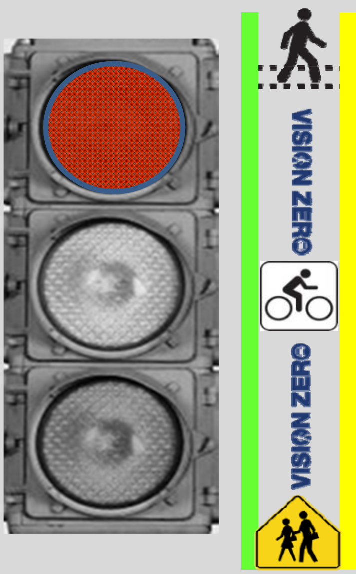
APPENDIX: TRANSPORTATION

TABLE OF CONTENTS

New York City
Department of Transportation



INTERSECTION
CONTROL ANALYSIS

LOCATION

REF#:

NEW YORK CITY DOT
I.C.U.

ELECTED OFFICIAL ACKNOWLEDGEMENTS

Location: ______________________________

Borough: ____________ **Reference #:** ____________ **CB#:** ________

DOT Case #: ______________________________

Date notification was Sent out ____________________

BOROUGH PRESIDENT ____________________

CONGRESS MEMBER ____________________

STATE SENATOR ____________________

ASSEMBLY MEMBER ____________________

COUNCIL MEMBER ____________________

C.B. MANAGER ____________________

REQUESTOR ____________________

Traffic Signal Approval

Location

☐ **APPROVAL**

☐ **DENIAL**

ROUMANY WASEF, P.E.
Traffic Operation- ICU

Date

☐ **APPROVAL**

☐ **DENIAL**

JAMES CELENTANO, P.E.
Traffic Operation-ITS Engineering

Date

Intersection Control Unit

Location: ______________________________

File#: ______________________________

DOT Case#: ______________________________

Request: ______________________________

Requestor: ______________________________

Determination Date: ______________________________

Determination: ______________________________

Comments: **Based upon our evaluation of data collected, it is our judgment that a traffic signal be approved under Warrant.** ______________________

____

WASEF, ROUMANY, P.E.

REF#: ____________________

THE STUDY SHOULD INCLUDE THE FOLLOWING:

CHECK LIST

☐ **Data Warehouse map with legend & measurements**
(Location of required Traffic Control Device to be highlighted with a red circle.)

☐ **School Map (if required)**
(Location of required Traffic Control Device to be highlighted with a red circle.)

☐ **Condition diagram** *(and proposed mitigations,markings, etc.)*

☐ **Block Front Survey. (if required)**

☐ **Field observation report**

☐ **Volume counts**

☐ **Gap** *(if required)*

☐ **Speed** *(& memorandums in speed enforcement- if required)*

☐ **Analysis Factor Sheet**

☐ **Memorandums (on proposed mitigations, pavement markings)**

FIELD OBSERVATION REPORT

LOCATION : ______________________________

BOROUGH: ____________________ **REF:** ____________________

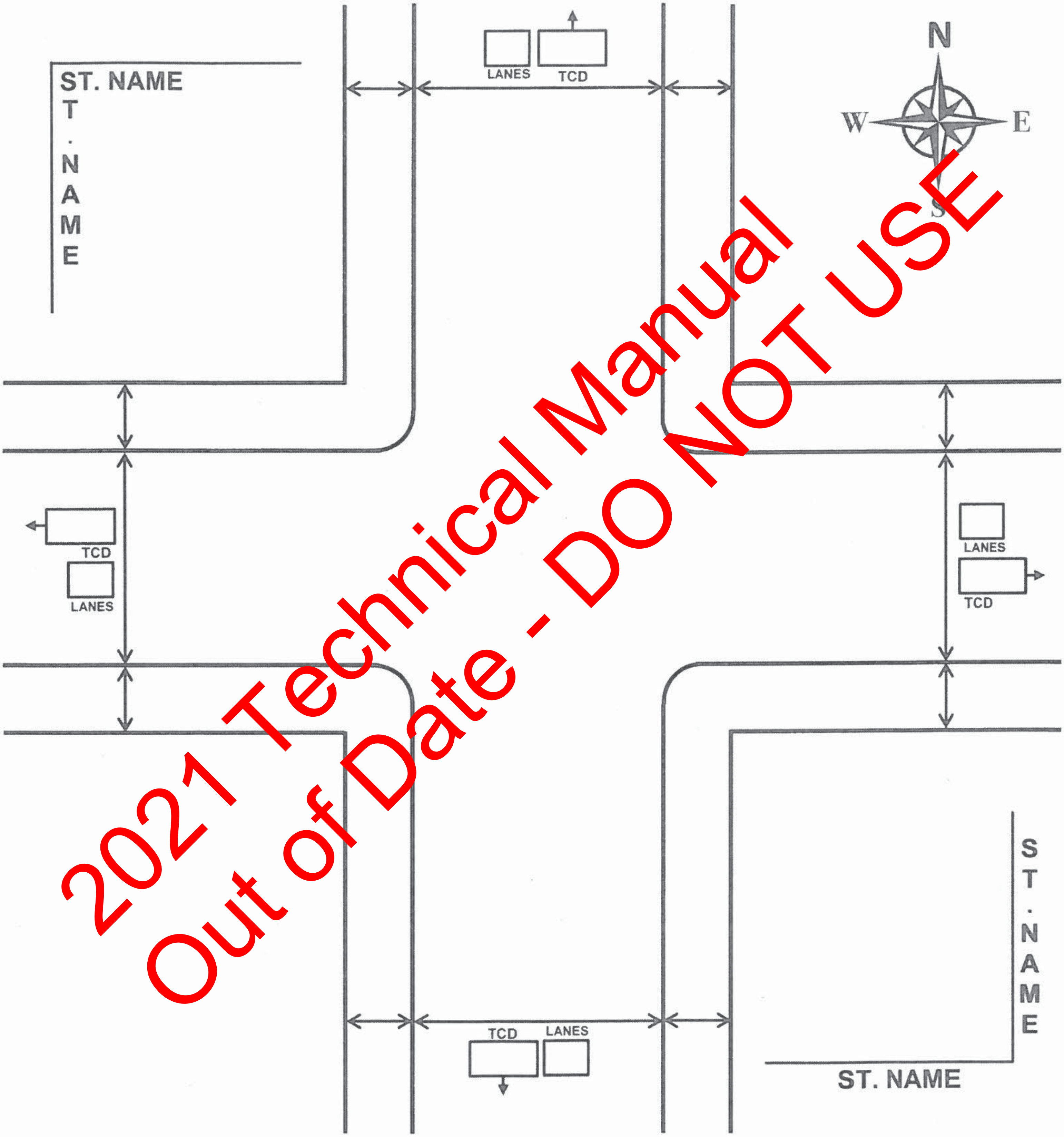
DATE: ____________________ **OBSERVER:** ____________________

OPERATIONAL CHECKLIST:	**NO / YES**	**WHERE AND WHAT ?**
1. Are there any obstructions blocking the view of opposing or conflicting vehicles?	____	____________
2. Are drivers complying with intersection controls?	____	____________
3. Are Speed limit signs posted?	____	____________
4. Is vehicle delay causing a safety problem?	____	____________
5. Is the approach grade causing safety problems?	____	____________
6. Do you recommend more stringent enforcement?	____	____________
7. Are signs faded, turned or defaced?	____	____________
8. Do pavement markings have to be refurbished? (e.g.: STOP Messages, STOP lines, Lane lines, Crosswalks, etc.)	____	____________
9. Is there a need to install channelization to reduce conflict areas?	____	____________
10. Do signs existing in field match current C-order?	____	____________
11. Do signs existing in field match current SC-order?	____	____________
12. Other	____	____________

NOTE: (N/A) NOT APPLICABLE

CONDITION DIAGRAM

Ref#________________ Date: ____________ Day: ____________ Inspector: __________________

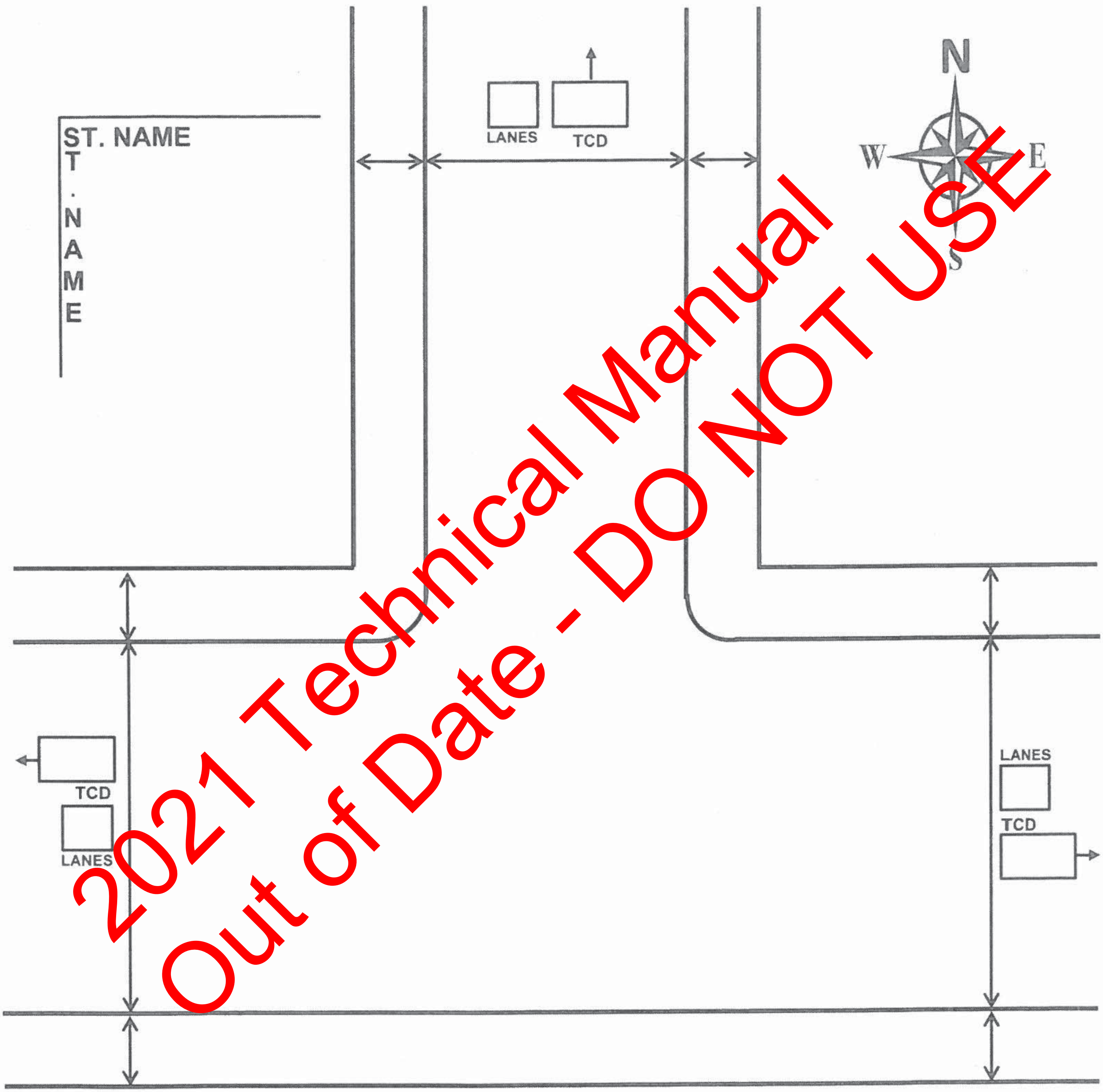


NOTE: Indicate all curb regulations, street furniture, curb cuts, and all pavement markings related to the intersection. The # of lanes observed are the traveled lanes for each approach; parking lanes are not included. Show street direction by placing an arrow(s), indicating direction on all legs of the intersection.

TCD = DISTANCE TO NEAREST TRAFFIC CONTROL DEVICE (Feet)
LANES = NUMBER OF MOVING LANES

CONDITION DIAGRAM

Ref#______________ Date: __________ Day: ____________ Inspector: ______________



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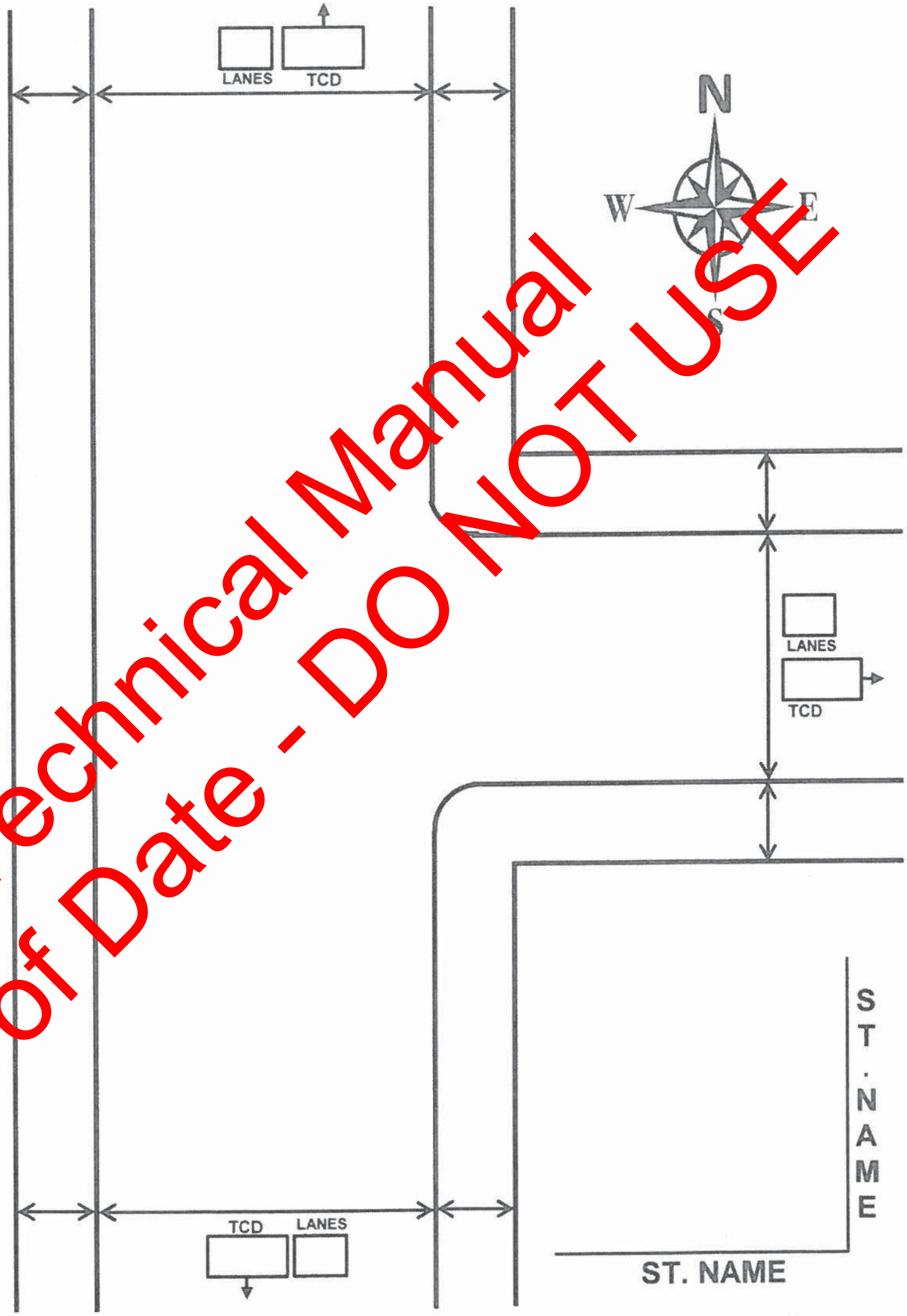
CONDITION DIAGRAM

Ref#_______________ Date: ____________ Day: ____________ Inspector: _______________

