ☐ Yes Explain: ____________
- ☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
WB	35	+0.3%	95'	3.5	3.5	1.0	2.2

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?

   ☒ Yes
   ☐ No

   Explain: WB LT Queues not clearing during peaks

   b. List comments or recommendations on potential signal timing or phasing changes: Consider increasing WB LT split if it can be done without impacting north/south operations significantly

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
WB	Loop	Left turn @ stop bar

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
WB	8,500	5%	830	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
NB	Rear End	3			
	Angle	2			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	6	0	0	1
SB	Rear End	1			
	Angle	2			2
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	3			
	Total	6	0	0	2
EB	Rear End				
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	1	0	0	0
WB	Rear End	1			
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1			
	Total	2	0	0	0

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a   Year: ____________

   b. Observed Violations:
      Date: July 2008   Time Period: 8 Hours

Approach	Traffic Volume	Number of Violations
WB	4,700	3

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is heavily developed with numerous turning conflicts that may hamper apprehension. Officer must pursue violator through red indication.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Low pedestrian volumes

      Number of pedestrians per hour: N/A
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: Buffalo Gap (FM 89) & S Clack Street (US 83 Frontage Road)
Eastbound Clack approach only

A. Intersection and Signal Data

1. Signal Visibility
   a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
EB	+0.9%	45	> 800'	460'

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

   b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
      Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
      Are other warning signs present in the vicinity of the intersection? ☐ Yes ☒ No
      Explain: ______

   c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
EB	12"	LED	N	N

2. Pavement and Markings Data
   a. Are stop bars in "good" condition? ☐ Yes ☒ No
      Explain: Faded w/ asphalt/oil

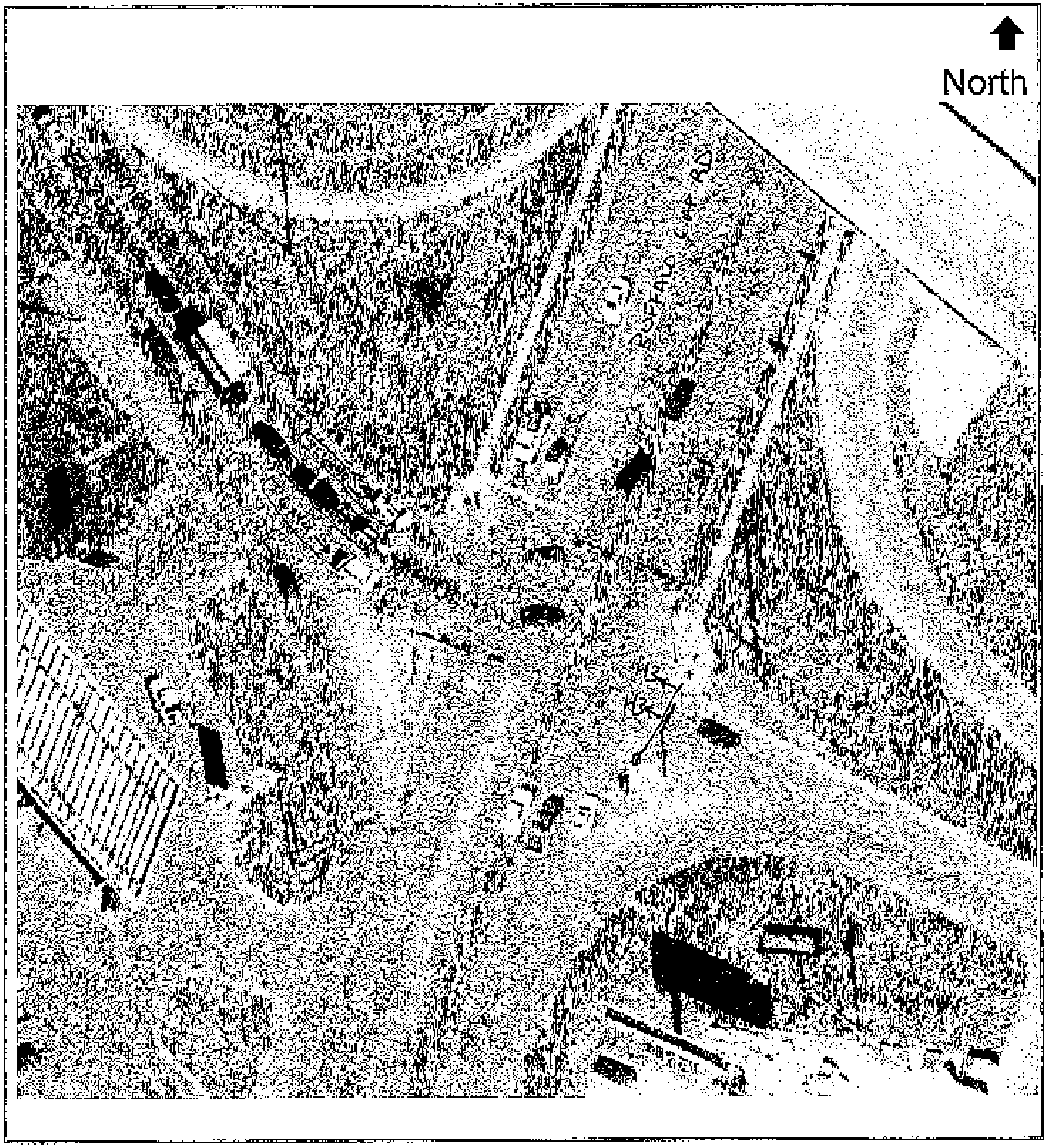
   b. Are lane lines "clearly" visible? ☒ Yes ☐ No
      Explain: ______

