STATE OF NORTH CAROLINA	**IN THE GENERAL COURT OF JUSTICE**
	SUPERIOR COURT DIVISION
COUNTY OF WAKE	**10-CVS-019930**

BRIAN CECCARELLI and LORI MILLETTE,	
Plaintiffs,	**AFFIDAVIT OF LISA MOON, P.E.**
v.	
TOWN OF CARY,	
Defendant.	

I, Lisa Moon, am over twenty one years of age and I am competent to testify in above-captioned matter.

1. I am a licensed professional engineer in the states of North Carolina, South Carolina, and Virginia. I was retained by the Town of Cary to review documents and to provide expert opinions and testimony in the above case. I have been a licensed professional engineer in North Carolina since 1997.

2. I am currently employed by Atkins as a Traffic Engineer. I have been continuously working as a Traffic Engineer since 1991. There are many facets to Traffic Engineering and, in my career I have been involved in many of those, including traffic signal design, traffic impact studies, corridor timing, sign and pavement marking design, traffic control, congestion management, intelligent transportation system design, parking studies, pedestrian refuge island design, utility coordination, and highway-rail grade crossing inventory and design. In my role as a Traffic Engineer I have prepared approximately 1,000 traffic signal plans, with over 900 of those in North Carolina and South Carolina. Determining the length of the yellow clearance time (Yellow Time) for each signal is part of a Traffic Engineer's job responsibilities when signing and sealing a signal plan in most states, including both North and South Carolina.

3. Part of my job as a Traffic Engineer is to be familiar with the Manual of Uniform Traffic Control Devices (MUTCD) and the MUTCD stated standards, guidances, and options for Yellow Clearance Times. Additionally, I am familiar with the contents and use of the NCDOT Traffic Management & Signal Systems Unit Design Manual ("Design Manual"), first issued in 2005.

4. I am familiar with the following intersections located within the Town of Cary, and each is owned by the state of North Carolina:

   a. Maynard Road and Kildaire Farm Road;

   b. Kildaire Farm Road and Cary Parkway;

   c. High House Road and Cary Parkway; and

d. Walnut Street and Meeting Street.

5. I have reviewed and am familiar with the official NCDOT Signal Plans of Record for the time period August 1, 2010 to August 18, 2012 for the above intersections on which the Yellow Times are shown. I have also reviewed and am familiar with the Clearance Time Sheet used by the licensed professional engineer to calculate the Yellow Times shown on the official NCDOT Signal Plan of Record for each of the above Signal Plans.

6. Additionally, I am familiar with the intersection of Cary Towne Boulevard and Convention Drive (formally known as Western Boulevard Ext. and Convention Drive – Principal Lane), which is located within the Town of Cary that is owned by the state of North Carolina. I have reviewed and am familiar with the official NCDOT Signal Plan of Record for the intersection of Cary Towne Boulevard and Convention Drive, indicating the Yellow Times for this intersection, between the time periods of December 2, 2009 through March 19, 2010. I have also reviewed and am familiar with the Clearance Time Sheet used by the licensed professional traffic signal engineer to calculate the Yellow Times shown on the official NCDOT Signal Plan of Record for the relevant Signal Plan.

7. I have reviewed the Yellow Clearance Times that are set forth on the Signal Plans of Record described above and all the Yellow Clearance Times shown on these Signal Plans are in full conformance with the requirements of the MUTCD.

8. Additionally, the Yellow Clearance Times I reviewed for the official NCDOT signal plans described above, were calculated using accepted engineering practices for traffic signal engineers in this State.

9. I want to explain the purpose of the yellow and red time intervals at signalized intersections. The yellow signal is to warn the drivers of an upcoming change of right of way and the all-red signal is used to allow vehicles to travel through the intersection past opposing traffic. Basically what that means is the yellow is the chance for the driver to make a stop or go decision. The yellow does not necessarily mean either explicitly. The intent of the yellow is to allow the motorist to choose to either stop before entering the intersection or to continue through the intersection. Of course, if a driver is further away from the yellow signal, and judges that they cannot reach the intersection at current speed, the intent is for them to stop. Such drivers will have enough distance to come to a stop prior to entering the intersection. Some drivers may increase their speed in order for them to reach the intersection, but the intent of the formula is to give those drivers enough distance to stop prior to entering the intersection on red. If a driver is closer to an intersection when the signal first turns yellow, there becomes a point that drivers cannot reasonably come to a stop prior to entering an intersection. In such case, the length of the Yellow Time is designed to give those drivers enough time on yellow to reach and to cross into the intersection.