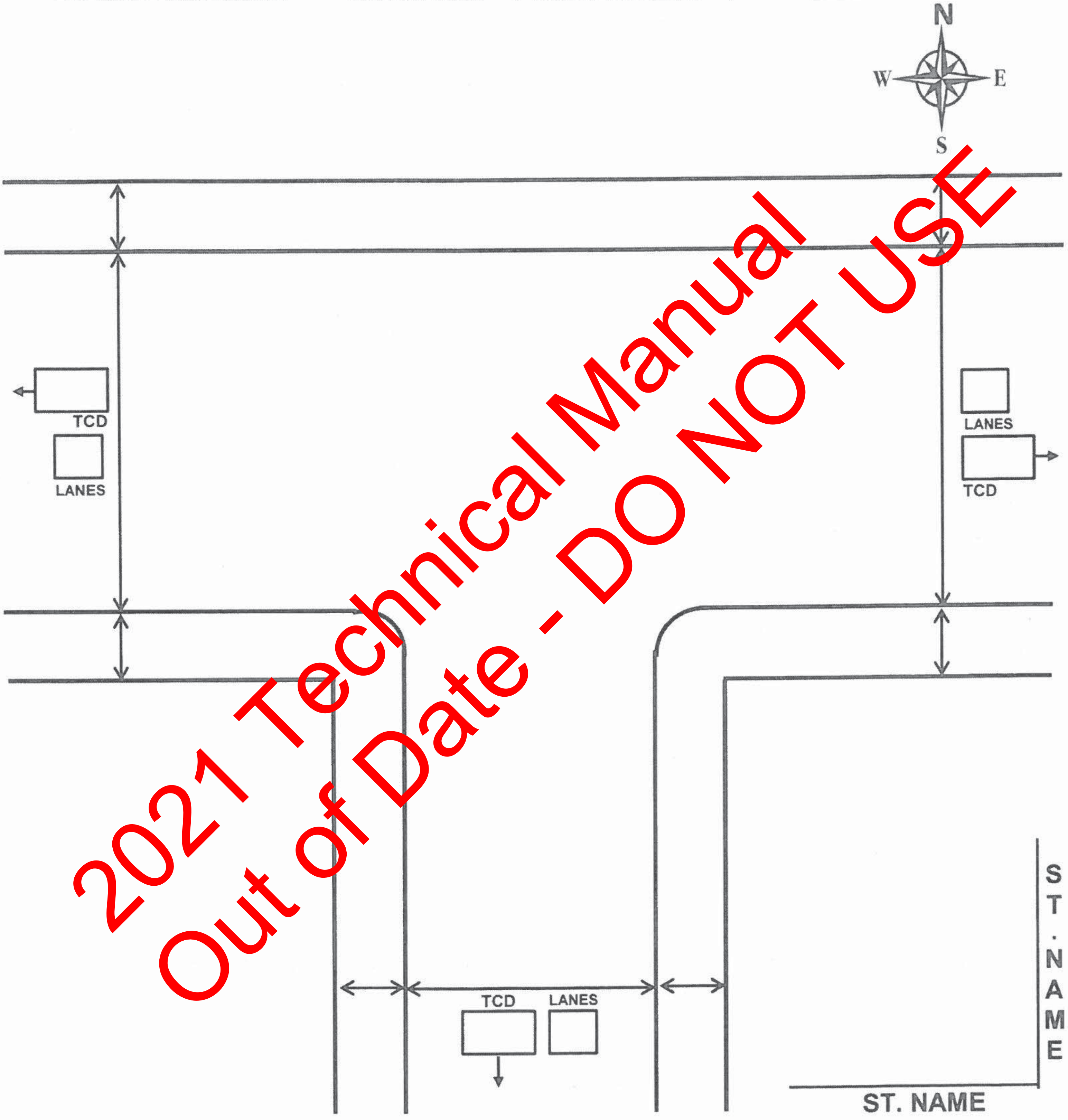


TCD = DISTANCE TO NEAREST TRAFFIC CONTROL DEVICE (Feet)
LANES = NUMBER OF MOVING LANES

NOTE: Indicate all curb regulations, street furniture, curb cuts, and all pavement markings related to the intersection. The # of lanes observed are the traveled lanes for each approach; parking lanes are not included. Show street direction by placing an arrow(s), indicating direction on all legs of the intersection.

CONDITION DIAGRAM

Ref#________________ Date: ____________ Day: ______________ Inspector: __________________

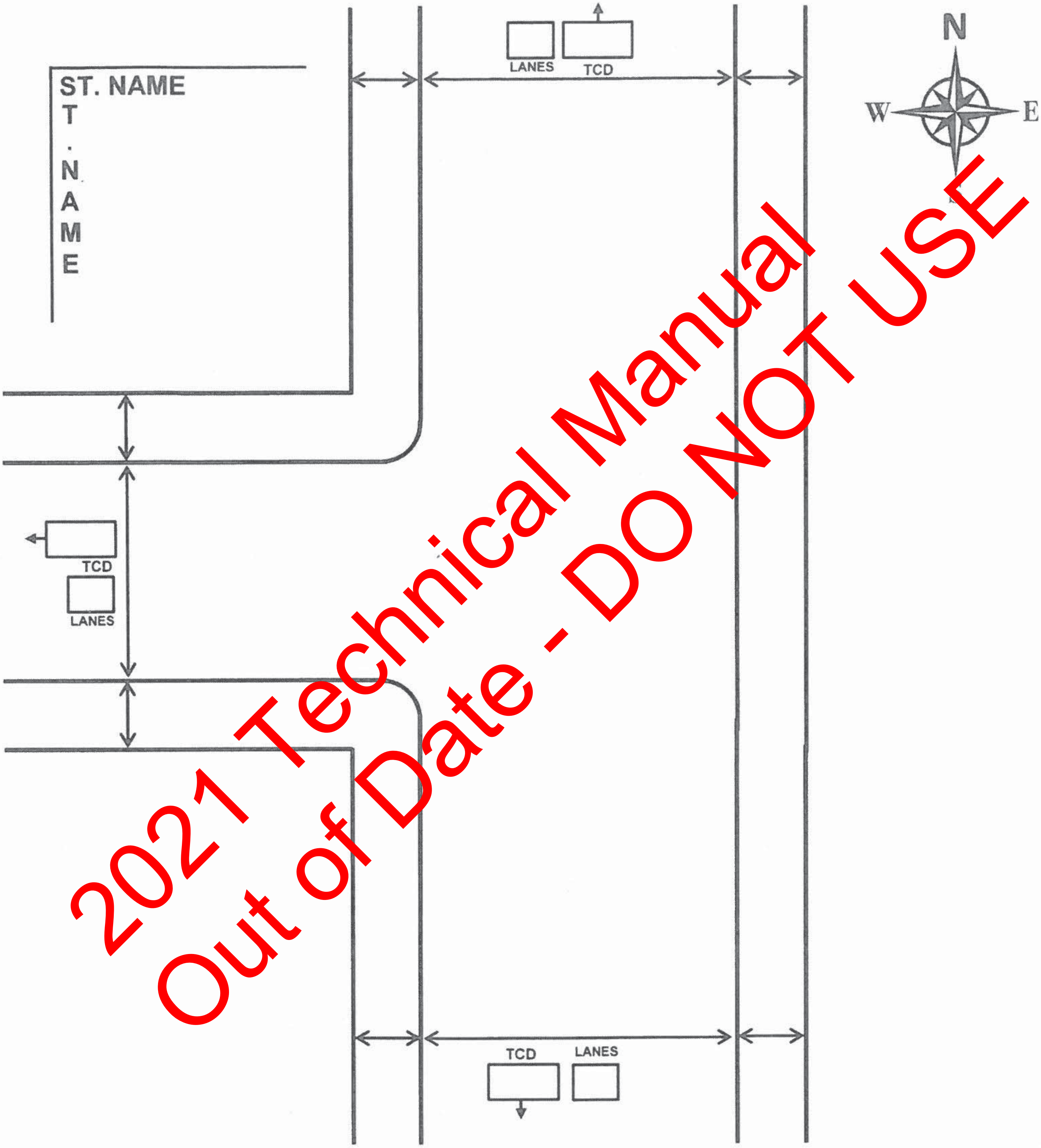


NOTE: Indicate all curb regulations, street furniture, curb cuts, and all pavement markings related to the intersection. The # of lanes observed are the traveled lanes for each approach; parking lanes are not included. Show street direction by placing an arrow(s), indicating direction on all legs of the intersection.

TCD = DISTANCE TO NEAREST TRAFFIC CONTROL DEVICE (Feet)
LANES = NUMBER OF MOVING LANES

CONDITION DIAGRAM

Ref#________________ Date: ____________ Day: ____________ Inspector: ________________



TCD = DISTANCE TO NEAREST TRAFFIC CONTROL DEVICE (Feet) LANES = NUMBER OF MOVING LANES

NOTE: Indicate all curb regulations, street furniture, curb cuts, and all pavement markings related to the intersection. The # of lanes observed are the traveled lanes for each approach; parking lanes are not included. Show street direction by placing an arrow(s), indicating direction on all legs of the intersection.

CONDITION DIAGRAM

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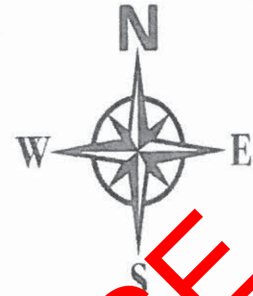

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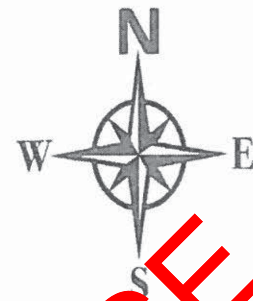
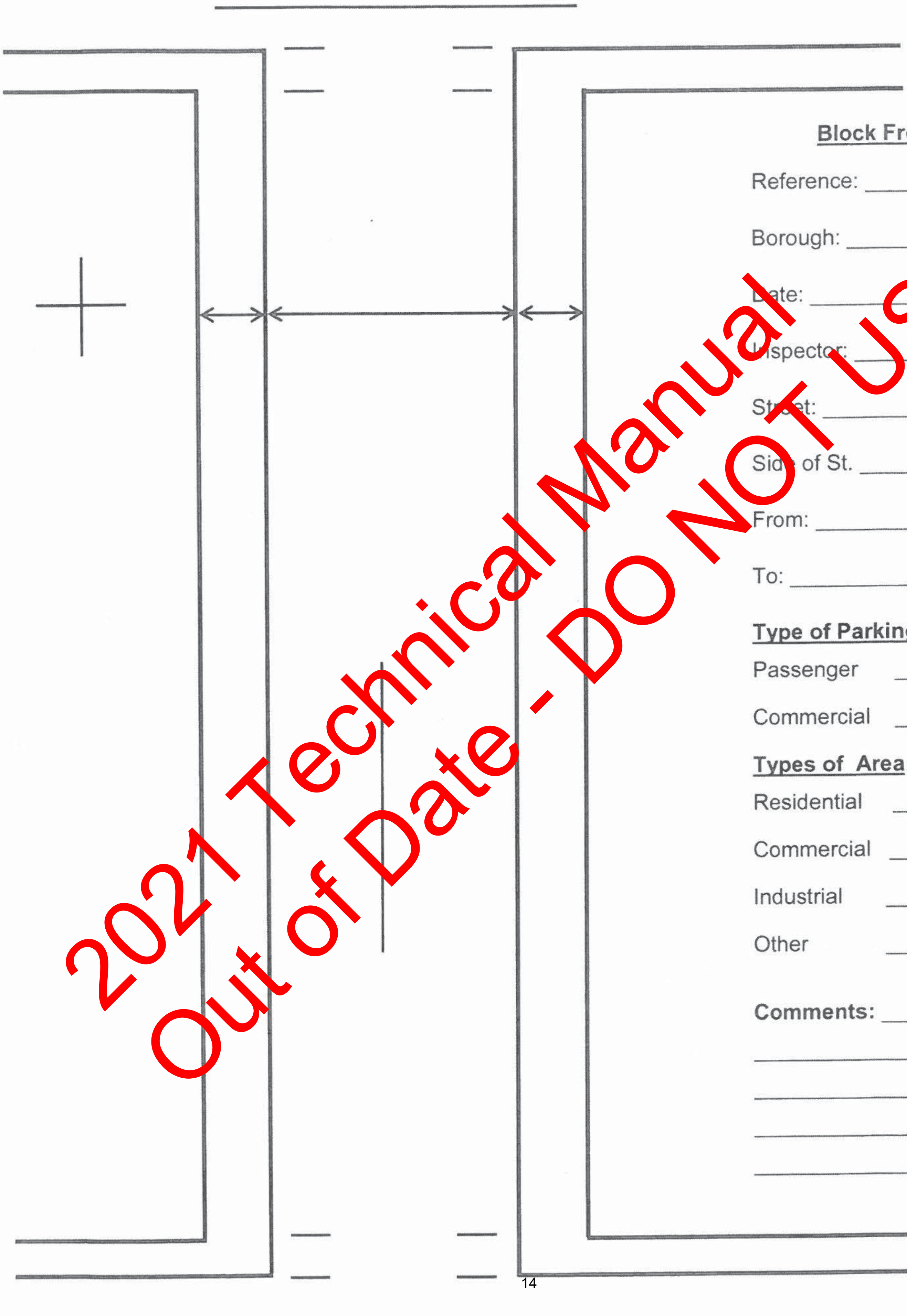
CONDITION DIAGRAM

Ref#________________ Date: ____________ Day: ____________ Inspector: __________________





Block Front Survey

Reference: ______________

Borough: ______________

Date: ______________

Inspector: ______________

Street: ______________

Side of St. ______________

From: ______________

To: ______________

Type of Parking

Passenger ________%

Commercial ________%

Types of Area

Residential ________%

Commercial ________%

Industrial ________%

Other ________%

Comments: ______________

____

____

____

____

FIELD OBSERVATION REPORT

LOCATION : ______________________________

BOROUGH: ______________ REF # : ______________

DATE: ______________ OBSERVER: ______________

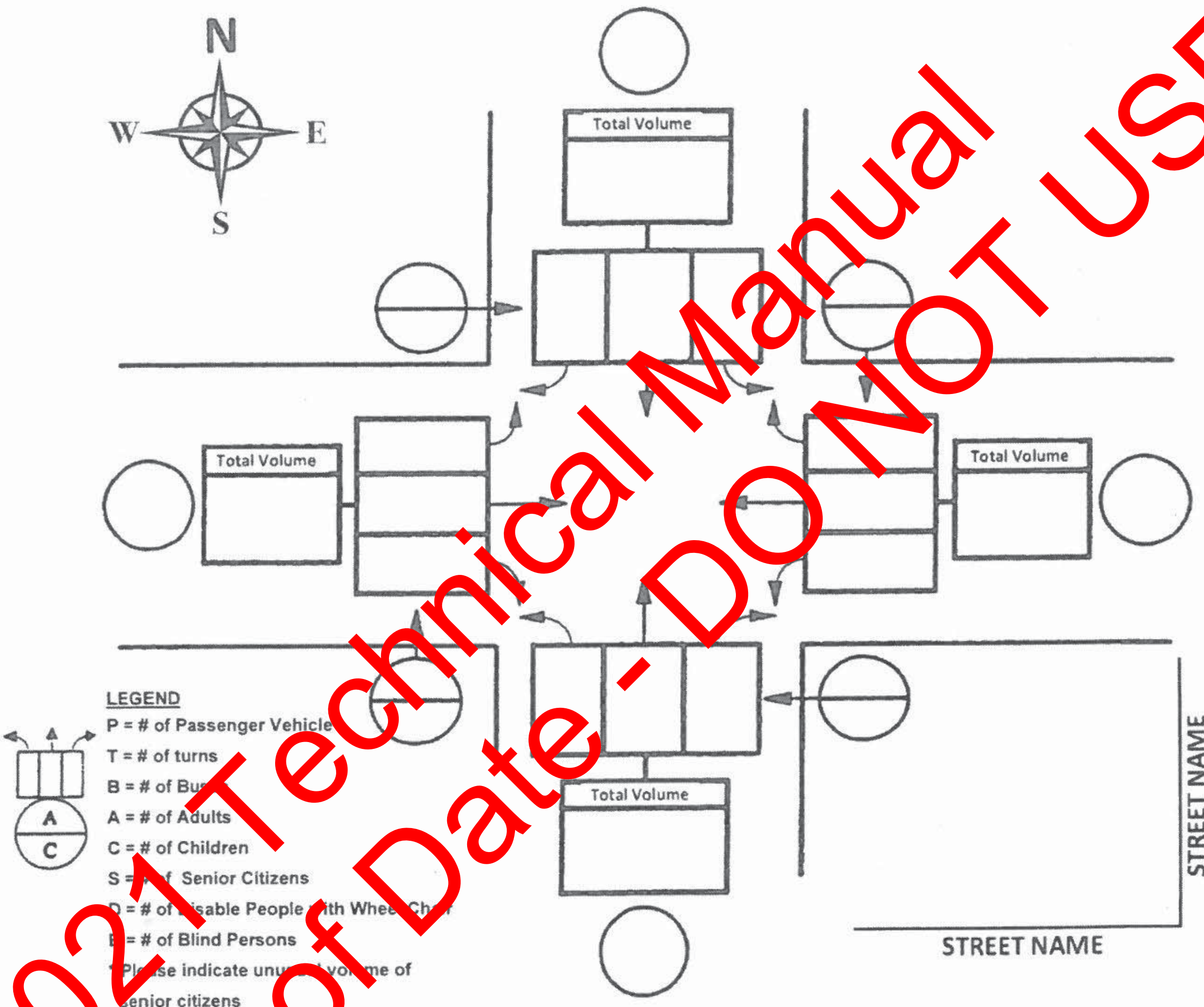
OPERATIONAL CHECKLIST:	NO	YES	WHERE AND WHAT
1. Are there any obstructions blocking the view of opposing or conflicting vehicles?	___	___	___
2. Are drivers complying with intersection controls?	___	___	___
3. Are Speed limit signs posted?	___	___	___
4. Is vehicle delay causing a safety problem?	___	___	___
5. Is the approach grade causing safety problems?	___	___	___
6. Do you recommend more stringent enforcement of any regulation?	___	___	___
7. Are signs faded, turned or defaced?	___	___	___
8. Do pavement markings have to be installed or refurbished? (e.g., STOP messages, STOP lines, lane lines, crosswalks, etc.)	___	___	___
9. Is there a need to install channelization to reduce conflict areas?	___	___	___
10. Do signs existing in field match current C-order?	___	___	___
11. Do signs existing in field match current SC-order?	___	___	___
12. Other	___	___	___