   c. Are crosswalks "clearly" marked? ☐ Yes ☒ No
      Explain: None present

d. What is the pavement condition (ruts, potholes, cracking, etc.)?
- ☒ Good Explain: Concrete w/ grooves
- ☐ Fair Explain:
- ☐ Poor Explain:

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?
- ☒ Yes Explain: Grooving
- ☐ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
EB	45	+0.9%	116'	4.0	4.2	0.0	2.1

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?
      ☒ Yes   Explain: Queues not clearing. Change period too short
      ☐ No

   b. List comments or recommendations on potential signal timing or phasing changes: Adjust phase time and change period

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
EB	Loop	

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
EB	9,700	5%	800	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
EB	Rear End	5	1		
	Angle	9	2		4
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	3			
	Total	17	3	0	4
NB	Rear End	2	2		
	Angle	2			
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	2			
	Total	6	2	0	0
SB	Rear End	4			
	Angle	5	1		
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	9	1	0	0
	Rear End				
	Angle				
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total				

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a Year:__________

   b. Observed Violations:
      Date: July 2008 Time Period: 8 hours

Approach	Traffic Volume	Number of Violations
EB	5,600	12

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is high speed with no shoulders. Officer must pursue violator through red indication. Also, violators may stop within diamond interior.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: n/a - Low pedestrian traffic volume

      Number of pedestrians per hour: n/a
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: South 1st Street (BI-20) & Pioneer Drive
Eastbound – South 1st Street approach only

A. Intersection and Signal Data

1. Signal Visibility
   a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
EB	+0.6%	45	> 1000'	460'

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

   b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
   Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
   Are other warning signs present in the vicinity of the intersection? ☐ Yes ☒ No
   Explain: ____________

   c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
EB	12"	LED	N	N

2. Pavement and Markings Data
   a. Are stop bars in "good" condition?
   EB - ☐ Yes ☒ No Explain: Faded, oil/asphalt residue

   b. Are lane lines "clearly" visible?
   EB - ☒ Yes ☐ No Explain: thermoplastic markings

