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OFFICE MEMORANDUM

DATE: September 2, 2016

TO: Selina Tisdale and Brian McManus – City of Midland

FROM: Wes Butch

SUBJECT: Main Street Streetscape Study - Signal Warrant Analysis and Four-Way Stop Safety Research

INTRODUCTION

As requested, we have investigated traffic signal warrants for Main Street and also performed a literature review for safety data related to two topics. Those topics are pedestrian safety at four-way stop intersections and safety related to removal of unwarranted signals.

EXECUTIVE SUMMARY

The following main conclusions are supported by the specific analysis and discussion presented below:

1. Traffic signal warrants are not met at any of the three existing traffic signals along Main Street (Rodd Street, McDonald Street, or Ashman Street). This means that engineering standards do not justify or support the use of traffic signals at these three intersections.
2. Automobile and pedestrian volumes would need to increase by approximately 145% above the projected year 2036 volumes before traffic signal warrants would be met. It is highly unlikely that traffic signals would be warranted in the future at these three intersections.
3. Crashes involving pedestrians are reduced when traffic signals that do not meet warrants are removed. This suggests that removal of the three traffic signals along Main Street could provide safety benefits for pedestrians.
4. Crashes involving pedestrians are reduced when intersections controlled by two-way stops are replaced by four-way stops. This suggests that four-way stop intersections could provide safety benefits for pedestrians relative to two-way stops.
5. The use of four-way stop controlled intersections notably reduces automobile crashes relative to traffic signals, especially traffic signals that do not meet warrants. This suggests that replacing the three existing traffic signals along Main Street with four-way stop control could provide safety benefits for automobiles.

SIGNAL WARRANT ANALYSIS

An analysis was conducted to determine if three study area intersections meet MUTCD Warrants for Signalized Intersections (these are the Main Street Intersections with McDonald, Rodd, and Ashman).