NOTE: (N/A) NOT APPLICABLE

VOLUME CLASSIFICATION AND TURNING COUNTS

DATE: ______________________ TIME: ______________________

DAY : ______________________ INSPECTOR: ______________________



COMMENTS:

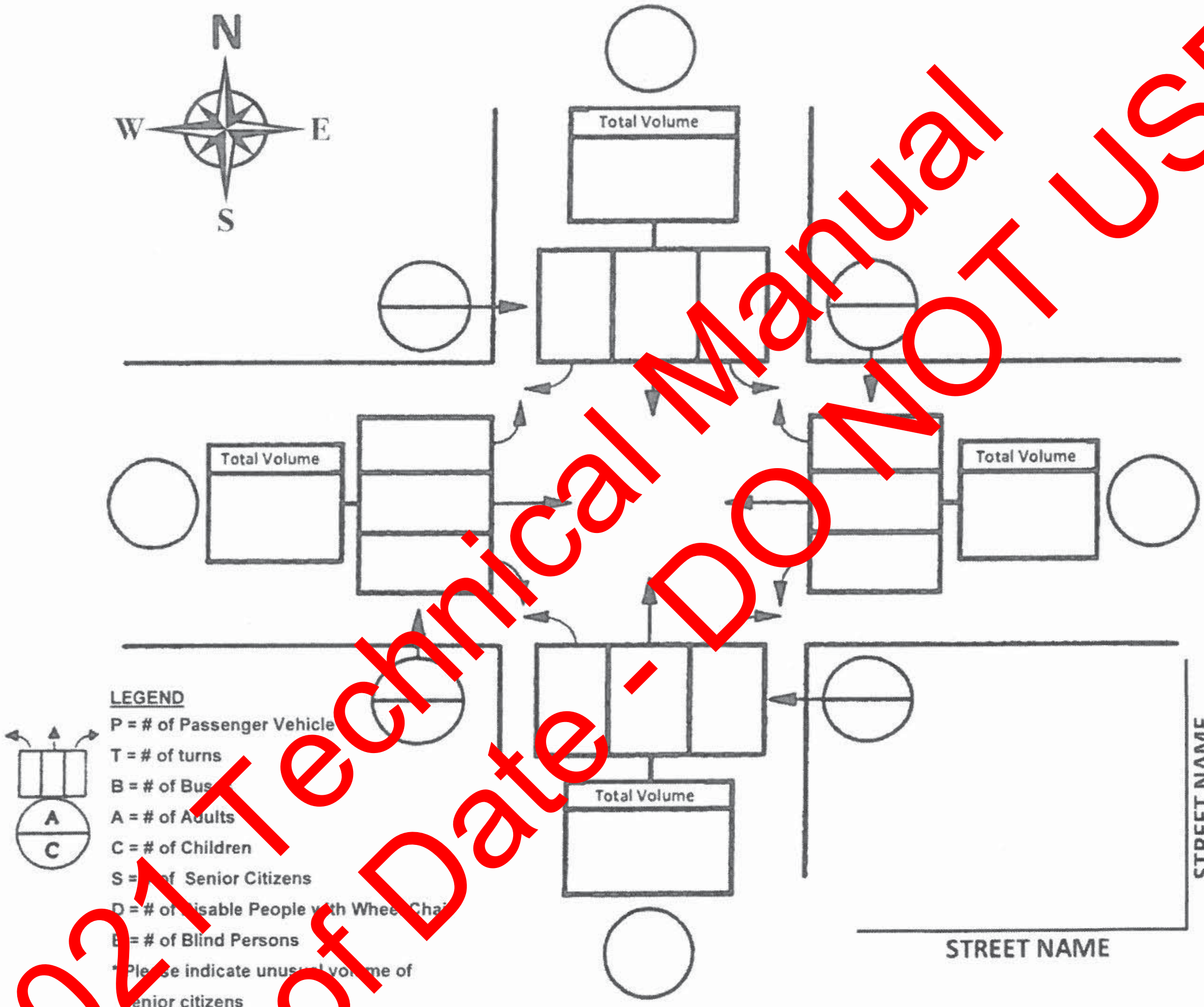
MAJOR	
MINOR	
PEDS	
SC	
Other	

Note: *Bikes in Crosswalks are assumed as pedestrians, While Bikes in roads and in bike-lanes are assumed as Vehicles*

VOLUME CLASSIFICATION AND TURNING COUNTS

DATE: ______________________ TIME: ______________________

DAY : ______________________ INSPECTOR: ______________________



COMMENTS:

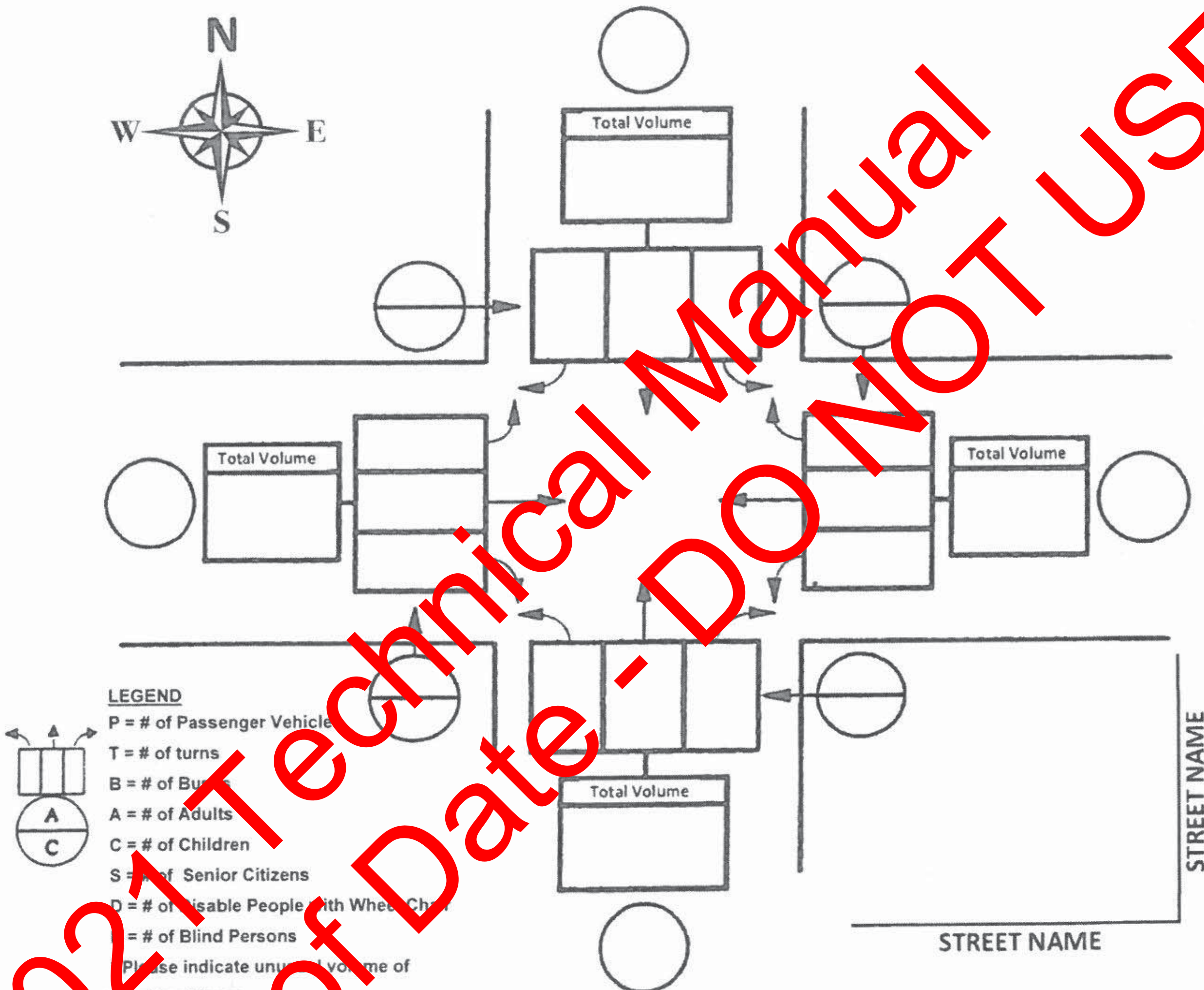
MAJOR	
MINOR	
PEDS	
SC	
Other	

Note: *Bikes in Crosswalks are assumed as pedestrians, While Bikes in roads and in bike-lanes are assumed as Vehicles*

VOLUME CLASSIFICATION AND TURNING COUNTS

DATE: ______________________ TIME: ______________________

DAY : ______________________ INSPECTOR: ______________________



LEGEND

P = # of Passenger Vehicle
T = # of turns
B = # of Bu
A = # of Adults
C = # of Children
S = f Senior Citizens
D = # of isable People ith Whee Ch
= # of Blind Persons
Pl se indicate un vo me of
senior citizens

COMMENTS:

MAJOR	
MINOR	
PEDS	
SC	
Other	

Note: *Bikes in Crosswalks are assumed as pedestrians, While Bikes in roads and in bike-lanes are assumed as Vehicles*

REF# ______ START: ______ END: ______

WEATHER: ______ DIRECTION: ______

MPH SPEED LIMIT: ______ POSTED: ______

DATE: ______ START: ______ END: ______

DAY: ______ DIRECTION: ______

UNPOSTED: ______

(MAJOR)

INTERSECTION CONTROL DATA COLLECTION ANALYSIS (FACTOR) SHEET

LOC.			
REF#:		INSP:	
Posted Speed Limit MPH		RADAR STUDY(Warrants 1A, 1B, 2, 3, 4 & SC Location) 85% SPEED	N/B : S/B :
DISTANCE TO THE NEAREST TRAFFIC CONTROL DEVICE ON MAJOR ST. **WARRANT # 6** (> 1000' both Direction)		Warrant # 5 & California Warrant	
		School X-Walk?	NO
		School X-ing Guard?	NO
Ft. to	Ft. to	Does A/W Stop Exist?	NO

GAP STUDY (For Warrant #'s 4 and 5) DATES and TIMES		Totals # of Gaps	VS. # of Minutes	
			60	Min.
			60	Min.
			60	Min.
			60	Min.
			60	Min.

DATE	TIME	OBSERVED VOLUMES: VEHICULAR VOLUMES (OBSERVED) Warr.s 1A,1B,2,3		PEDEDSRIAN VOLUMES (OBSERVED) Warrant # 4				WARRANT CRITERIA: WARRANT # 5 School Crossing		California Warrant	
		MAJOR Observed	Higher MINOR Observed	All PEDS observed	50% volume reduction if Ped speed < 3.5 fps	70% Factor if 85th percentile speed on major > 35 mph	All Senior Citizens observed	All School Children observed	20 or More School Children	20 or more School Children	500 or more Vehicles on Major

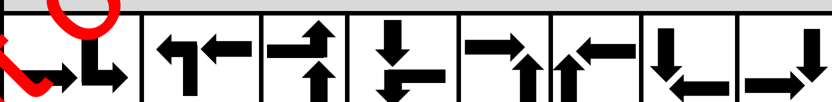
MAJOR STREET	MINOR STREET

MAJOR STREET VOLUMES ARE THE TOTAL OF BOTH APPROACHES
MINOR STREET VOLUMES ARE FOR THE HIGHER APPROACH ONLY

ATR'S Ordered? NO	EACH MAJOR APPROACH HAS ___ Lanes	EACH MINOR APPROACH HAS ___ Lanes	WARRANT CRITERIA: MAJOR STREET VOLUMES 100% abs	80% acc	70% spd	OBSERVED	MINOR STREET VOLUMES 100% abs	80% acc	70% spd	OBSERVED	ATR.s 8th Highest HR Major	Minor
WARRANT-1A Minimun Vehicular Volume	1 LANE	1 LANE	500	400	350		150	120	105			
	2 OR MORE LANE	1 LANE	600	480	420		150	120	105			
	2 OR MORE LANE	2 OR MORE LANE	600	480	420		200	160	140			
	1 LANE	2 OR MORE LANE	500	400	350		200	160	140			
WARRANT-1B Interuption of Traffic Conditions	1 LANE	1 LANE	750	600	525		75	60	53			
	2 OR MORE LANE	1 LANE	900	720	630		75	60	53			
	2 OR MORE LANE	2 OR MORE LANE	900	720	630		100	80	70			
	1 LANE	2 OR MORE LANE	750	600	525		100	80	70			

Abs= absolute basic minimum hourly volume. Acc= W/5 Preventable accidents= 80% of abs. spd= w/ speed of 40 mph = 70% of abs

WARRANT # 7. CRASH EXPERIENCE- ACCIDENT TYPES



ACC. Time Period: 12/36 Month Period	Were Accidents Ordered? N/A — Total Acc's	Tital Received	Accident types (arrow diagrams)								PEDS hit by Vehicles from Major	Actual Preventable after Accidents Received
TO												
TO												
TO												

Highest # of Preventable in any 12/36 month period: - **# Of Prev. Acc.** ______

Do You Have 5 or more Preventable and 300 ft or less to a T/S on the Major? NO If Yes, Possible Crash Warrant. ______

Do adjacent coordinated signals on major provide sufficient gaps? N/A If Yes, Traffic Signal may not be needed ______

**Count Classification is needed for L/T and LPI Study .*

Comments: ______

Improvements/changes: ______

WARRANT ANALYSIS

Warrant 1, Eight-Hour Vehicular Volume

Condition A – Minimum Vehicular Volume

Number of Lanes for moving traffic on each approach		MAJOR STREET VOLUMES: Vehicles per hour on major street (total of both approaches)				MINOR STREET VOLUMES: Vehicles per hour on higher volume minor-street approach (one direction only)			
Major Street	**Minor Street**	100%[a] Absolute Minimum Required	80%[b] of minimum Reduction for 5 Acc.	70%[c] of minimum Reduction for 40+MPH	ATR'S 8TH Highest Hour	100%[a] Absolute Minimum Required	80%[b] of minimum Reduction for 5 Acc.	70%[c] of minimum Reduction for 40+MPH	ATR'S 8TH Highest Hour
1…………….	1…………….	**500**	**400**	**350**		**150**	**120**	**105**	
2 or more….	1…………….	**600**	**480**	**420**		**150**	**120**	**105**	
2 or more….	2 or more….	**600**	**480**	**420**		**200**	**160**	**140**	
1…………….	2 or more….	**500**	**400**	**350**		**200**	**160**	**140**	

Condition B – Interruption of Continuous Traffic

Number of Lanes for moving traffic on each approach		MAJOR STREET VOLUMES: Vehicles per hour on major street (total of both approaches)				MINOR STREET VOLUMES: Vehicles per hour on higher volume minor-street approach (one direction only)			
Major Street	**Minor Street**	100%[a] Absolute Minimum Required	80%[b] of minimum Reduction for 5 Acc.	70%[c] of minimum Reduction for 40+MPH	ATR'S 8TH Highest Hour	100%[a] Absolute Minimum Required	80%[b] of minimum Reduction for 5 Acc.	70%[c] of minimum Reduction for 40+MPH	ATR'S 8TH Highest Hour
1…………….	1…………….	**750**	**600**	**525**		**75**	**60**	**53**	
2 or more….	1…………….	**900**	**720**	**630**		**75**	**60**	**53**	
2 or more….	2 or more….	**900**	**720**	**630**		**100**	**80**	**70**	
1…………….	2 or more….	**750**	**600**	**525**		**100**	**80**	**70**	