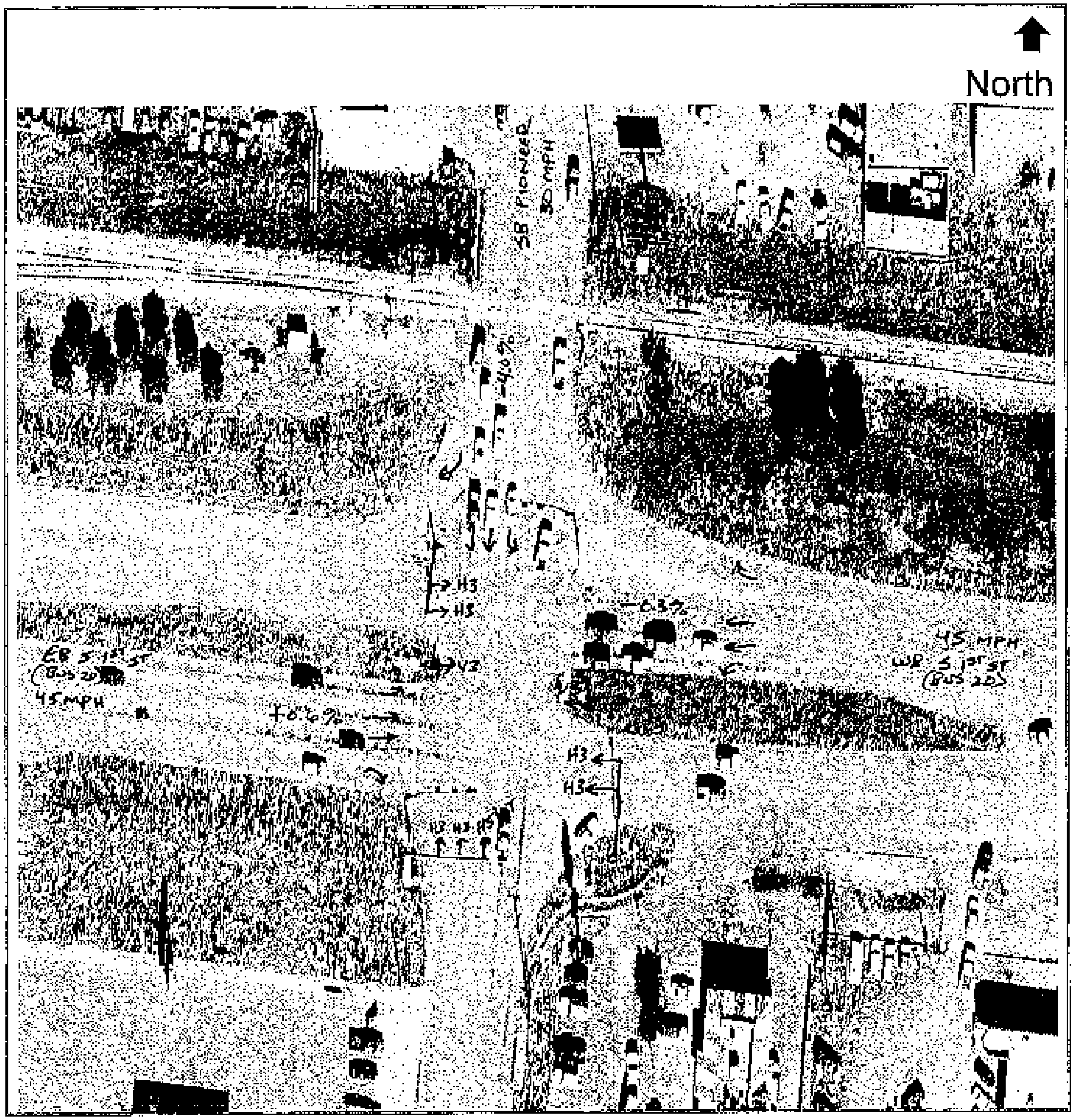
   c. Are crosswalks "clearly" marked?
   EB - ☐ Yes ☒ No Explain: None present

d. What is the pavement condition (ruts, potholes, cracking, etc.)?
   EB
   - ☐ Good Explain: ____________
   - ☒ Fair Explain: Asphalt – cracking, but has been sealed
   - ☐ Poor Explain: ____________

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?
   - ☐ Yes Explain: ____________
   - ☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.