10. Since 1941, the Institute of Transportation Engineers (ITE) has published recommendations for Traffic Engineers to calculate these times. "The Institute of Transportation Engineers is a non-profit international educational and scientific association of transportation professionals who are responsible for meeting mobility and safety needs. ITE facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development and management for any mode of ground

transportation. Through its products and services, ITE promotes professional development of its members, supports and encourages education, stimulates research, develops public awareness programs and serves as a conduit for the exchange of professional information." ITE's membership is made up of transportation professionals, including Traffic Engineers and Transportation Planners. Since 1941, the recommended formulas for Yellow and Red Times have been refined based on research and practitioner's experience applying the formulas. There is not one set national standard for Yellow and Red Times, but there are numerous variations that consist of several generally accepted practices that are utilized by traffic engineers. Over the years, traffic engineers in various parts of the country have applied what they feel are best practices for their area of the country. Sometimes that means a standard Yellow and Red Time for all intersections regardless of the speed or grade. Sometimes that means a standard yellow for each posted speed limit. Most drivers, as long as there is a consistent method applied in the area where they drive, adapt, adjust, and are able to successfully pass through signalized intersections. In the past fourteen years with Atkins and working with other states besides North Carolina, as a traffic engineer designing Yellow and Red Times, I have seen more and more jurisdictions move toward some version or variation of the ITE formula. A study of the state of the practice conducted and published by ITE in 2004, indicated that the most common method for calculating change intervals is based upon using the ITE formula.

11. Currently the recommended ITE formula, which the majority of traffic engineers use in some form or fashion, for calculating the change interval (Yellow plus All Red Times) is broken down into two portions. The first part of the equation is for the Yellow Time and the second is for the All Red Time. The All Red Time portion of the equation is just the amount of time a car needs to travel through the intersection before the opposing traffic gets the green and can enter the intersection. Width of the intersection divided by speed gives us the time.

12. To explain the Yellow Time, recall that the driver must make a decision when he or she first sees the yellow light as to whether it is best to stop or go. If you are going to stop, you do not need a specific length of Yellow Time because you are stopping and will not enter the intersection to potentially conflict with the opposing traffic. When a driver decides to stop, he or she will apply the necessary braking they need to ensure that he or she can stop prior to the stop bar. However, if the driver chooses to continue through the intersection (because they make a decision that they cannot reasonably stop prior to entering the intersection), the driver needs enough time to enter the intersection before the signal turns red (this is the Yellow Time) and then enough time to clear the intersection (this is the All Red Time). To calculate the yellow time needed, you once again look at distance divided by speed. The distance is the distance it would have taken a driver to stop on this approach. The driver has decided to continue through the intersection because they do not feel they can reasonably stop prior to entering into the intersection. In this situation, the maximum distance a driver would be from the intersection is the distance it would take to reasonably stop. Once we have this distance, it is just a matter of dividing by speed to get time.

13. Most of the time, the decision to stop or go is clear to the driver. There are locations on the approach to an intersection (that vary based upon the speed of travel) where a "zone of indecision" can be experienced by the driver. Traffic engineers are aware of this zone, and use techniques to limit the amount of drivers that experience this zone.

14. The portion of the ITE formula for calculating the yellow time does have

variables that can be applied differently based upon how they are interpreted by the Traffic Engineer. Below you will see how NCDOT has reached consensus within the State as to what these variables will be for a consistent, accepted traffic engineering practice for North Carolina Traffic Engineers. In my experience as a Traffic Engineer who has licenses in multiple states, it is typical that state DOT's publish the value that they consistently apply in a design manual for their state.

15. From the beginning of my career in 1991 as a Traffic Engineer at NCDOT, I have used a version of the ITE formula to calculate Yellow and Red Times. From at least 1991, NCDOT has had a consistent practice of using a modified version of the ITE formula for these calculations. The modifications to that formula have been tweaked over the years. Since 2005, virtually all North Carolina traffic engineers that have prepared signal plans for state-owned intersections have used a modified version of the ITE formula that was the result of a recommendation by a NCSITE Joint Task Force.

16. The Joint Task Force was created to review the yellow and red calculations and determine a practice that would be implemented statewide by, not only NCDOT, but by all municipalities and private engineering firms, for use on any roadways within the State of North Carolina, public or private. I was a member of this Task Force. The first meeting of the Task Force was January 27, 2005. Twenty nine traffic engineering professionals attend this meeting. In this meeting we reviewed the NCDOT methodologies from 1990 to present. From the discussion topics, four subcommittees (or work groups) were formed to address the issues in brainstorming sessions. The work groups and their associated topics were:

a. General Clearance issues
    i. Start up delay for conflicting movements
        1. Time to reach conflict points
    ii. How clearance distances should be measured
        1. Should right turn lanes be cleared
        2. Do we include ped/bike paths
            a. Should we measure the path of a turn vehicle instead of the diagonal
        3. What is an appropriate length of vehicle
        4. How should triple lefts be handles
    iii. What is an appropriate design vehicle
    iv. What can be done to reduce intersection "size," and by that reduce clearance
b. Clearance Interval Constraints:
    i. Should there be a min/max value for Total Clear, Yellow or All Red
    ii. How should we divide the Total Clear into Yellow and All Red
    iii. Should we allow a deviation in All Red
        1. Drivers "see" yellow
        2. Drivers do not "see" All Red
    iv. Can we determine the safety impact of longer yellows versus longer red
    v. How do drivers perceive/ how well do they understand clearance intervals
c. Speed issues
    i. What should the left turn speed be

1. Where should the speed be measured
2. Should there be two left turn speeds

ii. Do we/ how do we address overspeed design

d. Numerical Inputs into ITE Formula

i. What are appropriate perception/ reaction times and deceleration rates

ii. Should we consider the "benefit" of positive grade

17. Each work group, with between 4-9 traffic engineers, reviewed the topics related to their task and reported back to the committee as a whole with recommendations. The committee reviewed the recommendations, asked questions, and gave the work groups opinions that were further reviewed. I was involved in the work group that discussed the Clearance Interval Constraints. We, a work group of six, reviewed the practice for each of the topics listed above, under the Clearance Interval Constraints and gave recommendations to the committee. We met a minimum of five times and worked for over a five month period of time.