[a] **Basic minimum hourly volume**

[b] **Used for combination of Condition A and B after adequate trial of other remedial measures.**

[C] **May be used when the major street speed exceeds 40 mph(70km/h) or in an isolated community with a population of less than 10,000.**

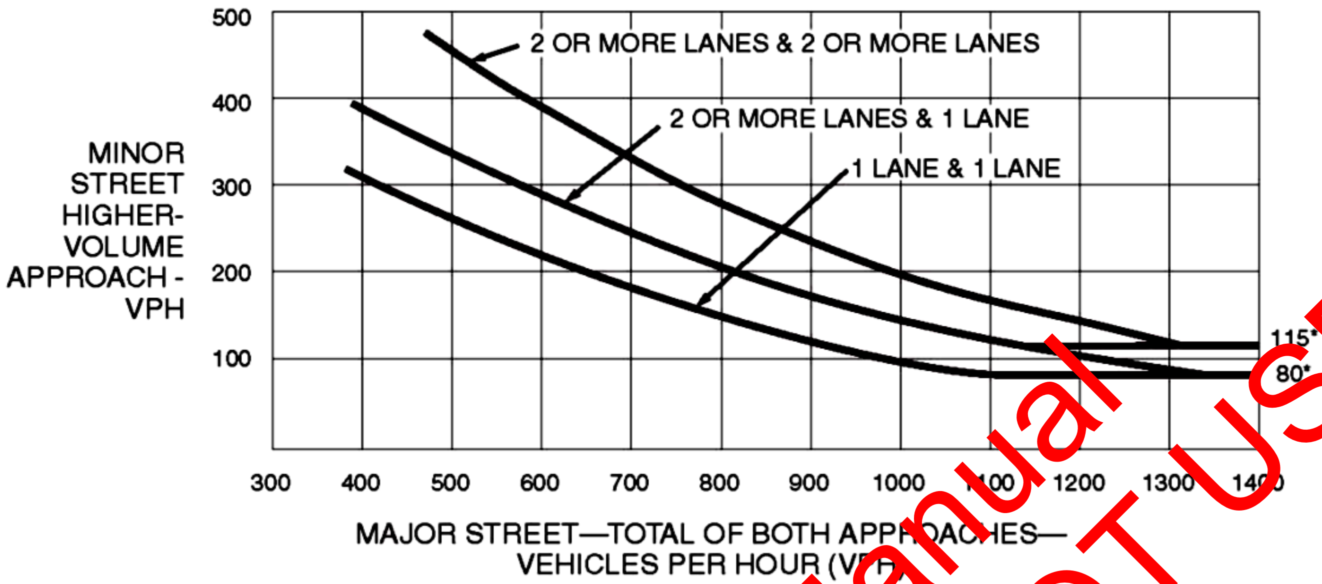
Accident Reduction Table for Warrant 1: Eight-Hour Vehicular Volume

Condition A – Minimum Vehicular Volume															
		MAJOR STREET VOLUMES							**MINOR STREET VOLUMES**						
Number of Lanes for moving traffic on each approach		**Vehicles per hour on major street (total of both approaches)**							**Vehicles per hour on higher volume minor-street approach (one direction only)**						
Major Street	**Minor Street**	100% a	96% b	92% c	88% d	84% e	80% f	70% g	100% a	96% b	92% c	88% d	84% e	80% f	70% g
1………..	**1………..**	500	480	460	440	420	400	350	150	144	138	132	126	120	105
2 or more	**1……….**	600	576	552	528	504	480	420	150	144	138	132	126	120	105
2 or more	**2 or more**	600	576	552	528	504	480	420	200	192	184	176	168	160	140
1……….	**2 or more**	500	480	460	440	420	400	350	200	192	184	176	168	160	140

Condition B – Interruption of Continuous Traffic															
		MAJOR STREET VOLUMES							**MINOR STREET VOLUMES**						
Number of Lanes for moving traffic on each approach		**Vehicles per hour on major street (total of both approaches)**							**Vehicles per hour on higher volume minor-street approach (one direction only)**						
Major Street	**Minor Street**	100% a	96% b	92% c	88% d	84% e	80% f	70% g	100% a	96% b	92% c	88% d	84% e	80% f	70% g
1………..	**1………..**	750	720	690	660	630	600	525	75	72	69	66	63	60	53
2 or more	**1……….**	900	864	828	762	756	720	630	75	72	69	66	63	60	53
2 or more	**2 or more**	900	864	828	792	756	720	630	100	96	92	88	84	80	70
1……….	**2 or more**	750	720	690	660	630	600	525	100	96	92	88	84	80	70

aAbsolute minimum hourly volume
b4% reduction for 1 preventable accident
c8% reduction for 2 preventable accidents
d12% reduction for 3 preventable accidents
e16% reduction for 4 preventable accidents
f20% traffic volume reduction for 5 preventable accidents
g30% traffic volume reduction may be used when the 85th percentile major street speed exceeds 40 mph (70 km/h) or in an isolated community with a population of less than 10,000.

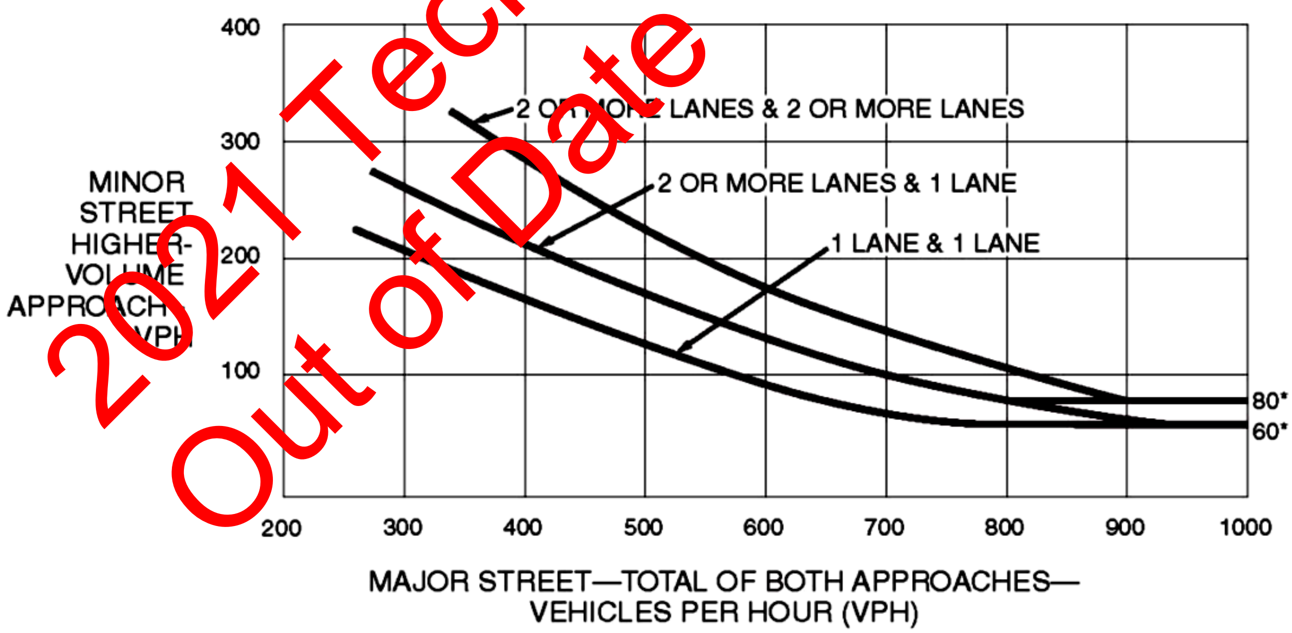
Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume



*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4C-2. Warrant 2, Four-Hour Vehicular Volume (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



*Note: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

WARRANT 3, PEAK HOUR:

WARRANT # 3 condition A

Total volume for intersection W/3 Approaches = 650 or more VPH (   )
Total volume for intersection W/4 Approaches = 800 or more VPH (   )
Higher Minor Approach W/1 Lane = 100 or more VPH (   )
Higher Minor Approach W/2 Lane = 150 or more VPH (   )

INTERSECTION DELAY STUDY

TOTAL DELAY = TOTAL VEHICLES STOPPED X SAMPLING INTERVAL

= ____________ X 15 = _________________Veh. Sec.

AVERAGE DELAY PER APPROACH VEHICLE = $\frac{\text{TOTAL DELAY}}{\text{APPROACH VOLUME}}$ = ______________

= ___________________ Sec.

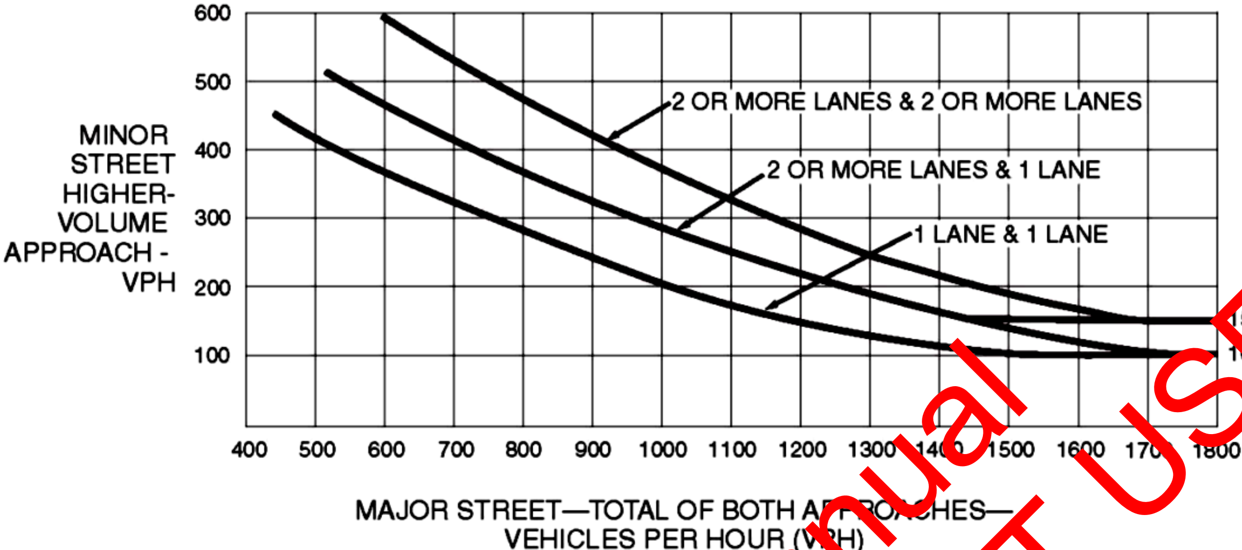
AVERAGE DELAY FOR WARRANT 3 = AVERAGE DELAY XPEAK HOUR VOLUME FROM MACHINECOUNTS

= _________________ X __________________

= _________________ Veh. -Sec.

NOTE:
The above information will be used for Warrant 3 – Peak Hour analysis.

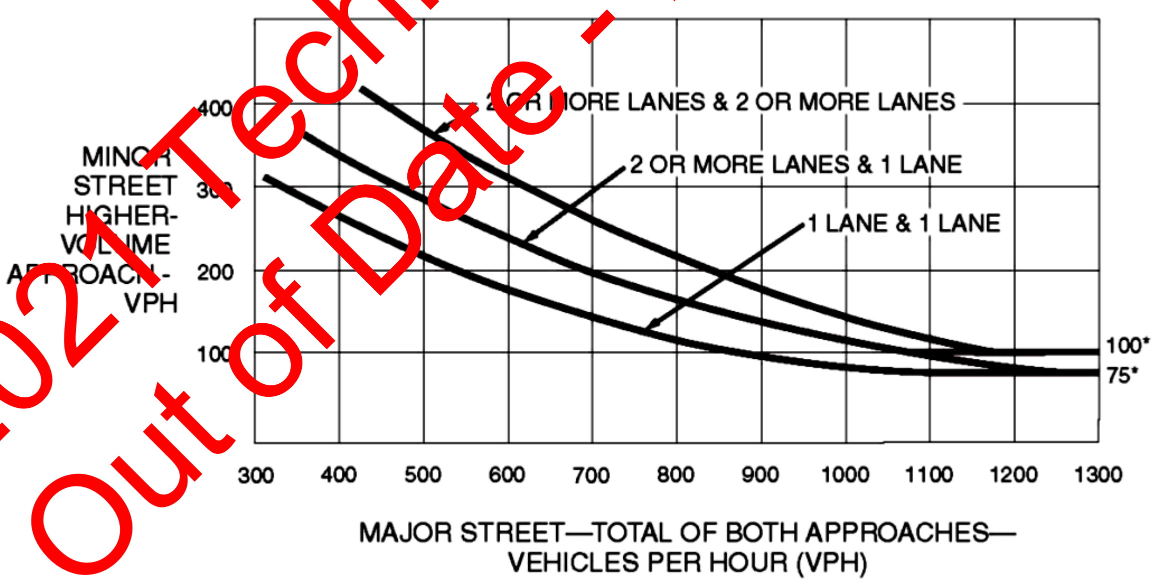
Figure 4C-3. Warrant 3, Peak Hour



*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4C-4. Warrant 3, Peak Hour (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



*Note: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4C-5. Warrant 4, Pedestrian Four-Hour Volume

*Note: 107 pph applies as the lower threshold volume.

Figure 4C-6. Warrant 4, Pedestrian Four-Hour Volume (70% Factor)

*Note: 75 pph applies as the lower threshold volume.

Warrant #4 - Peak Hour Pedestrian Factor Tables

Figure 4C-7, Warrant 4, Pedestrian Peak Hour (100% Factor)