North



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
EB	45	+0.6%	71'	4.0	4.2	1.0	1.4

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?
      ☒ Yes ☐ No Explain: Adjust change intervals

   b. List comments or recommendations on potential signal timing or phasing changes: Red clearance for SB needs to be adjusted, yellows need adjusted

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
EB	Loop 6' x 40'	Left turn detection

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
EB	8,700	5%	760	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
NB	Rear End	1			
	Angle	2			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	3	0	0	1
SB	Rear End	1			
	Angle	1			
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	2	0	0	0
EB	Rear End	2	1		
	Angle	3	2		1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	2			
	Total	7	3	0	1
WB	Rear End	3	1		
	Angle	1			
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1	1		
	Total	5	2	0	0

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a Year: ________

   b. Observed Violations:
      Date: Nov 4-5, 2008 Time Period: 2 Hours

Approach	Traffic Volume	Number of Violations
EB	1,535	8

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is high speed with no shoulders. Officer must pursue violator through red indication.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Light pedestrian traffic volume

      Number of pedestrians per hour: n/a
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: South 1st Street (BI-20) & Pioneer Drive
Westbound – South 1st Street approach only

A. Intersection and Signal Data

1. Signal Visibility
   a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
WB	-0.3%	45	> 1000'	460'

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

   b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
   Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
   Are other warning signs present in the vicinity of the intersection?
   ☐ Yes ☒ No
   Explain: ______

   c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
WB	12"	LED	N	N

2. Pavement and Markings Data
   a. Are stop bars in "good" condition?
   WB - ☐ Yes ☒ No Explain: Faded. oil/asphalt residue

   b. Are lane lines "clearly" visible?
   WB - ☒ Yes ☐ No Explain: thermo

   c. Are crosswalks "clearly" marked?
   WB - ☒ Yes ☐ No Explain: Crosswalk is marked but stripes within vehicle path are faded/dirty.

d. What is the pavement condition (ruts, potholes, cracking, etc.)?