18. The entire Task Force met four times to review the work group recommendations and came to a consensus on June 23, 2005.

19. Although I was not on all subcommittees that were part of the Task Force, I was a part of the entire committee that reviewed the recommendations about general clearance issues, speed, perception/reaction time, and grades. Each work group did research on each of these issues and shared highlights of their research when the recommendations were made to the Task Force committee as a whole. Based on the research conducted and recommendations of the professional traffic engineers of the sub groups who were tasked to look at the issue at hand, I agreed with all of the recommendations made – including the increase of the perception/ reaction time from 1.0 to 1.5, to address the needs of older and distracted drivers, the increase in the deceleration rates (due to the greater stopping abilities, such as antilock brakes, on the vehicles currently using our roads), to continue to use 20 mph for the value of design speed or approach speed used in the Yellow Time formula for dedicated left turns (research done by work group on actual speeds and some independent research done by my own work group on this issues as it related to the length of the yellow time), and the continued use of the posted speed limit as speed in the ITE equation.

20. For example, the AASHTO Policy for both 2001 and 2011 states "Approximately 90 percent of all drivers decelerate at rates great than 3.4 m/s^2 [11.2 ft/s^2]. Such decelerations are within the driver's capability to stay within his or her lane and maintain steering control during the braking maneuver on wet surfaces. Therefore, 3.4 m/s^2 [11.2 ft/s^2] (a comfortable deceleration for most drivers) is recommended as the deceleration threshold for determining stopping sight distance…….The friction available on most wet pavement surfaces and the capabilities of most vehicle braking systems can provide braking friction that exceeds this deceleration rate."

21. Also in the AASHTO Policy 2011, there is discussion about reaction times. The Policy refers to studies done for brake reaction time and the effects of an expected event and an unexpected event. Based on three studies, the average/mean reaction time of drivers to an expected event is less than 0.7 seconds, with 10% or less needing anywhere from 1 to 1.7 seconds.

22. The AASHTO Policy on Geometric Design of Highway and Streets which does recommend a 2.5s reaction time, is not applicable to reaction times needed to observe a change in signal right of way – clearly a simple and expected event. The Policy on Geometric Design of Highway and Streets is written for and encompasses all the factors related to design of highways and streets. This policy is not specifically about the design and timing of traffic signals, but covers the overall design of the roadway.

23. The ITE recommended perception/reaction time (PRT) of 1.0 s is based on research that has been done specifically for use by traffic engineers as it relates to our practice. Previous research has always supported the recommended 1.0 s PRT and is being validated by current research as well. In NCHRP Report 731, completed in 2012, the observed mean brake reaction time of 2,422 observed vehicles was 1.00 seconds. Also, practicing traffic engineers have not had any issues with using the PRTs of 1.0 or 1.5 seconds. Traffic engineers drive too, and typically drive in the area where they practice engineering. We would not design a traffic signal to operate in a way we ourselves would be uncomfortable using. I personally have designed and / or revised traffic signals along my route from my home to office to the same standards as all others that I design. A survey done in 2009 on the State of the Practice as discussed in NCHRP Report 731 (2012), indicates that 89% of all practicing traffic engineers use a value of 1.5s or below for PRTs.

24. The extension of the yellow time beyond what is currently calculated by NCDOT encourages aggressive behavior. Human nature seems to put us on a course that if the "extra" yellow time is available, then most drivers will use it. We get to the point that the yellow time means "hurry up, you can make it" instead of "stop if you can." NCDOT's current practice encourages the correct intent of the yellow, which is "stop if you can." If the yellow gets "too long," motorists give it less meaning. The intent of a traffic signal and the yellow and red time is for the safety of the traveling public, but also must meet and respect the driver's expectation to efficiently travel the public roads.

25. Traffic Engineering methods have mathematical equations as a base, but the practicing traffic engineer knows that a lot of what we do is about driver characteristics and behaviors. It is a fun and challenging profession when there are so many variables to consider while designing safe and efficient roadways for the public.

26. Further this affiant says naught.

Lisa M. Moon

Lisa Moon, P.E.

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Wake County, North Carolina

Sworn to and subscribed before me this day by Lisa M. Moon

Date: 12.7.2012

(Seal)

Brenda J. Cox
Notary Public

Brenda J. Cox
Notary Public Printed Name

My Commission Expires: My Commission Expires 9-5-2015.