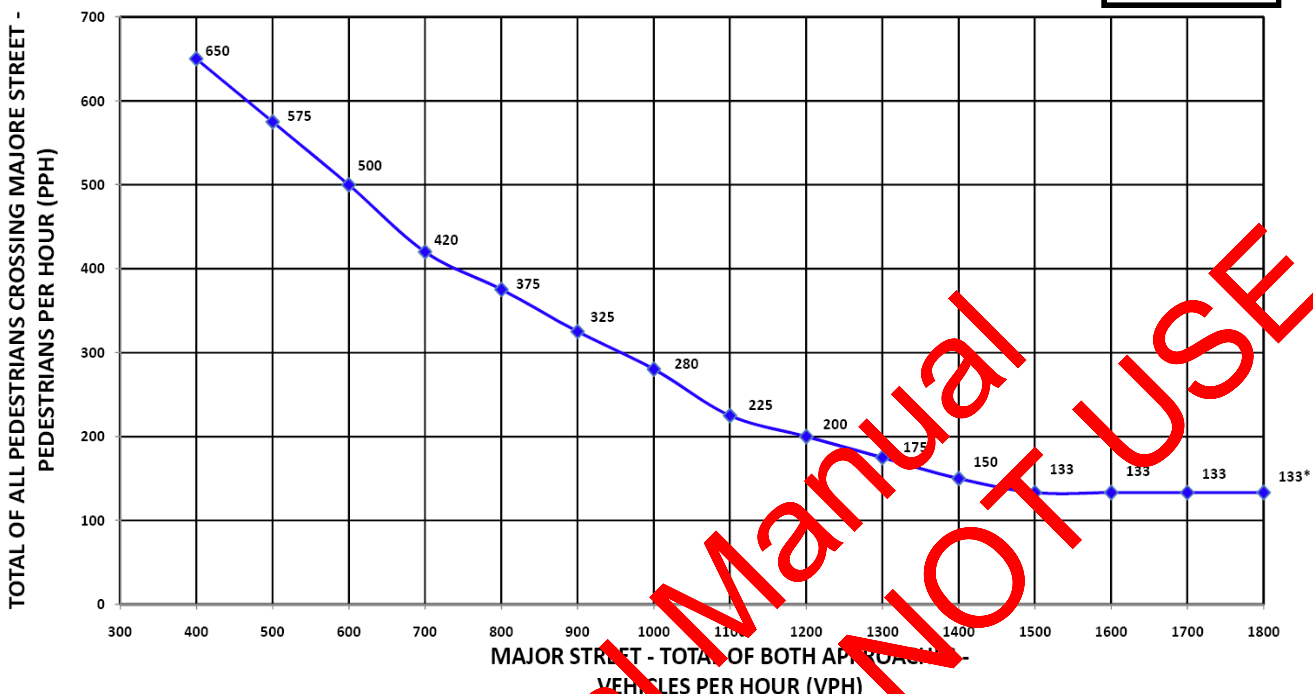
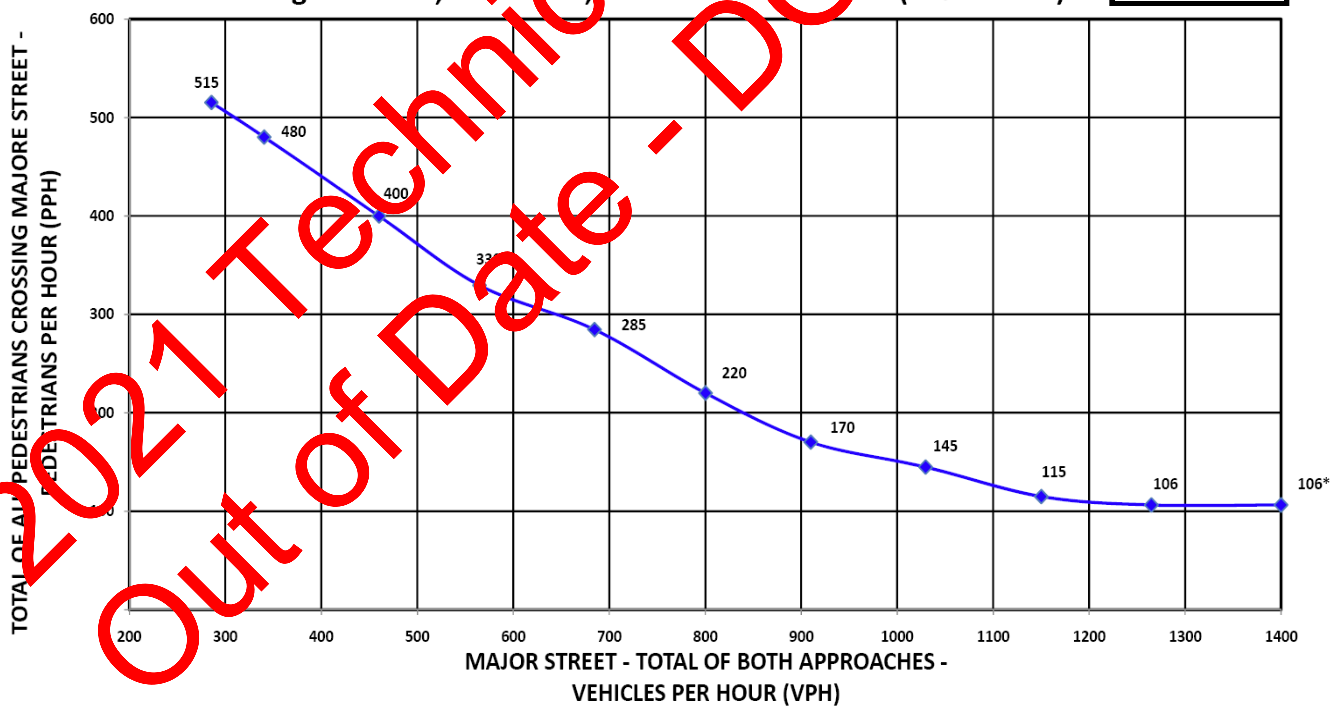
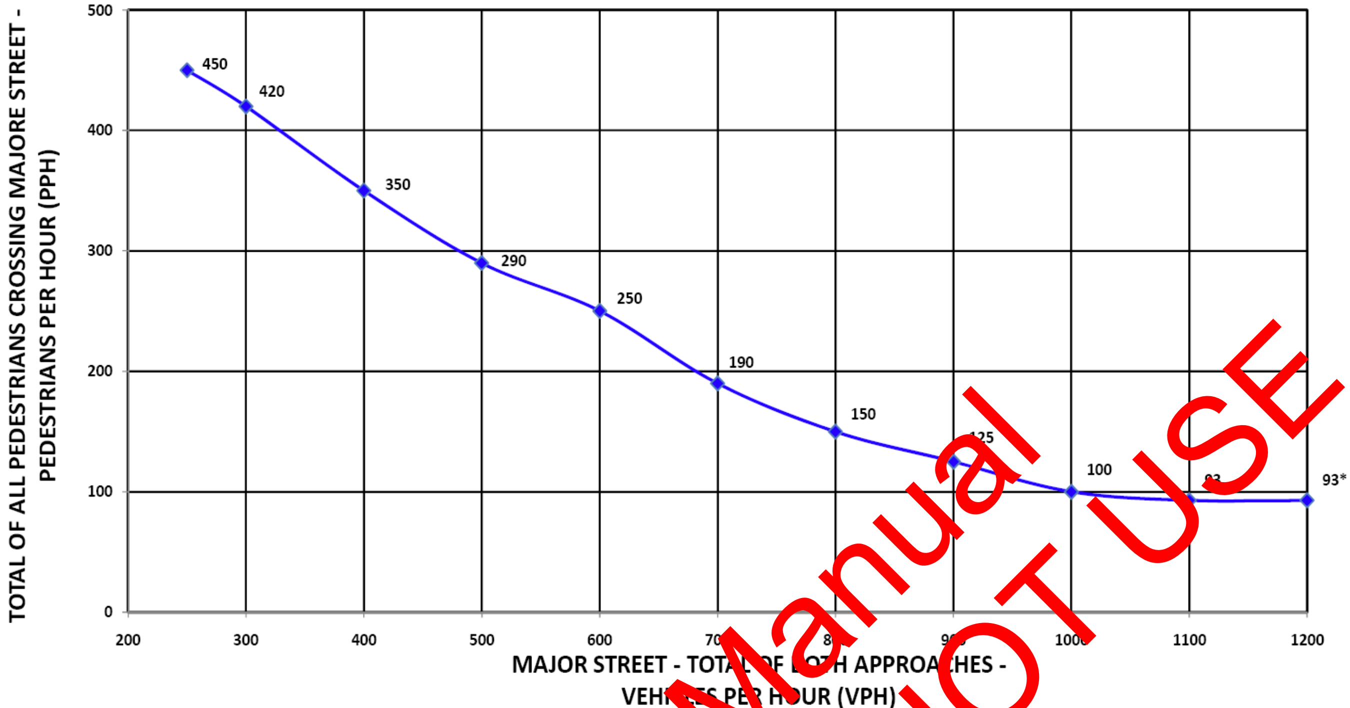


Figure 4C-7a, Warrant 4, Pedestrian Peak Hour (80% Factor)



The 80% factor graph shall be used for intersections having 1-2 preventable crashes in a 12-month period.

Figure 4C-7b, Warrant 4, Pedestrian Peak Hour (70% Factor)



The 70% factor graph shall be used for intersections having 3-5 preventable crashes in a 12-month period or if the 85th percentile speed on the major street exceeds 35 mph.

Figure 4C-7c, Warrant 4, Pedestrian Peak Hour (60% Factor)

The 60% factor graph shall be used for intersections having at least 1 preventable crash and 1 KSI in a 12-month period or more than 5 preventable crashes in a 12-month period.

Figure 4C-7d, Warrant 4, Pedestrian Peak Hour (50% Factor)

The 50% factor graph shall be used if the 15th-percentile crossing speed of pedestrians is less than 3.5 fps or if 15% of the crossing population is school children and/or senior pedestrians.

SECTION 4C.05 WARRANT 4, PEDESTRIAN VOLUME

Support:

01 The Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street.

Standard:

02 **The need for a traffic control signal at an intersection or midblock crossing shall be considered if an engineering study finds that one of the following criteria is met:**

A. For each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) all fall above the curve in Figure 4C-5; or

B. For 1 hour (any four consecutive 15-minute periods) of an average day, the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) falls above the curve in any of Figure 4C-7, 4C-7a, 4C-7b¸4C-7c & 4C-7d.

Option:

03 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 35 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000,Figure 4C-6 may be used in place of Figure 4C-5 to evaluate Criterion A in Paragraph 2, and Figure 4C-8 may be used in place of Figure 4C-7 to evaluate CriterionB in Paragraph 2.

WARRANT 5, SCHOOL CROSSING:

Section 4C.06 Warrant 5, School Crossing

The School Crossing signal warrant is intended for applications where the fact that Schoolchildren cross the major street is the principal reason to consider installing a traffic control signal.

The word "Schoolchildren" includes elementary through High School students

The need for a traffic control signal shall be considered when an engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of school children at an established school crossing across the major street shows that the number of adequate gaps in the traffic stream during the period when the school children are using the crossing is less than the number of minutes in the same period and there are a minimum of 20 Schoolchildren during the highest crossing hour.

School Crossing Warrant (California Warrant):

The School Crossing Warrant (Warrant# 5) as contained in the federal Manual on Uniform Traffic Control Devices (MUTCD) is dependent on the frequency and adequacy of gaps in the traffic stream. At certain intersections with designated school crosswalks, gaps cannot be measured due to the presence of a school crossing guard, all way stop control, or other field conditions.

In such cases, if no other warrant contained in the MUTCD is satisfied, the engineer, upon review of the traffic conditions and physical characteristics of the intersection, can use guidelines outlined in the California Department of Transportation (CALTRANS) Traffic Manual. These guidelines are based on satisfying minimum vehicular and schoolchildren volume requirements. In an urban area, 500 vehicles (total in both directions on the major street) and 100 schoolchildren for each of any two hours (not necessarily consecutive) are required.

California Warrant = A School Crossing with All-Way stop or School Crossing Guard present and 500 vehicles on major street and 100 schoolchildren crossing major street for each of any two hours.

WARRANT 6, COORDINATED SIGNAL SYSTEM:

The need for a traffic control signal shall be considered if an engineering study finds that one of the following criteria is met:

A. On a one-way street or a street that has traffic predominantly in one direction, the adjacent traffic control signals are so far apart that they do not provide the necessary degree of vehicular platooning.

B. On a two-way street, adjacent traffic control signals do not provide the necessary degree of platooning and the proposed and adjacent traffic control signals will collectively provide a progressive operation.

Note: *The Coordinated Signal System signal warrant should not be applied where the resultant spacing of traffic control signals would be less than 300 m (1000 ft).*

WARRANT 7, CRASH EXPERIENCE:

The crash experience signal warrant conditions are intended for applications where the severity and frequency of crashes are the principal reason to consider installing a traffic signal.

The need for a traffic control signal shall be considered if an engineering study finds that all of the following criteria are met:

A. Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency; and

B. One of the following conditions apply to the reported crash history (where each reported crash considered is related to the intersection and apparently exceeds the applicable requirements for a reportable crash):

1. The number of reported angle crashes and pedestrian crashes within a one-year period equals or exceeds the threshold number in Table 4C-2 for total angle crashes and pedestrian crashes (all severities); or

2. The number of reported fatal-and-injury angle crashes and pedestrian crashes within a one-year period equals or exceeds the threshold number in Table 4C-2 for total fatal-and-injury angle crashes and pedestrian crashes ; or

3. The number of reported angle crashes and pedestrian crashes within a three-year period equals or exceeds the threshold number in Table 4C-3 for total angle crashes and pedestrian crashes (all severities); or

4. The number of reported fatal-and-injury angle crashes and pedestrian crashes within a three-year period equals or exceeds the threshold number in Table 4C-3 for total fatal-and-injury angle crashes and pedestrian crashes; and

C. For each of any 8 hours of an average day, the vehicles per hour (VPH) given in both of the 80 percent columns of Condition A or the VPH in both of the 80 percent columns of Condition B exists on the major-street and the higher-volume minor-street approach, respectively, to the intersection, or the volume of pedestrian traffic is not less than 80 percent of the requirements specified in the Pedestrian Volume warrant. These major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be onthe same approach during each of the 8 hours.

D. Crash experience should be applied when the resultant spacing of Traffic Control Signal would be 300ft or less & there are more preventable crashes as per table 4C-2 & 4C-3 below.

Table 4C-2. Minimum Number of Reported Crashes in a One Year Period

Urban Area					
Number of through lanes on each approach		Total of Angle and Pedestrian Crashes (all severities)[a]		Total of Fatal-and -Injury Angle And Pedestrian Crashes[a]	
Major Street	Minor Street	Four legs	Three Legs	Four Legs	Three Legs
1	1	5	4	3	3
2 or more	1	5	4	3	3
2 or more	2 or more	5	4	3	3
1	2 or more	5	4	3	3
Rural Area[b]					
Number of through lanes on each approach		Total of Angle and Pedestrian Crashes (all severities)[a]		Total of Fatal-and -Injury Angle And Pedestrian Crashes[a]	
Major Street	Minor Street	Four legs	Three Legs	Four Legs	Three Legs
1	1	4	3	3	3
2 or more	1	10	9	6	6
2 or more	2 or more	10	9	6	6
1	2 or more	4	3	3	3

[a]Angle crashes include all crashes that occur at an angle and involve one or more vehicles on the major streetand one or more vehicles on the minor street

[b]"Rural Area" value apply to intersections where the major-street speed exceeds 40 mph or intersections located in an isolated community with a population of less than 10,000.

Table 4C-3. Minimum Number of Reported Crashes in a Three Year Period

Urban Area					
Number of through lanes on each approach		Total of Angle and Pedestrian Crashes (all severities)[a]		Total of Fatal-and -Injury Angle And Pedestrian Crashes[a]	
Major Street	Minor Street	Four legs	Three Legs	Four Legs	Three Legs
1	1	6	5	4	4
2 or more	1	6	5	4	4
2 or more	2 or more	6	5	4	4
1	2 or more	6	5	4	4
Rural Area[b]					
Number of through lanes on each approach		Total of Angle and Pedestrian Crashes (all severities)[a]		Total of Fatal-and -Injury Angle And Pedestrian Crashes[a]	
Major Street	Minor Street	Four legs	Three Legs	Four Legs	Three Legs
1	1	6	5	4	4
2 or more	1	16	13	9	9
2 or more	2 or more	16	13	9	9
1	2 or more	6	5	4	4

[a]Angle crashes include all crashes that occur at an angle and involve one or more vehicles on the major streetand one or more vehicles on the minor street

[b]"Rural Area" value apply to intersections where the major-street speed exceeds 40 mph or intersections located in an isolated community with a population of less than 10,000.

Section 4C.09 Warrant 8, Roadway Network:

01 Installing a traffic control signal at some intersections might be justified to encourage concentration and organization of traffic flow on a roadway network.

Standard:

02 The need for a traffic control signal shall be considered if an engineering study finds that the common intersection of two or more major routes meets one or both of the following criteria:

A. The intersection has a total existing, or immediately projected, entering volume of at least 1,000 vehicles per hour during the peak hour of a typical weekday and has 5-year projected traffic volumes, based on an engineering study, that meet one or more of Warrants 1, 2, and 3 during an average weekday; or

B. The intersection has a total existing or immediately projected entering volume of at least 1,000 vehicles per hour for each of any 5 hours of a non-normal business day (Saturday or Sunday).

03 A major route as used in this signal warrant shall have at least one of the following characteristics:

A. It is part of the street or highway system that serves as the principal roadway network for through traffic flow.

B. It includes rural or suburban highways outside, entering, or traversing a city.

C. It appears as a major route on an official plan, such as a major street plan in an urban area traffic and transportation study.

Section 4C.10 Warrant 9, Intersection Near a Grade Crossing:

Support:

01 The Intersection near a Grade Crossing signal warrant is intended for use at a location where none of the conditions described in the other eight traffic signal warrants are met, but the proximity to the intersection of a grade crossing on an intersection approach controlled by a STOP or YIELD sign is the principal reason to consider installing a traffic control signal.

Guidance:

02 This signal warrant should be applied only after adequate consideration has been given to other alternatives or after a trial of an alternative has failed to alleviate the safety concerns associated with the grade crossing. Among the alternatives that should be considered or tried are:
A. Providing additional pavement that would enable vehicles to clear the track or that would provide space for an evasive maneuver, or
B. Reassigning the stop controls at the intersection to make the approach across the track a non-stopping approach.

Standard:

03 The need for a traffic control signal shall be considered if an engineering study finds that both of the following criteria are met:

A. A grade crossing exists on an approach controlled by a STOP or YIELD sign and the center of the track nearest to the intersection is within 140 feet of the stop line or yield line on the approach; and

B. During the highest traffic volume hour during which rail traffic uses the crossing, the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the minor-street approach that crosses the track (one direction only, approaching the intersection) falls above the applicable curve in Figure 4C-9 or 4C-10 for the existing combination of approach lanes over the track and the distance D, which is the clear storage distance as defined in Section 1A.13.

Guidance:

04 The following considerations apply when plotting the traffic volume data on Figure 4C-9 or 4C-10:

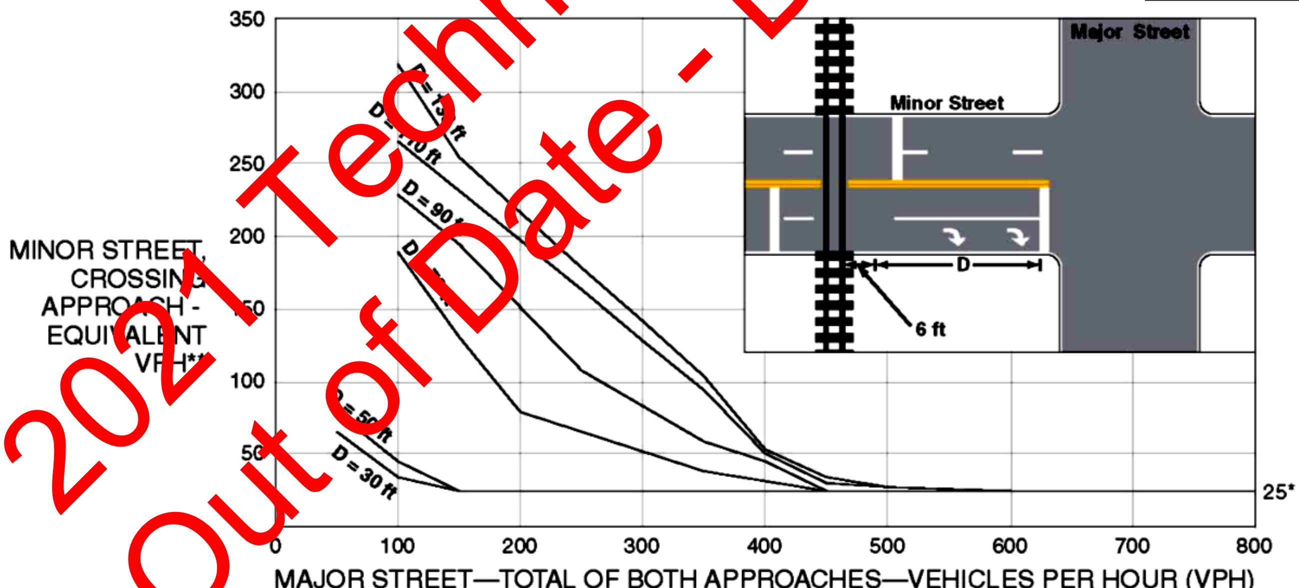
A. Figure 4C-9 should be used if there is only one lane approaching the intersection at the track crossing location and Figure 4C-10 should be used if there are two or more lanes approaching the intersection at the track crossing location.

Figure 4C-9. Warrant 9, Intersection Near a Grade Crossing (One Approach Lane at the Track Crossing)

* 25 vph applies as the lower threshold volume

** VPH after applying the adjustment factors in Tables 4C-2, 4C-3, and/or 4C-4, if appropriate

Figure 4C-10. Warrant 9, Intersection Near a Grade Crossing (Two or More Approach Lanes at the Track Crossing)



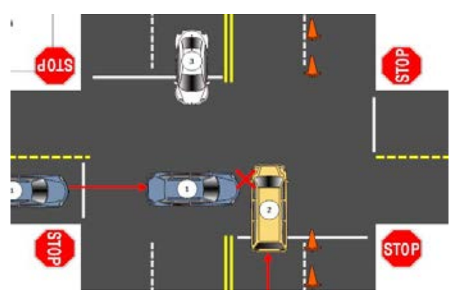
* 25 vph applies as the lower threshold volume

** VPH after applying the adjustment factors in Tables 4C-2, 4C-3, and/or 4C-4, if appropriate

Attach all relevant crash reports and summaries

(Pedestrians hit by Vehicles crossing Major, Right Angle, and Left-Turn Crashes)

FOR A SAFER NYC
SPEED LIMIT 25
VISION ZERO



Prepared by: M. Rahman - 03/04/2015 – Updated- 7/10/2018

NEW YORK CITY
DEPARTMENT OF TRANSPORTATION
TRAFFIC OPERATIONS

Left Turn Signal Survey Sheet

Borough: ______________________ **Log #:** __________ **Ref. #:** __________

Location: ______________________ **CB #:** __________

Requestor: ______________________ **Investigator:** ______________________

Date Completed: ______________________

Date: __________

Time: __________

Peak Hour
Traffic Volume Counts

VPH

Signal Timing	D1	D2	D3	D4
Green				
Yellow				
All Red				
Cycle Length:				Seconds

T/S ft.

ft. T/S →

D1 D2 D3 D4

VPH

VPH ft.

← T/S ft.

T/S = Traffic Signal

VPH = Vehicles / Hour
(Total of the four 15 minute periods)

Total Number of Lanes
(including Left Turn Bays)

D1 ☐ D3 ☐

D2 ☐ D4 ☐

ft. T/S ↓

VPH

← ft. →

Street Name

Street Name

1. Separate movement with solid line.
2. Separate shared movements with dashed line.
3. Indicate ped column with solid line.
4. Indicate movements with arrow and label as follows: L (left); T(thru); R(right); Ped (ped); U(u-turn); I (illegal) or other and specify.

Engineer: ______________________ **Date:** __________

Reviewed ☐ ______________________ **Date:** __________ **Satisfied** ☐

Recommended ☐ ______________________ **Date:** __________ **Warrant #** ☐

Denied ☐ ______________________ **Date:** __________ **Not Satisfied** ☐

NEW YORK CITY
DEPARTMENT OF TRANSPORTATION
TRAFFIC OPERATIONS

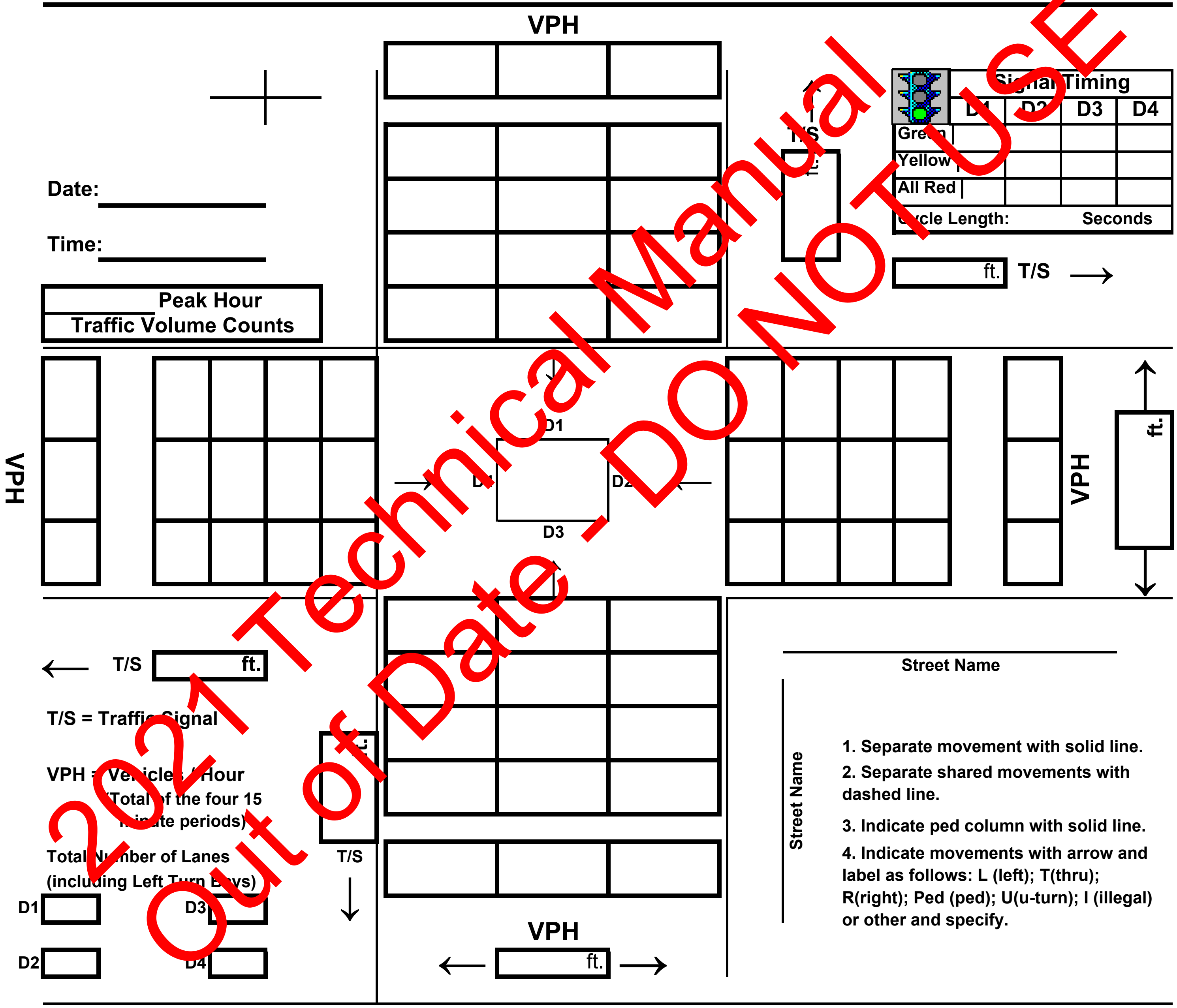
Left Turn Signal Survey Sheet

Borough: ______________________ Log #: __________ Ref. #: __________

Location: ______________________________ CB #: __________

Requestor: ______________________ Investigator: ______________________

Date Completed: ______________________



1. Separate movement with solid line.
2. Separate shared movements with dashed line.
3. Indicate ped column with solid line.
4. Indicate movements with arrow and label as follows: L (left); T(thru); R(right); Ped (ped); U(u-turn); I (illegal) or other and specify.

Engineer: ______________________ Date: __________

Reviewed ☐ ______________________ Date: __________ Satisfied ☐

Recommended ☐ ______________________ Date: __________ Warrant # ☐

Denied ☐ ______________________ Date: __________ Not Satisfied ☐

NEW YORK CITY
DEPARTMENT OF TRANSPORTATION
TRAFFIC OPERATIONS

Left Turn Signal Warrant Sheet

WARRANT 1 (Accident Experience)

Satisfied ☐
Not Satisfied ☐

This Warrant is satisfied when a minimum of 5 related left turn accidents exist in the latest 12 month period in which accident records are available.

Year	Total Accidents	Left Turn Accidents

Accident sheets must be attached.

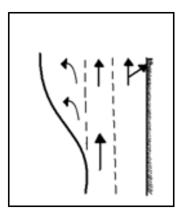
WARRANT 2 (Left Turn Capacity)

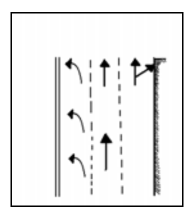
Satisfied ☐
Not Satisfied ☐

This Warrant is satisfied when for the analyzed direction the Left-Turn flow rate exceeds the left-turn capacity.
The left-turn capacity is the maximum flow rate that may be assigned to the designated phase.

– **On approaches with exclusive left-turn bays / lanes, the left-turn capacity is computed by using the following equations:**

(1A) $C_{ELT} = (1{,}400 - V_O)\,(g/c)_{LT}$


Exclusive Left-Turn Bay


Exclusive Left –Turn Lane

Or

(2) C_{ELT} = 2 vehicles per signal cycle

where:

C_{ELT} = capacity of the left-turn protected / permitted phase, in vph;

V_O = opposing thru plus right-turn service flow rate*, in vph, and

$(g/c)_{LT}$ = effective green** ratio for the protected / permitted phase, in seconds.

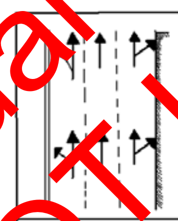
*Service flow rate is the equivalent hourly rate at which vehicles pass a roadway during a given time interval less than one hour, usually 15 minutes.

Service flow rate = (highest 15 minute count) x 4.

**Effective green time is the time during a given phase that is effectively available to the permitted movements: this is generally taken to be the green time (G) plus the change interval (Y + AR) minus the lost time (3.0 seconds) for the designated phase.

On approaches with <u>shared left-turn and thru vehicles</u>, the left-turn capacity is computed by using the following equations:

(1B) $C_{SLT} = [\,(1{,}400 - V_O)\,(g/c)_{LT}\,]\,f_{SLT}$



Shared Lanes

Or

(2) C_{SLT} = 2 vehicles per signal cycle

where:

C_{SLT} = capacity of the left-turn in the shared lane, in vph:

f_{SLT} = adjustment factor for left-turn vehicles

The adjustment factor basically accounts for the fact that the left-turn movements cannot be made at the same saturation flow rates as thru movements. They consume more of the available green time, and consequently more of the intersection's available capacity.

The adjustment factor is computed as the ratio of the left-turn flow rate (which is converted to an approximate equivalent flow of thru vehicles) to the thru vehicles that share the same lane.

The following TABLE 1 may be used to convert the left-turn vehicles to equivalent thru vehicles.

TABLE 1			
TOTAL OPPOSING FLOW RATE (V_O)	CONVERSION FACTOR (f_{pce})	TOTAL OPPOSING FLOW RATE (V_O)	CONVERSION FACTOR (f_{pce})
0 – 200	1.50	1001 – 1050	5.00
201 – 500	2.00	1051 – 1075	5.50
501 – 700	2.50	1076 – 1100	6.00
701 – 800	3.00	1101 – 1125	6.50
801 – 900	3.50	1126 – 1145	7.00
901 – 950	4.00	> 1146*	
951 - 1000	4.50		

*Use exclusive Left-Turn lane procedure.

Comments:____

COMPUTATIONS
EXCLUSIVE LEFT-TURN LANE

Opposing Thru Plus Right Turn Service Flow Rate

V_O = (highest 15 minute count) x 4

V_O = ______ x 4 = ______ vph

Left Turn Service Flow Rate (Direction analyzed for Left-Turn Phase)

V_{LT} = (highest 15 minute count) x 4

V_{LT} = ______ x 4 = ______ vph

Left Turn Capacity

$$C_{ELT} = (1{,}400 - V_O)\,(g/c)_{LT}$$

where:

$g = [\,G + Y + AR - 3.0\,] \times f_q{}^{*}$ = ______ x ______ = ______ seconds

* Adjustment factor used to calculate the portion of the green phase that is not blocked by an opposing queue of vehicles. The fq factor is given for each case in TABLE 2.

c = cycle length = ______ seconds

thus, $(g/c)_{LT}$ = ______

TABLE 2	
OPPOSING THRU LANES	f_q
1	.85
2	.90
$\geq$ 3	.95

and

C_{ELT} = (1400 – ______) (______)$_{LT}$ = ______ vph

or

C_{ELT} = 2 vehicles per signal cycle

$C_{ELT} = 2 \times (3600 \div C)$ = ______ vph

V_{LT} = ______ vph	>	or	<	$C_{ELT}{}^{**}$ = ______ vph

**Select the highest left turn capacity

- If V_{LT} (Left turn service flow rate) is greater than (>) the C_{ELT} (left turn capacity), the Warrant is satisfied and a left turn phase is needed.
- If V_{LT} is less then (<) the C_{ELT} the Warrant is not satisfied because the signal and geometric design can accommodate the left turn volume at the intersection.

COMPUTATIONS
SHARED LEFT-TURN / THRU LANE

Adjustment Factor for Left-Turn Vehicles
(Opposing Thru Plus Right Turn Service Flow Rate)

V_O = (highest 15 minute count) x 4

V_O = ______ x 4 = ______ vph

Using TABLE 1, f_{PCE} = ______

V_{TV} = ______ x 4 = ______ vph

where: V_{TV} = Thru vehicles in the shared lane.

Left Turn Service Flow Rate
(Direction analyzed for Left-Turn Phase)

V_{LT} = (highest 15 minute count) x 4

V_{LT} = ______ x 4 = ______ vph

$V_{PCE} = V_{LT} \times f_{PCE}$ = ______ x ______ = ______ vph

$f_{SLT} = V_{PCE} \div (V_{TV} + V_{PCE})$ = ______ ÷ (______ + ______) = ______

TABLE 2	
OPPOSING THRU LANES	f_q
1	.85
2	.90
≥ 3	.95

Left Turn Capacity

$C_{SLT} = [(1{,}400 - V_O) (g/c)_{LT}] \; f_{SLT}$

where:

$g = [G + Y + AR - 3.0] \times f_q$ = ______ x ______ = ______ seconds

c = cycle length = ______ seconds thus, $(g/c)_{LT}$ = ______

and C_{SLT} = [(1400 - ______) (______ $)_{LT}$] x ______ = ______ vph

or

C_{SLT} = 2 vehicles per signal cycle

$C_{SLT} = 2 \times (3600 \div C)$ = ______ vph

V_{LT} = ______ vph | > | or | < | C_{SLT}* = ______ vph

*Select the highest left turn capacity

-If V_{LT} (Left turn service flow rate) is greater than (>) the C_{SLT} (left turn capacity), the Warrant is satisfied and a left turn phase is needed.

-If V_{LT} is less then (<) the C_{SLT}, the Warrant is not satisfied because the signal and geometric design can accommodate the left turn volume at the intersection.

SHARED LEFT TURN ANALYSIS COMPUTATION SHEET

Access computation sheet here.

EXCLUSIVE LEFT TURN ANALYSIS COMPUTATION SHEET

Access computation sheet here.

GUIDELINES FOR INTERSECTION ANALYSIS AND PROPOSED IMPROVEMENTS/MITIGATIONS

Part A of this memorandum provides the New York City Department of Transportation's guidance for intersection level-of-service (LOS) analysis to reflect prevailing traffic operational conditions when using the Highway Capacity Software (HCS) or Synchro. Part B provides guidelines for proposed improvement or mitigation measures.

A. Intersection Level-of-Service Analysis

This section provides guidance for input values for LOS analysis using HCS or Synchro and describes how to handle situations that HCS and Synchro do not directly address (such as turn bay spillback, and double parking). Some of the guidance provides leeway for changing default values (i.e., Base Saturation Flow Rate, Start-up Lost Time, Extension of Green, Lane Utilization, and Arrival Type) in order to calibrate the LOS analysis to field observed conditions. Before making any modifications to the HCS or Synchro default factors, input values, including traffic volumes, peak hour factor (PHF), heavy vehicle percentage, number of parking maneuvers, bus blockages, conflicting pedestrians, lane utilization, signal timing/offset, etc. should be verified. Adjustment to the default values should be applied when the LOS analysis results do not reflect prevailing traffic operations. Some common causes are:

- the volume-to-capacity (v/c) ratio for a lane group exceeds 1.05 under the existing conditions for ***volumes that are actually processed in the field***;
- queue spillback, due to downstream congestion or insufficient turn-bay storage length, impedes the traffic volumes to be processed; and/or
- the LOS analysis needs to be calibrated to reflect actual field conditions based on field-verified/quantified information (i.e., double/illegal parking, unmet demand, delays, queue lengths, travel speeds, etc.).

Once the LOS analysis for existing conditions is calibrated and validated following the guidelines described below, ***no further modifications shall be made to calibrated and/or default values for any future conditions analyses.***

Traffic Volumes

If traffic volumes between adjacent intersections are not balanced, all sinks and sources must be identified and described. NYC DOT recommends the use of video technology in collecting turning movement and vehicle classification counts, as well as pedestrian counts. Video technology provides opportunity to review and verify previously-collected data if turning movement counts are not in agreement with Automatic Traffic Recorder (ATR) counts. Given the unreliability of ATR counts under congested conditions and potential discrepancies between ATR and video/manual turning movement counts, care must be exercised in using ATR counts to develop and balance traffic flows.

ATRs and Standing or Queued Vehicles
Oftentimes, queued or standing vehicles are not adequately reflected in ATR counts, producing low traffic volumes which, if not properly accounted for, contribute to a favorable level-of-service when the opposite exists. Vehicle queues should be observed and documented at congested locations and should be reflected in the LOS analysis.

Downstream Congestion
Many times, delay experienced at an intersection is not due to the signal at that particular intersection, but rather is due to downstream congestion spilling back into the subject intersection. Evidence of this is when vehicles cannot be processed even though the signal is green, because the downstream block is filled and vehicles have "nowhere to go." This could be caused by downstream signals at major cross streets that are bottlenecks (due to multiple signal phases and/or reduced green times), or when multiple lanes must merge downstream as they approach bridges, tunnels or highways.

When this situation occurs, HCS is not an appropriate tool, because, as stated in the *Highway Capacity Manual*, its methods do not account for downstream congestion of this type. Synchro employs methods that attempt to model this using "queue delay," but experience in New York City has shown that these results are often unrealistic. Therefore, HCS and Synchro are not recommended as modeling tools for this type of situation. Instead, more sophisticated traffic simulation modeling software (in consultation with NYC DOT) should be used to account for the effects of downstream congestion. The simulation model network must extend into the bottleneck that is the source of the congestion for upstream intersections under study.

Volume vs. Demand
When a lane group is over capacity, not all of the traffic that arrives at the intersection gets processed, and queues develop. The volume that does not get processed is referred to as unmet demand. HCS and Synchro models give proper results only when all the volume that arrives at the intersection is entered, including not just the processed volume, but also the unmet demand. Queuing observations must be conducted in the field to determine the unmet demand, which may also be determined from volume imbalances between intersections with no sinks or sources.

For intersections that are over capacity, interim HCS or Synchro runs can be used to determine if the model needs additional calibration. For these interim runs, only the processed volume is entered. The v/c ratios for lane groups that are known to be over capacity should be close to 1.0 when only the processed volume is entered. If the v/c ratio is greater than 1.05, then calibration is necessary, using the guidelines provided below, to bring v/c ratio close to 1.0. Please note that the *CEQR Technical Manual* allows for a maximum (calibrated) existing v/c ratio of 1.05 for volumes that are actually processed.

Once the model is calibrated for interim runs when only processed volume is entered, then the final run is performed with the entire arrival demand entered, including processed volume plus unmet demand. The output from this run is what shall be reported, ***which may result in a v/c ratio greater than 1.0.***

Peak Hour Factor (PHF)

To guard against the use of unreasonably low PHFs under the existing condition that may not reflect the typical field conditions, the following formula should be used to calculate a minimum PHF to be compared against the field calculated PHF:

$$PHF_{minimum} = 0.8033 * 1.000083 \wedge Volume$$
$$1 \leq Volume \leq 2300$$

The attached Excel file can be used to automatically calculate the minimum PHF. The minimum PHF should only be used if the field-calculated PHF is lower than the minimum PHF as described below.

$$PHF = Max\{PHF_{field}, PHF_{minimum}\}$$

Where:
PHF_{field} = Field-calculated PHF
$PHF_{minimum}$ = Minimum PHF based on formula above

Note: Approximately 642,900 records of raw ATR counts from NYC DOT's Traffic Information Management System were used to develop the minimum PHF formula above. Empirical distribution functions for PHF, with respect to volume, were created from this data. The tenth-percentile PHF, which represents a lower bound, was determined for each volume interval. Non-linear regression was used to determine the relationship between one explanatory variable (volume), and the resulting dependent variable (PHF). The model has an $R^2 = 0.94$.

The use of PHF lower than the minimum is permitted if it is associated with adjacent land uses with defined shift/schedule changes or other significant traffic peaking characteristics (e.g., schools, manufacturing/industrial uses, construction sites, sporting event or concert venues, etc.) during the analysis period.

HCS 2010 and higher versions require the use of a single PHF for the entire intersection, as opposed to previous versions that use a PHF for each movement. ***For these higher versions, the above guidelines should be applied to each movement volume before estimating a weighted PHF.***

Parking Maneuvers

The Parking Maneuvers is to be checked only for lane groups adjacent to the parking lane and within 250 feet upstream of the crosswalk. The default number of parking maneuvers per hour in HCS is 20. This is an appropriate number for an area with high parking turnover. However, care must be exercised using this default number of parking maneuvers, because it has significant effect on the adjusted SFR. Therefore, it is recommended that the number of parking maneuvers be based on field-verified/collected information. In absence of the field-data, the following guidelines for determining the number of parking maneuvers may be used:

- Non-metered parking – 0.25 times the number of parking spaces within the 250 feet, and round up.

- Two or more hour metered parking – 0.75 times the number of parking spaces within the 250 feet, and round up.
- One-hour metered parking – 1.5 times the number of parking spaces within the 250 feet, and round up.

Base Saturation Flow Rate

The default value for the Base Saturation Flow Rate (Ideal Saturated Flow in Synchro) is 1,900 passenger cars per hour per lane (pcphpl). This default value may be changed to calibrate to field conditions. The maximum Base SFR, permitted by NYC DOT, is 2,050 pcphpl. Entering a value greater than the maximum permissible Base SFR of 2,050 pcphpl, or lower than the default value of 1,900 pcphpl, should be based on field-verified information and is contingent upon NYC DOT's review and approval. The following sections describe situations where it is appropriate to use a lower Base SFR than the default value.

<u>*Adjustment of Base SFR due to queue spillback from turn bay*</u>

HCS reports queue-to-storage (Q/S) ratio (which can also be estimated using Synchro output information), but does not factor this condition into the analysis. When the Q/S ratio for a turn pocket exceeds 1.0 in existing and/or future conditions, the potential effects of queue spillback into the adjacent through lane can be accounted for by changing the Base SFR of the affected lane-group.

The Base SFR for the affected lane group is calculated using the following equation, which is based on a Poisson probability distribution:

$$\text{Affected Lane Group Base SFR} = \frac{\text{ALISFR}\cdot(\text{No. of Lanes}-1)+(\text{P}\cdot\text{ ALISFR})+(1-\text{P})\cdot\left(\frac{3600}{\text{EGT}}\right)\cdot\left(\frac{\text{SL}}{25}\right)}{\text{No. of Lanes}}$$

Where:

ALISFR: Adjacent lane Base SFR in pcphpl (without blockage)
P: Percent time queue accommodated (based on Poisson distribution with avg. queue)
EGT: Effective green time in seconds
SL: Storage length in feet

For example, if an approach has a left-turn pocket with a storage length of 200 feet, a left-turn queue that is accommodated 31 percent of the time during the analysis period, an effective green time of 71 seconds, and four adjacent through lanes, the adjusted Base SFR for the affected lane group is 1,643 pcphpl:

$$\text{Affected Lane Group Base SFR} = \frac{1900\cdot(4-1)+(.31\cdot 1900)+(1-.31)\cdot\left(\frac{3600}{71}\right)\cdot\left(\frac{200}{25}\right)}{4}$$

The attached Excel file named "Queue Spillback Adjustment" can be used to automatically calculate Base SFR for the affected lane group.

An alternative method for accounting for the effects of queue spillback from a turn bay, which is more appropriate for the existing conditions, is to leverage the Lane Utilization factor. The through lane adjacent to the turn bay with spillover will have lower utilization of through vehicles than the other through lanes in the lane group. Therefore, under existing conditions, it may be easier to count volumes by lane to estimate a Lane Utilization factor.

Double Parking Blocking a Travel Lane
There are no friction factors for double-parking in HCS or Synchro. The duration of double-parked vehicles blocking moving lanes should be recorded in the field and the saturation flow rate should be adjusted accordingly. However, the Area Type (CBD) factor can partially account for double-parking because it reduces the lane-group capacity by 10%, which in many cases is sufficient to account for occasional double-parking for a short duration (such as taxi pick-up/drop-off). On the other hand, double-parking can be so prevalent, and/or for a longer duration, that the lane should not be used as an effective moving lane (such as truck loading/unloading activity). For situations where double-parking occurs under the existing conditions, one of the following four procedures should be followed in accordance with the nature of the lane blockage described above:

- As with queue spillback, a method to account for the effects of double parking is to leverage the Lane Utilization factor. The travel lane adjacent to the parking lane will have lower utilization of processed vehicles due to double parking than the other lanes in the lane group. Therefore, for locations with observed double parking, it is recommended to count volumes by lane to estimate a Lane Utilization factor.
- Convert the duration of double-parking to number of equivalent parking maneuvers, assuming one parking maneuver takes 18 seconds. For example, if a lane is blocked for 15 minutes, this equates to 50 parking maneuvers (i.e., [15 minutes*60 seconds/minute]/18 seconds/maneuver = 50 parking maneuvers).
- A weighted average of the base saturation flow rate may be used. For example, if field conditions indicate that double-parking uses up 1/2 of the capacity of one of three lanes of a lane group, the base saturation flow rate should be entered as (1+1+1/2)/3*1900 = 1583 pcphpl.
- For extreme cases, do not code the lane adjacent to the parking lane as a travel lane.

Please note that double-parking (lane blockage) may affect the operation of upstream intersections/lane-groups and the intersection LOS analysis, including lane configuration (i.e., one of the upstream through lanes due to the downstream lane blockage can be coded as a turn bay), should be adjusted accordingly.

Curbside Travel Lanes Occupied by Standing Vehicles
Caution must be exercised when coding a curbside lane as a travel lane, even though "No Standing" regulations may be present and in effect during the analysis time period. The duration of illegally parked or standing vehicles blocking curbside moving lanes should be recorded in the field and the Base SFR adjusted accordingly. As with double-parking, oftentimes vehicles that illegally stand or park make it unrealistic to code the curbside lane as an effective moving lane. Depending on the severity, the procedure used above

for double-parking in a travel lane may also be used for reducing the Base SFR for curbside lanes (such as coding it as a travel lane, but with a reduced base saturation flow rate). When "No Parking" regulations are in effect, it is usually not appropriate to code the curbside lane as travel lane (even one with reduced capacity), because standing and loading are still permitted and often take place.

Lane Utilization

The Lane Utilization adjustment factor for a lane-group should be closer to 1.0 as demand approaches capacity. On the contrary, if not all lanes are observed to be equally utilized by motorists (for example: far side lane drops, or lanes approaching tunnels or bridges), the appropriate adjustment to Lane Utilization factor should be made to calibrate properly. In addition, as mentioned previously, the Lane Utilization factor may be decreased to account for spillback of a turn bay, double parking, or illegal standing in a curbside travel lane. Any adjustment to the Lane Utilization factor should be based on actual traffic volume data collected on a lane-by-lane basis.

Start-up Lost Time (HCS only)

The HCS default value for Start-up Lost Time is 2.0 seconds. This is sometimes conservative, especially when conditions are at or near capacity, when "jackrabbit" start-ups become prevalent. As a calibration measure, this value may be reduced to as low as 1.0 second, if warranted. Any further decrease to Start-up Lost Time should be supported by field verified/quantified information. On the contrary, any increase to the Start-up Lost Time due to queue spillback from a downstream intersection should be supported by field verified/quantified information.

Extension of Green (HCS only)

The HCS default value for Extension of Green into the yellow interval is 2.0 seconds. This is sometimes conservative, especially when conditions are at or near capacity and aggressive drivers utilize more of the yellow interval. As a calibration measure, this value can be increased to as high as 3.0 seconds, if warranted. Any further increase to Extension of Green time should be supported by field verified/quantified information.

Lost Time Adjustment (Synchro only)

Synchro combines the Start-up Lost Time and the Extension of Green with one Lost Time Adjustment factor, which is 0.0 seconds. Consistent with the preceding two sections, the Lost Time Adjustment factor may be reduced to as low as -2.0 seconds, if warranted. Any further decrease to Lost Time Adjustment should be supported by field verified/quantified information.

Bus Lanes

HCS and Synchro do not model bus lanes. Designated bus-only lanes should be eliminated as through travel lanes from the LOS analysis at intersections, and any associated bus volumes should be removed from the through traffic, and the heavy vehicle percentage should be adjusted accordingly. However, if right-turns are permitted from the bus lane (typically an allowable condition for such lanes), the lane should be incorporated into the LOS analysis as an exclusive right-turn lane.

Bus Blockages

Bus blockages should be applied only where near and/or far side bus stops are present within 250 feet of an intersection and the bus would totally, or partially, block a travel lane. In addition, actual bus dwell-time for the applicable stop should either be field-verified or obtained from NYCT/NYC DOT Transit Development to determine if the default value of 14.4 seconds/bus is an appropriate duration for bus blockage.

The appropriate NYC DOT Divisions (Traffic Engineering & Planning and Transit Development), in coordination with MTA/NYCT, will review the bus dwell-time vs. number of passengers alighting/boarding, if available, to develop an appropriate Bus Blockage factor to be used in LOS analysis. The default bus blockage time of 14.4 seconds per bus is usually not be sufficient to account for deceleration, passenger discharge/pick-up, and acceleration, as well for the adjustment of additional space and its operating capabilities. As a calibration measure, default value of 14.4 seconds per bus should be revised accordingly in HCS. In Synchro, it is not possible to change this value directly; instead the number of bus blockages should be revised. For example, if bus blockage time per bus is determined to be 40 seconds, then the number of bus blockages should multiplied by a factor of 40/14.4 = 2.78.

Heavy Vehicle Percentages (HV%)

The estimated HV% should be based on vehicle classification counts collected concurrently with manual turning movement counts. According to the *Highway Capacity Manual* (HCM): "The heavy-vehicle factor accounts for the additional space occupied by these vehicles and for the difference in operating capabilities of heavy vehicles compared with passenger cars." ***Therefore, all buses—including those that stop at a near-side or far-side bus stop within 250 feet of the stop line, as well as those buses not stopping at bus stops—should be accounted for in the heavy-vehicle percentage*** because these buses occupy additional space in the traffic stream and have different operating capabilities than passenger cars.

Conflicting Pedestrians

The number of conflicting pedestrians crossing at crosswalks should be collected concurrently with manual turning movement counts. In addition, the conflicting pedestrian volumes used for the intersection LOS analysis should be the same as those used in the pedestrian crosswalk analysis. Please note that HCS allows up to 5,000 (Synchro allows up to 3,000) conflicting pedestrians per hour. Arbitrary conflicting pedestrian volumes should not be used under any circumstances.

<u>Pedestrian Walking Speed</u>

Please note that walking speed for pedestrian clearance time is provided on NYC DOT's official signal timing plans and should be used accordingly in the LOS analysis. A walking speed of 3.0 fps should be used (as a conservative assumption for slow walking speeds associated with children, seniors, and other vulnerable street users) if the pedestrian walking speed is not provided on the official signal timing plan. Walking speeds in excess of 3.0 fps should be verified with staff in NYC DOT's Signals Division.

Arrival Type (HCS Only)
The HCS default for Arrival Type is 3, which assumes random vehicle arrivals at the intersection (typically where there is no effective signal coordination). Synchro does not utilize an Arrival Type factor; it uses off-set for signal coordination. The Arrival Type used in all HCS analyses should be applied in accordance with HCM guidelines, and should be considered for each approach to the intersection. Please note that Arrival Type is used in calculating uniform delay and it does not affect the v/c ratio. The use of an Arrival Type higher or lower than 3 in the HCS analysis should be supported by field-verified/quantified information following the HCM guidelines. Favorable progression, which can be determined from the offsets on the timing sheets, may also be used to justify Arrival Type greater than 3.

Upstream Filtering/Metering Adjustment (I-Value)
The use of a default I-Value (1.0) is acceptable and considered conservative. Any adjustment to an I-Value should be based on the degree of saturation at the adjacent upstream intersections following the HCM guidelines. I-Values should not be modified based on assumptions. Please note that HCS calculates an I-Value for the subject lane-group using the HCS information from adjacent upstream intersections. Further, the I-Value is used to estimate incremental delay and does not affect the v/c ratio.

Right Turn on Red (RTOR)
RTOR is not allowed on New York City streets except where allowed via posted signs (and usually after requiring drivers to first stop). Therefore, RTOR should not be used in intersection LOS analysis unless posted signs designate that this movement is permitted. Where RTOR is permitted, the number of vehicles turning right on red should be counted separately and coded in the LOS analysis accordingly. This is particularly important when right turns are made from a shared lane-group. RTOR should not be estimated using the proportion of red time to cycle length.

Initial Unmet Demand
It is critical to use initial unmet demand in LOS analysis at intersections/approaches/lane-groups experiencing congestion prior to analysis peak hours. The value for initial unmet demand should be based on field observations. Unmet demand is used to estimate initial queue delay and does not affect the v/c ratio.

Lane Widths
Field measured/verified lane widths should be used in the LOS analysis.

Timing/Phasing
NYC DOT's official signal timing plans should be used in all intersection LOS analyses. Should field observations show a discrepancy in phasing, timing or offset with the official signal timing plan, please notify the NYC DOT Signals for verification.

Area Type
Checking the Area Type as CBD lowers capacity by 10% to account for extra miscellaneous friction (or relative inefficiency) that occurs in central business districts. Manhattan south of 60th Street, Downtown Brooklyn, Downtown Flushing, Downtown Jamaica and Long Island City certainly should be checked as CBD. Other areas, such as small commercial areas, or even commercial strips in residential areas, should also be checked as CBD if they experience friction common to CBDs, such as narrow street rights-of-way, frequent parking maneuvers, double parking/vehicle blockages, significant taxi drop-off and pick-ups, bus activity, high pedestrian activity, etc. (please see HCM for further guidance).

Right- and Left-Turn Factors
Under ***no circumstances should the estimated right- and left-turn factors in HCS or Synchro be modified*** unless it is first discussed with NYC DOT and supported by quantified information collected in the field**.**

B. Proposed Improvements or Mitigations

This section provides guidance for acceptable improvement or mitigation proposals.

Lane Widths
If a proposed improvement or mitigation includes changing the lane arrangement at an intersection approach, lane widths should be entered as whole numbers in feet without decimals. They should generally be no wider than 11 feet, unless on a curve or on a highway. It is generally not permissible to create extra travel lane width by reducing sidewalk width.

New Signal
If a proposal is to signalize an intersection that is currently unsignalized, a warrant analysis should be completed for the NYC DOT Signals' review and approval. Intersection phase times and intervals should be whole numbers in seconds without decimals.

Protected Left-Turn Phases
If a protected left turn phase is proposed, a warrant analysis should be completed for the NYC DOT Signals' review and approval. The phase time for a protected left-turn phase should be at least 11 seconds: six seconds of green, three seconds of yellow and two seconds of all-red. Permitted plus protected lagging left turn phases are not allowed because of left-turn trap, unless there is no left turn in the opposing direction. For example, a permitted plus protected lagging left turn phase for a northbound left-turn is not allowed unless 1) the southbound left-turn is banned, 2) the cross street is one-way westbound, so that southbound left-turns are impossible, 3) it is a "T" intersection where there is no east leg, so that southbound left turns are impossible 4) the southbound left-turn is leading protected-only (not permitted during ball green), or 5) it is dual left-turn phasing.

Green Interval

The minimum green time for any phase is six seconds. For ball green with adjacent crosswalk, pedestrian considerations will usually dictate that the minimum green is much higher than six seconds.

Yellow Interval

The minimum yellow time is three seconds. Rule of thumb is one second for each 10 mph speed limit (speed limit/10), and round up.

All-Red Interval

The minimum all-red time at the end of a phase is two seconds. It should be longer for streets that approach wide roadways (such as Queens Boulevard) because it takes longer for vehicles to clear the intersection.

Pedestrian Clearance

Pedestrian Clearance is defined as the time to cross the street, which is crossing distance ÷ walking speed. Use 3.0 ft/sec walking speed, but may use 3.5 ft/sec if there are multiple phases and not in a senior safety area. The pedestrian clearance includes the Flashing Don't Walk (FDW) and Steady Don't Walk at the end (DW). The DW should be the sum of the yellow plus all-red intervals (usually five seconds). The FDW is Pedestrian Clearance minus DW. The minimum FDW, no matter how small the crossing distance, is six seconds.

WALK Interval

After figuring the Pedestrian Clearance as described above, the remainder of the phase time should be given to the WALK interval. The minimum time for the WALK interval is seven seconds. This means the minimum phase time for a movement with an adjacent crosswalk is seven seconds plus Pedestrian Clearance.

Leading Pedestrian Interval (LPI)

An LPI, which is a phase where all traffic is held with red signals to give a pedestrians in the crosswalks adjacent to an approach a head start, should be at least seven seconds.

Split LPI

A split LPI gives pedestrians in the crosswalk a head start like a regular LPI, but does not penalize through traffic. During the first part of the Split LPI, through traffic has the green indication while the turning movements into the conflicting crosswalks are held with red turning-arrows to allow pedestrians in the conflicting crosswalks a head start without conflict. During the second part, the red turning-arrows turn to flashing yellow turning arrows, thus allowing the turns, but providing the message that the turning vehicles must yield to the pedestrians who have already started crossing. During both parts, through traffic has the green indication. It is better for traffic than a regular LPI, because through traffic is not penalized. However, a prerequisite is that turning bays are required. Shared lanes are not permitted on approaches that feature Split LPI. The minimum time for the first part of a Split LPI is seven seconds.

Split Phase

A split phase completely separates turning movements from pedestrians in the conflicting crosswalks. During the first part of the split phase, through traffic has the green indication while the turning movements into the conflicting crosswalks are held with red turning-arrows for conflict-free crossing. The conflicting crosswalks must be given enough time for WALK, FDW and DW as described in previous sections. During the second part of the split phase, the red turning-arrows turn to green turning-arrows, while the pedestrians are held with DW for conflict-free turning. Enough time must be given to process the turning vehicles. During both parts, through traffic has the green indication. It provides greater protection for pedestrians than Split LPI, but often is not as efficient. However, it is useful when pedestrian volume is so high that turning vehicles never find a gap. As with Split LPI, a prerequisite is that turning bays are required. Shared lanes are not permitted on approaches that feature Split LPI.

NYC DOT MINIMUM PEAK HOUR FACTOR (PHF) CALCULATOR

Access calculator here.

NYC DOT QUEUE SPILLBACK ADJUSTMENT CALCULATOR

Access calculator here.

Highway Capacity Manual 2000 Intersection Level of Service Criteria

Level of Service Criteria (LOS) at Signalized Intersections	
LOS	**Control Delay per Vehicle (s/veh)**
A	≤ 10
B	$> 10 - 20$
C	$> 20 - 35$
D	$> 35 - 55$
E	$> 55 - 80$
F	> 80
Source: Transportation Research Board, *Highway Capacity Manual 2000*	

Level of Service Criteria at Unsignalized Intersections	
LOS	**Average Control Delay (s/veh)**
A	$0 - 10$
B	$> 10 - 15$
C	$> 15 - 25$
D	$> 25 - 35$
E	$> 35 - 50$
F	> 50
Source: Transportation Research Board, *Highway Capacity Manual 2000*	

Level of Service Criteria at Freeway-Ramp Junctions	
LOS	**Density (passenger car/mile/lane)**
A	≤ 10
B	$> 10 - 20$
C	$> 20 - 28$
D	$> 28 - 35$
E	> 35
F	Demand exceeds capacity
Source: Transportation Research Board, *Highway Capacity Manual 2000*	

	Weekday Directional Split Percentage						Saturday Directional Split Percentage	
	AM		Midday		PM			
	In	Out	In	Out	In	Out	In	Out
Land Use								
Office (multi-tenant type building)*	89	11	48	52	17	83	50	50
Residential (3 or more floors)*	22	78	50	50	63	37	51	49
Residential (2 floors or less)*	22	78	50	50	63	37	51	49
Residential (NYCHA)*	25	75	51	49	76	24	44	56
Hotel*	34	66	44	56	54	46	53	47
Home Improvement Store*	52	48	50	50	51	49	50	50
Supermarket*	51	49	51	49	50	50	50	50
Supermarket (Staten Island only)*	56	44	48	52	51	49	47	53
Museum***	100	0	43	57	31	69	54	46
Passive Park Space**	59	41	55	45	55	45	55	45
Active Park Space**	59	41	55	45	55	45	55	45
Local Retail*	53	47	50	50	50	50	50	50
Destination Retail**	63	37	53	47	49	51	52	48
Fast Food Restaurant with Drive Through Window*	51	49	48	52	51	49	49	51
Fast Food Restaurant without Drive Through Window*	49	51	49	51	47	53	51	49
Sit Down/High Turnover Restaurant*	64	36	54	46	53	47	56	44
Public School (Students)	100	0	N/A	N/A	0	100	N/A	N/A
Public School (Parents)	50	50	N/A	N/A	50	50	N/A	N/A
Public School (Staff)	100	0	N/A	N/A	0	100	N/A	N/A
Daycare (Children)	100	0	N/A	N/A	0	100	N/A	N/A
Daycare (Parents)	50	50	N/A	N/A	50	50	N/A	N/A
Daycare (Staff)	100	0	50	50	0	100	N/A	N/A
Academic University***	94	6	46	54	44	56	57	43
Cineplex***	95	5	62	38	54	46	56	44
Health Club*	57	43	57	43	52	45	45	55
Health Club with Preschool/Guest Room Service*	54	46	43	56	56	44	48	52
Television Studio***	74	26	49	51	34	66	N/A	N/A
Medical Office*	62	38	47	53	35	65	49	51
Senior Center*	66	34	50	50	35	65	24	76

Note:
*Based on DOT Trip Generation Survey
** Based on ITE Trip Generation Manual 10th Edition
***Based on previous approved projects

List of Common Shy Distances:

- Curb side of a sidewalk: 1.5 ft
- Building face (without window display) 2.0 ft
- Building face with window display: 3.0 ft
- Fence: 1.5 ft
- Bollard: 0.5 ft (from either side)
- Front of newsstand: 3.0 ft
- Back of newsstand: 2.0 ft
- Subway stairwell: 1.5 ft
- Tree pit or grass strip: 0.5 ft
- Planter: 0.5 ft
- Pole: 1.5 ft
- Parking meter: 1.0 ft
- Traffic signs: 1.0 ft
- Hydrant: 0.5 ft
- Trash can: 1.0 ft
- Telephone booth/LinkNYC booth: 1.5 ft
- Bus shelter: 1.5 ft
- Fire alarm boxes: 1.0 ft
- Mail box: 1.0 ft
- Benches: 1.5 ft
- Raised subway vents: 0.5 ft
- EV charging station: 1.0 ft
- Bike racks: 0.5 ft (from end of bicycle)
- Cellar doors: 0.5 ft
- Sidewalk café: 1.5 ft
- Stoop: 0.5 ft

Treatments for Reducing Conflicts between Turning Vehicles and Pedestrians

1. **Leading Pedestrian Interval (LPI).** This is the simplest treatment for addressing the conflict between turning vehicles and pedestrians in the adjacent crosswalk. The entire approach that contains the conflicting turning movement is held with a red signal, while the adjacent conflicting crosswalk(s) display the WALK indication. This is the LPI phase, typically about seven seconds, sometimes more. During the next phase, the adjacent traffic is released with a green indication, while the crosswalk movement(s) continue with the WALK, then FDW and steady DW intervals. The LPI phase gives pedestrians a head start to "take" the crosswalk before the adjacent traffic is released. This improves motorists' visibility of pedestrians as they establish themselves in the crosswalk. It also discourages aggressive "jackrabbit" starts by motorists trying to turn before pedestrians get in their way. However, this type of treatment does not completely eliminate the conflict. The adverse effect on traffic is that green time must be reduced for both turning vehicles and through vehicles.
2. **Split LPI.** Another treatment is the split LPI. Like the standard LPI, pedestrians are given a head start into the intersection while adjacent turning traffic is held. Unlike the standard LPI, the adjacent through traffic is not penalized. Turning traffic is held with a red turning-arrow while through traffic is released by simultaneously displaying a green through-arrow (or green ball). A turning lane must be provided to accomplish this; it is not acceptable to have a green through arrow and red turning arrow displayed at the same time to a shared through/turning lane. During the next phase, the red arrow changes to a flashing yellow arrow to release the turning vehicles and to emphasize they must yield to pedestrians in the crosswalk while the green for the through traffic continues. As with standard LPI treatment, split LPI does not completely eliminate the conflict. However, the duration of the LPI can often be longer than with standard LPI, because only the green time of the turning movement must be reduced, not the through movement.
3. **Split Phase.** A third treatment is the split phase, in which green time for the approach that contains the conflicting turning movement would be split into two parts. In the first part of the split phase, the conflicting crosswalk would have the WALK display, while the turning vehicles are held with a red arrow to provide conflict-free crossing. In the second part, the conflicting crosswalk would display the DW steady hand, while the turning vehicles have a green arrow for conflict-free turning. During both parts of the split phase, a green through-arrow would be displayed for through traffic, and the non-conflicting opposing crosswalk (in the case of one-way street) would display the WALK indication. A disadvantage of split phase treatment is that the WALK time for the conflicting crosswalk and green time for the conflicting turning movement are both drastically reduced in order to completely eliminate the conflict. The green time for the through movement, however, is not penalized. As with Split LPI treatment, a prerequisite to split phase treatment is that a turning lane must be provided.

   The split phase is more "civilized" than the Split LPI because the turning vehicles and the conflicting crosswalk gets their own phase, which eliminates the conflict, but often the Split LPI is more efficient. However, for situations where there are so many pedestrians that turning vehicles must aggressively force their way in, split phases are preferred. Regular LPIs are utilized when there is no room for turning lanes, or when one of the approaches are two-way.