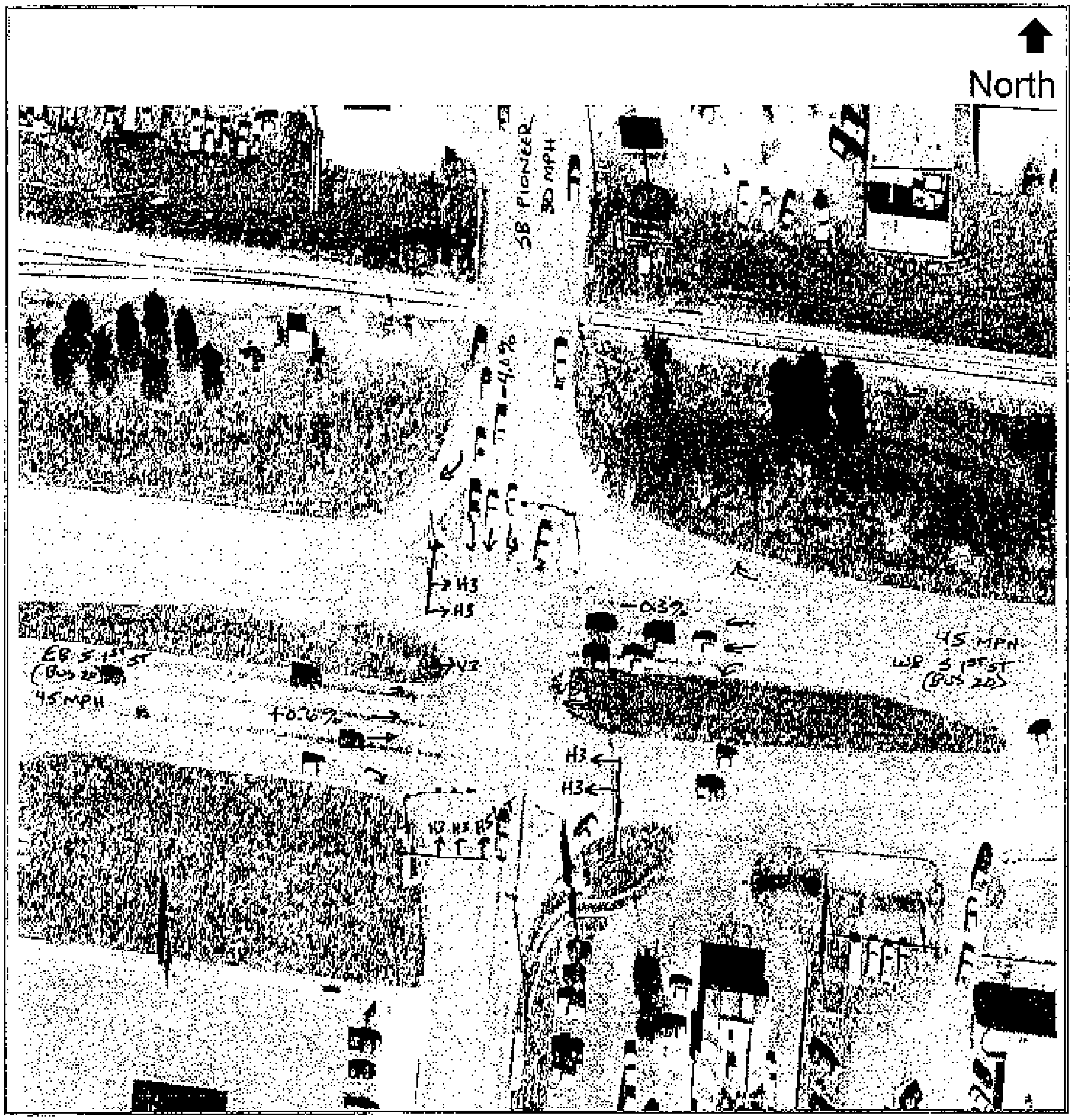
WB

- ☐ Good Explain: ____
- ☒ Fair Explain: Asphalt – cracking, but has been sealed
- ☐ Poor Explain: ____

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?

- ☐ Yes Explain: ____
- ☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
WB	45	-0.3%	75'	4.0	4.3	1.0	1.4

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?
   ☒ Yes ☐ No Explain: Westbound left turn does not always clear queue – Adjust change intervals

   b. List comments or recommendations on potential signal timing or phasing changes: Modify change periods and left turn phase timing

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
WB	Loop 6' x 40'	Left turn detection

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
WB	8,900	5%	860	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
NB	Rear End	1			
	Angle	2			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	3	0	0	1
SB	Rear End	1			
	Angle	1			
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	2	0	0	0
EB	Rear End	2	1		
	Angle	3	2		1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	2			
	Total	7	3	0	1
WB	Rear End	3	1		
	Angle	1			
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1	1		
	Total	5	2	0	0

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a Year: ______
   b. Observed Violations:
      Date: Nov. 4-5, 2008 Time Period: 2 Hours

Approach	Traffic Volume	Number of Violations
WB	1,332	5

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is high speed with no shoulders. Officer must pursue violator through red indication.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Light pedestrian traffic volume

      Number of pedestrians per hour: n/a
      Pedestrian crosswalk provided? ☒ Yes ☐ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information:

Evaluation of the Need for Red Light Running Cameras
Engineering Analysis Template

City: ABILENE County: TAYLOR

Intersection: South 1st Street (BI-20) & Pioneer Drive
Southbound Pioneer Drive approach only

A. Intersection and Signal Data

1. Signal Visibility

a. Minimum Sight Distance to Signal

Approach	Grade	Speed Limit (mph)	Measured (ft)	Required (ft)*
SB	-4.0%	30	> 400'	270'

* See TMUTCD Table 4D-1 for minimum sight distance requirements.

b. Are "SIGNAL AHEAD" warning signs present? ☐ Yes ☒ No
Are "SIGNAL AHEAD" warning signs needed? ☐ Yes ☒ No
Are other warning signs present in the vicinity of the intersection? ☐ Yes ☒ No
Explain: ______

c. Information on Signal Heads

Approach	Lens Size	Lens Type (LED or Bulb)	Back Plates (Y or N)	Retroreflective Border (Y or N)
SB	12"	LED	N	N