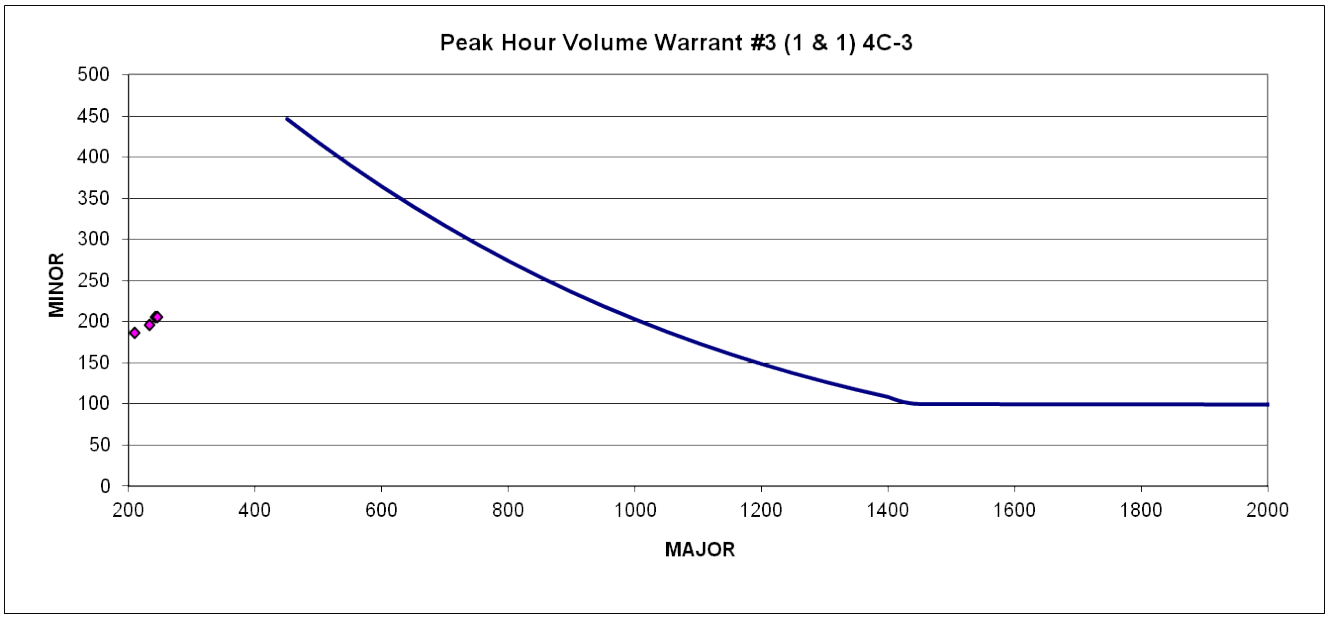
Methodology

DLZ performed this analysis at the intersection of Main Street and Ashman Street which for the PM peak hour. Of the three signalized intersections along Main Street, this location (during the PM peak hour) has the highest total entering vehicle volume (452 total entering vehicles) of the three signalized intersections. Therefore, this intersection would be most likely to meet a warrant, and was analyzed as the test case. Based on relevant factors, Warrant #3 (Peak Hour) was determined to be the most likely warrant that might be met. Warrant #4 (Pedestrian Volume) was also initially evaluated. However, based on the estimated future pedestrian growth during a typical weekday, the pedestrian volumes will not be high enough to meet the warrant criteria. The peak hour warrant analysis was performed for traffic volumes for existing conditions (year 2016) and Scenario 7 (year 2036). Since Warrant #3 was not met for the Scenario 7 analysis, a sensitivity analysis was conducted to determine the percent increase in traffic volumes (beyond the year 2036 forecast) that would need to occur in order for a signal to be warranted.

Existing Conditions (Year 2016)

The Warrant #3 (Peak Hour) analysis for the PM peak hour at the Main Street and Ashman Street intersection showed that the existing (year 2016) traffic volumes (452 total entering vehicles and 55 pedestrians) and approach lane configuration do not meet the criteria for warranting a signalized intersection. Furthermore, when the existing intersection volumes were analyzed with a one-lane approach at each leg, warrants still were not met. Exhibit A below shows the peak hour major street volume (Main Street) and minor street volume (Ashman Street) data falls well below the 1-Lane Approach curve as determined by the MUTCD.

Exhibit A – Existing Conditions (Year 2016 Traffic)
Main St at Ashman St-PM Peak Hour



Scenario 7 (Year 2036)

The Warrant #3 (Peak Hour) analysis for the PM peak hour at the Main Street and Ashman Street intersection showed that the Scenario 7 (Year 2036) traffic volumes (489 total entering vehicles and 69 pedestrians) do not meet the criteria for warranting a signalized intersection. Exhibit B below shows the peak hour major street volume (Main Street) and minor street volume (Ashman Street) data falls well below the 1-Lane Approach curve as determined by the MUTCD.

Scenario 7 (Year 2036) – Estimated Traffic Increase to Meet Warrant

Utilizing the volumes from the Scenario 7 (Year 2036) analysis as a starting point, a sensitivity test was performed. This analysis showed that traffic volumes would need to increase by more than 145% (1,199 total entering vehicles and 169 pedestrians) before the criteria are met for Warrant #3. Exhibit C below shows the peak hour major street volume (Main Street) and minor street volume (Ashman Street) data for the 145% traffic increase to lie just below the 1-Lane Approach curve as determined by the MUTCD.

Exhibit B – Scenario 7 (Year 2036 Traffic)
Main St at Ashman St-PM Peak Hour

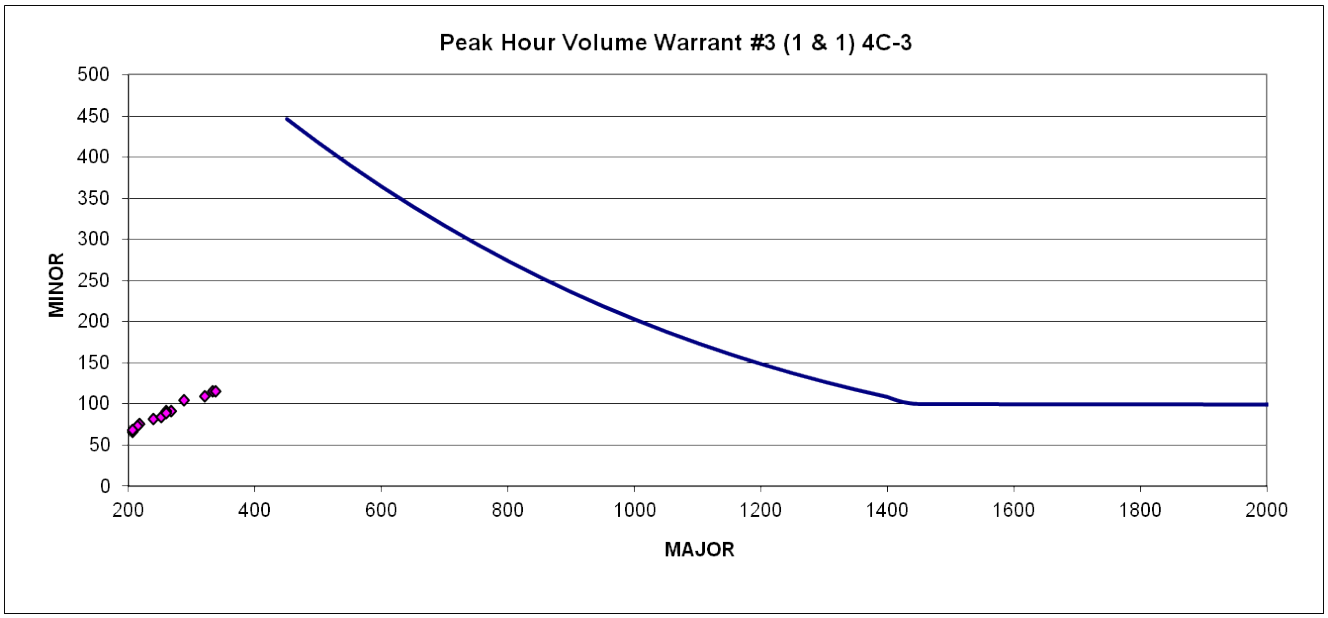
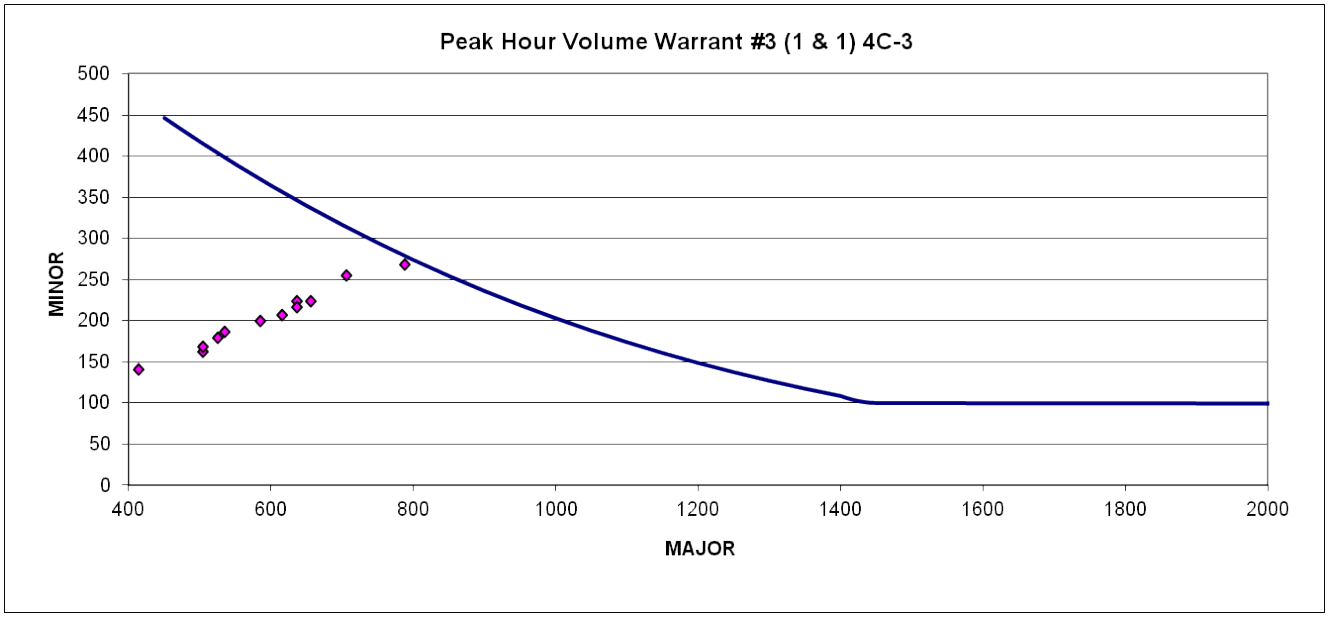


Exhibit C – Scenario 7 (Year 2036 Traffic Plus 145% Increase)
Main St at Ashman St-PM Peak Hour



LITERATURE REVIEW – TWO TOPICS

We conducted a literature search of available studies regarding pedestrian safety at 4-way stop intersections and also for the safety implications of removing signals that do not meet warrants.

Pedestrian Safety

A review of available literature showed the following two main results that are relevant to the situation at hand. Both of these are from the FHWA's *Desktop Reference for Crash Reduction Factors*.

- When an unwarranted signal is removed on a one-way street, it is expected that pedestrian crashes will be reduced by 17%
- Conversion of 2-way stop to all-way stop control results in an expected drop in pedestrian crashes of between 19% and 39%.

Taken together, these two results suggest that using all-way stop controlled intersections would likely provide better pedestrian safety performance than continuing the use of unwarranted signals or the use of two-way stop control intersections.

Auto Safety - Signal Removal/Unwarranted Signals

Several studies have shown that unwarranted traffic signals can result in higher crash rates and higher delays, and that removal of unwarranted signals can reduce crashes, especially rear-end crashes.

Per the National Cooperative Highway Research Program (NCHRP) Report 500[1], "*Traffic signals can remedy many safety and operational problems at intersections. However, signals often can adversely affect intersections. It is possible that a signal may no longer be warranted due to changes in traffic conditions. Problems created by an unwarranted signal, such as excessive delay, increased rerouting of traffic to less-appropriate roads and intersections, higher crash rates, and disobedience of the traffic signal can be addressed by removing the signal if doing so would not create worse problems.*"

In 2005, a study reported that removing unwarranted signals may result in a 24% decrease in all crashes, a 53% decrease in injury crashes, a 24% decrease in right-angle crashes, and a 29% decrease in rear-end crashes."

NCHRP Report 491[2] states that, "*Accident experience frequently increases at unwarranted traffic control signals or at locations where only minimum warrants are met and where the installation was not based on sound engineering analysis.*"

A report by the Kentucky Transportation Center[3] noted that, *"The number of crashes per year increased at intersections after installation of an unwarranted traffic signal (28.3) percent. This was a result of the dramatic increase in rear end crashes (222 percent).* The study also found that, *"The removal of unwarranted traffic signals did not result in a crash problem*."

The Criteria for Removing Traffic Signals[4] *Technical Report* found that in conversion of a traffic signal to a multi-way stop control for a group of 26 intersections, *"there was a decrease in the average annual accident frequency of more than one accident per year. Annual accident frequency was reduced 60 percent from 1.70 to 0.68 accidents per year, a statistically significant change. Annual injury accident frequency per intersection was also reduced significantly from 0.50 to 0.19."*

In *The Safety Effect of Conversion to All-Way Stop Control in Philadelphia*[5] it was found that, *"The overall reduction in crashes found in this study of one-way street traffic signals converted to multiway stop sign control was approximately 24%. For all crash types, there were significant reductions in crashes for both day and night. Overall and for all crash types, the percent reduction in crashes resulting in severe injuries (as coded by police) was substantially larger than those crashes involving minor injuries."*

An Institute of Transportation Engineers (ITE) publication[6] stated, "*an unwarranted or poorly designed signal is ineffective, inefficient, and a potential danger to motorists and pedestrians.*"

The ITE publication also stated, *"Unwarranted signals, however, often generate an increase in vehicle stops, traffic delays, fuel consumption, traffic accidents, and motorist disrespect for traffic signals."*

References

1. Antonucci, N.D. et al., *NCHRP Report 500, Guidance for Implementation of the AASHTO Strategic Highway Safety Plan, Volume 12: A Guide for Reducing Collisions at Signalized Intersections*, National Cooperative Highway Research Program, Washing D.C., 2004

2. McGee, H., Persaud, B., *NCHRP Report 491, Crash Experience Warrant for Traffic Signals*, National Cooperative Highway Research Program, Washing D.C., 2004

3. Agent, K.R., Green E.R., *Crash History After Installation of Traffic Signals (Warranted vs. Unwarranted*), KTC-08-01/SPR328-07-1I, Kentucky Transportation Center, January 2008

4. Kay, J.L. et al., *Criteria for Removing Traffic Signals*, Report No. FHWA/RD-80/104, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., (1980).

5. Persaud, B., E. Hauer, J. Lovell, *The Safety Effect of Conversion to All-Way Stop Control in Philadelphia*, University of Toronto, November 1984.

6. Morales, J.M., *Improving Traffic Signal Operations A Primer,* Institute of Transportation Engineers, Federal Highway Administration (FHWA) Highway Administration, U.S. Department of Transportation, 1995.

7. FHWA – *Desktop Reference for Crash Reduction Factors* – Publication FHWA-SA-07-015, September 2007.

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