2. Pavement and Markings Data

a. Are stop bars in "good" condition?
SB - ☐ Yes ☒ No Explain: Faded, oil/asphalt residue

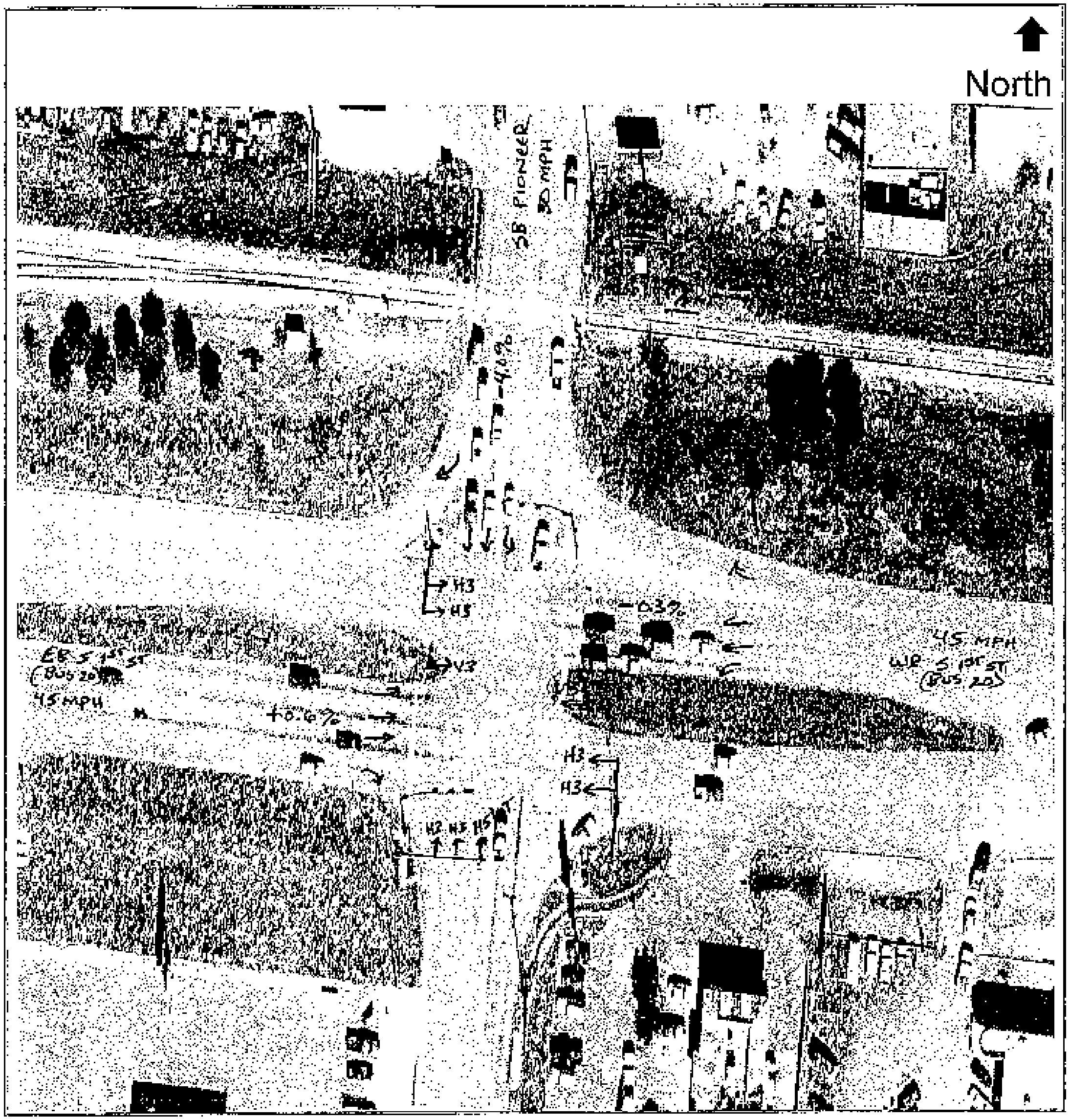
b. Are lane lines "clearly" visible?
SB - ☒ Yes ☐ No Explain: Lane lines marked with buttons

c. Are crosswalks "clearly" marked?
SB - ☐ Yes ☒ No Explain: Not present

d. What is the pavement condition (ruts, potholes, cracking, etc.)?
SB
- ☐ Good Explain: ______
- ☒ Fair Explain: Asphalt – cracking, but has been sealed
- ☐ Poor Explain: ______

e. Do pavement surface treatments exist (rumble strips, texturing, pavers, etc.)?
- ☐ Yes Explain: ______
- ☒ No

3. Provide diagram of intersection including: pavement markings, width of lanes and medians, location of signal heads and signs, locations of loops/detectors, and grades.



B. Signal Timing and Traffic Data

1. Clearance Intervals

Approach	Posted Speed Limit	Grade	Width of Intersection	Yellow Interval		All Red Interval	
				Existing	Calculated*	Existing	Calculated*
SB	30	-4.0%	112'	4.0	3.5	1.0	3.0

* Reference ITE for calculation of clearance intervals.

2. Include existing controller settings for each phase and each time-of-day. Information should include applicable settings such as minimum green, max 1 & 2, passage, minimum gap/ext, protected-permissive, lead-lag, yellow and all red, walk and ped clearance time, recall settings, offsets, cycle length, etc. Include analysis of peak hour conditions and a determination of whether signal timings are contributing to red-light running problems.

   a. Does signal timing or phasing factor in as a possible contributor to red light running at this intersection?[1]
      ☒ Yes ☐ No Explain: SB possibly gaps out prematurely

   b. List comments or recommendations on potential signal timing or phasing changes: Red clearance for SB needs to be adjusted.

3. Vehicle Detection Data

Approach	Detection Type (loop, video, etc.)	Detector Location (measured from stop bar)
SB	Loop 6' x 40'	Left turn detection

4. Traffic Volume Data

Approach	Daily Volumes		Peak Hour Volumes	
	Total	Heavy Vehicles	Total	Heavy Vehicles
SB	4,500	5%	450	n/a

C. Crash and Enforcement Data

1. 18 Months of "Before" Crash Data

Approach	Collision Type	Total	Number of Injury Crashes	Number of Fatal Crashes	Crashes Associated with Red Light Running
NB	Rear End	1			
	Angle	2			1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	3	0	0	1
SB	Rear End	1			
	Angle	1			
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other				
	Total	2	0	0	0
EB	Rear End	2	1		
	Angle	3	2		1
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	2			
	Total	7	3	0	1
WB	Rear End	3	1		
	Angle	1			
	Head-On				
	Pedestrian				
	Pedalcyclist				
	Other	1	1		
	Total	5	2	0	0

2. Violation Rate
   a. Number of red light running citations per year issued by law enforcement
      Number: n/a______ Year:____________

   b. Observed Violations:
      Date: Nov. 4-5, 2008 Time Period: 2 Hours____

Approach	Traffic Volume	Number of Violations
SB	580	0

3. Enforcement and Operational Issues
   a. Describe the difficulty experienced by law enforcement officers in patrol cars or on foot in apprehending violators. Difficult and unsafe for officer to pursue violator through intersection on red.

   b. Describe the ability of law enforcement officers to apprehend violators safely within a reasonable distance from the violation. Possible, but arterial is high speed with no shoulders. Officer must pursue violator through red indication.

   c. Are pedestrians at risk due to violations? ☐ Yes ☒ No
      Explain: Light pedestrian traffic volume

      Number of pedestrians per hour: n/a
      Pedestrian crosswalk provided? ☐ Yes ☒ No

   d. Have there been any changes to the operations of the intersection (signal timing, restriping, increased enforcement, etc.) with the past three years? ☒ Yes ☐ No

D. Other Supporting Information: