REGION OF OTTAWA CARLETON — REPORT
RÉGION D'OTTAWA CARLETON — RAPPORT

Our File/N/Réf. **50** 20-98-0201
Your File/V/Réf.

DATE 10 August 1998

TO/DEST. Co-ordinator Transportation Committee

FROM/EXP. Director Mobility Services and Corporate Fleet Services
Environment and Transportation Department

SUBJECT/OBJET **WARRANTS FOR PEDESTRIAN SIGNALS AND TRAFFIC CONTROL SIGNALS**

DEPARTMENTAL RECOMMENDATION

That Transportation Committee and Council receive this report for information.

BACKGROUND

At the Transportation Committee meeting of 06 August 1997, Committee directed, "That staff bring forward a report/briefing in January 1998 on current warrants for intersection signalization including the rationale for the warrant norms. The report would also consider whether the existing warrant system is still appropriate in view of the new Transportation Master Plan."

DISCUSSION

There are currently two types of situations which justify the installation of a traffic control signal. For each type, a warrant system has been developed which differentiates between pedestrian traffic and vehicular traffic. These are the Pedestrian Signal Warrants as adopted by Regional Council at its meeting of 13 February 1991 (the Ontario Ministry of Transportation (MTO) has similar warrants) and the Ministry's Traffic Control Signal Warrants which have been used as guidelines for signal justification over the past 30 years.

PEDESTRIAN SIGNAL WARRANTS

The pedestrian signal warrants are the former Regional Pedestrian Crossover Warrants renamed when Council at its meeting of 13 February 1991 decided that pedestrian crossovers would no longer be installed on Regional roads and that the systematic removal of pedestrian crossovers

would be undertaken. The first pedestrian crossovers used in the Ottawa area were established in 1963.

The pedestrian crossover was developed as an economical traffic control device that was supposed to permit pedestrians to cross roadways safely and effectively with minimum delay to both pedestrian and vehicular traffic. However, since full control signals are now used, both pedestrian and vehicular delays are experienced. Pedestrians must push a button and wait until the timing cycle for the device calls up the pedestrian walk signal display while the vehicular signal display changes from green to amber to red. Likewise, the vehicular traffic is delayed for the time it takes a pedestrian to cross curb to curb plus a safety factor. Thus, there are longer delays for all users.

Before considering a pedestrian signal installation, a sidewalk must be present at each end of the crosswalk(s), as specified in Condition "m" of the Pedestrian Signal Warrants, which states: "Sidewalks necessary for the safe and effective use of a pedestrian signal are available, or will be provided prior to a pedestrian signal being installed."

Pedestrian signal installations can take one of the following forms:

1. a pedestrian traffic control signal which is identical to a full traffic control signal installation which has both pedestrian and vehicular traffic head displays facing all approaches to an intersection;

2. an intersection pedestrian signal also known as a half signal which has only a single pedestrian crosswalk on one side of an intersection controlled by pedestrian heads and stop sign(s) controlling the minor road(s) vehicular approach(es) and vehicular signal heads controlling both approaches on the major road; or

3. a mid-block pedestrian signal which has a single crosswalk controlled by pedestrian heads and vehicular signal heads controlling both approaches on the major road.

The warrant system for a pedestrian signal is based on two sub-warrants which consider the number of pedestrians crossing the roadway, the traffic volume on the roadway, and the time that the pedestrians must wait (i.e. are delayed) for an appropriate gap in traffic on the roadway before starting to cross.

Volume Warrant: This sub-warrant compares the *weighted* number of pedestrians crossing the roadway in a eight-hour period (usually 7:30 to 9:30 a.m., 11:30 a.m. to 2:00 p.m., and 2:30 to 6:00 p.m.) with the twelve-hour vehicle volume of traffic on the roadway. (The Ministry's warrant system specifies eight-hour vehicle volume, but results are comparable -- twelve-hour volumes were specified in the original Regional warrants for convenience and ease of collection using automatic traffic recorders.) *Weighted* means that children, seniors and disabled persons are each counted as two pedestrian crossings, a number arbitrarily selected to reflect the greater waiting time required by these groups for a safe crossing gap. The weighted number of pedestrians is called the adjusted pedestrian crossing volume.

The point where the twelve-hour vehicular volume of the roadway intersects with the eight-hour adjusted pedestrian volume is plotted on the "Pedestrian Signal Evaluation Volume Warrant" graph. If the point is within the "Warranted Zone", the Volume Warrant is at least 100% satisfied. It should be noted that locations with vehicle volumes less than 2,000 or adjusted pedestrian volumes less than 200 will always fall outside the warranted zone. In the former case, empirical studies have shown that pedestrians generally do not experience excessive delays when volumes are less than 2,000. In the latter case, the number 200 was selected to prevent possible over-use of the device.

The "percent warranted" is calculated as the ratio of the measured eight-hour adjusted pedestrian volume to the minimum eight-hour adjusted pedestrian volume falling within the warranted zone, expressed as a percentage, for the particular twelve-hour vehicle volume measured. It can be greater or less than 100%.

Delay Warrant: This sub-warrant compares the number of crossing pedestrians (measured, not weighted) that are delayed more than 10 seconds in starting to cross the road with the eight-hour adjusted pedestrian volume (from above). The value of 10 seconds was selected as the point at which delays start to become noticeable.

The point where the eight-hour adjusted pedestrian volume intersects with the number of pedestrian delays greater than 10 seconds is plotted on the "Pedestrian Signal Evaluation Delay Warrant" graph. If the point is within the "Warranted Zone", the Volume Warrant is at least 100% satisfied.

The "percent warranted" is calculated as the ratio of the number of measured pedestrian delays to the minimum number of pedestrian delays falling within the warranted zone, expressed as a percentage, for the specific adjusted pedestrian volume measured. It can be greater or less than 100%.

The Pedestrian Signal Warrant is satisfied only when **both** the Volume Warrant and the Delay Warrant are 100% or greater. The overall percent warranted for the location is the minimum of the volume or delay percent warranted.

Refer to Annex A for the warrant analysis sheet and the two graph evaluation sheets.

TRAFFIC CONTROL SIGNAL WARRANT

This warrant system is set by the Ministry of Transportation of Ontario and has been in use since the inception of the Region of Ottawa-Carleton as a guideline for the installation of signal lights. Until recently, the Region would receive from the Province approximately 40% subsidy in funding for each warranted signal installation. Proof of warrant would have to be submitted to MTO for approval.

The warrant system is based on the availability of acceptable gaps in traffic flow on the major roadways that allow the minor street traffic to merge with or cross through safely. Data shows that for an average driver a total crossing time (safe gap) of nine seconds (comprised of actual

travel time plus perception/reaction time) is required to clear an intersection on a two-lane street from the side/minor street. Under very heavy traffic (urban) conditions this average time can drop to six seconds.

Annex B illustrates an average rural intersection. The total distance from the stop bar (Point A) to clear the major road (to Point B) is 19.2 metres. From the stop condition, assuming an average acceleration rate of 2.7 metres/second/second, the physical crossing time is 3.75 seconds. In addition to the crossing time (3.75 seconds), additional time has to be considered in making the crossing. This time is comprised of two components: the time to perceive a satisfactory gap in the major road traffic and the time to react. The perception/reaction time for an average driver is 5.25 seconds. Total crossing time is then 3.75 + 5.25 = 9.0 seconds. As previously stated, in the urban area this crossing time can be reduced to 6 seconds due to the preparedness of the driver, which reduces the reaction time. Changing demographics, such as a larger proportion of older drivers may require re-evaluation of these parameters in the future.

The theory of justifying traffic control signals is based on comparing the minor street volumes to the number of safe gaps (a function of traffic volume) on the major road. If the number of safe gaps on the major road is less than the number of minor road vehicles trying to cross the intersection, then a traffic control signal may be warranted.

The warrants for a traffic control signal have been developed for two types of conditions on a major roadway:

1. Restrictive Flow Conditions - normally encountered in urban areas where operating speed is less than 70 km/h; and

2. Free Flow Conditions - normally encountered where operating speed is equal to or greater than 70 km/h.

<u>Considerations</u>

1. A traffic control signal serves no useful function when traffic volume on the major road is such that gaps of at least nine seconds in length for rural situations (six seconds for urban) occur as often as minor road vehicles wanting to cross over the major road. Therefore, the minimum required traffic volumes providing gaps of nine and six seconds as developed from the theory of random traffic flow have been selected as the values in the Ontario Warrants.

2. Also, there should be at least one vehicle (or pedestrian) on the minor road during each signal cycle; otherwise, a delay to the major flow of traffic would occur unnecessarily and the net result of signalization would be increased delay and increased frequency of rear-end collisions. Therefore, the minimum volume of traffic on the minor road required to provide at least one vehicle per cycle has been determined from the theory of random traffic flow. These values are reflected in the Ontario Warrant.

3. The only remaining point to be considered is the length of time during which these volume warrants should be fulfilled. Eight hours has been selected as the standard in most jurisdictions. This is the period that encompassed both peaks and the majority of the working day. For the Ontario warrants, therefore, the minimum volume conditions must occur during at least eight (8) hours (not necessarily consecutive) of an average day.

The MTO warrant system consists of five separate warrants described in Annex C. Warrant 1 (Minimum Vehicular Volume) and Warrant 2 (Delay to Cross Traffic) have been developed based on traffic flow theory and many empirical studies have shown that signals installed under these conditions will result in reduced overall intersection delay. These are the two warrants that are most extensively used to justify a traffic control signal. If either of these two warrants are 100% satisfied, then a traffic control signal is considered warranted.

Pedestrians crossing the major road are addressed in Warrant 2, where the number of pedestrians is combined with the vehicular cross traffic in determining the overall warrant value.

Warrant 3 (Accident Hazard) addresses locations where a high number of right-angle collisions have occurred, combined with a relatively high vehicular volume where remedies less restrictive (and costly) than traffic control signals have not reduced the collision hazard to an acceptable level. In these cases signals may be justified.

Warrant 4 (Combination) is used to justify signals at intersections where two of the three previous warrants are between 80% and 100% satisfied.

Warrant 5 (Pedestrian Volume) provides values justifying mid-block pedestrian signals. These values are generally more restrictive than the Region's Pedestrian Signal Warrants.

The current Ontario Traffic Control Signal Warrants have been in existence for over 30 years and drivers' behaviour still conforms to the theory behind their development. The application of the warrants should be accompanied by knowledgeable engineering judgement and awareness of local conditions.

PEDESTRIAN AND BICYCLE CONSIDERATIONS

Although pedestrian volumes are considered, the traffic control signal warrants are geared primarily to vehicular traffic flow (which includes bicycles). The Pedestrian Signal Warrants, on the other hand, consider the volume of and delay to pedestrians (with cyclists considered as pedestrians) and are consistent with the Transportation Master Plan policies to facilitate and encourage pedestrian and bicycle travel.

One concern often raised is that in many cases measured pedestrian volumes are low because people are afraid to cross the road, i.e. the "potential pedestrian crossing demand" is much higher and providing signals would encourage more crossings, possibly enough to satisfy the warrants.

The Regional pedestrian signal warrants could certainly be modified to use a shorter time period or possibly higher factors for seniors, children and disabled persons. The "potential pedestrian crossing demand" is hard to obtain and likely varies greatly with each location.

The Department could examine historical data at various recent pedestrian signal installations to determine how much volumes had actually increased since installation to see if this condition is significant.

NUMBER OF HOURS CONSIDERATIONS

Another concern often raised is that the need to satisfy the guidelines for the full eight hours, rather than two or four (the peak hours) is onerous. The MTO recently considered modifying the existing traffic control signal warrants to use four-hour values. While this could be considered, reducing the eight-hour requirement would have a significant effect on the number of signals warranted each year. Based on 1998 counts to date, a total of nine new locations would warrant signals based on the eight-hour criterion. Reducing the requirement to six hours would add an additional three, to four hours an additional seven, and to just the two peak hours, an additional eleven. The number of warranted new locations could jump from nine per year to 30.

CONCLUSIONS

In the end, it is primarily a political judgement to determine if "unwarranted" signals are justified. The current set of guidelines is considered more than adequate for an initial technical screening. Council may then decide whether or not to approve an unwarranted device, bearing in mind that each new signal costs at least $70,000 to install (without roadway modifications -- intersection modifications add $200,000 to $750,000 to these costs) and averages $3,500 per year to maintain. Signals certainly can provide benefits in the areas of safety and convenience, but there are trade-offs -- increased vehicle and pedestrian delay, increased number of stops, and an increased probability of rear-end collisions.

Approved by G. Malinsky on behalf of
Doug Brousseau

GM/JAF/HLD/sc

Attach. (3)

Regional Municipality of Ottawa-Carleton

Transportation Department
P.X.O. WARRANT ANALYSIS

LOCATION _____ *YEAR* _____

ZONES USED _____ % ASSIGNED _____

ZONES USED _____ % ASSIGNED _____

ZONES USED _____ % ASSIGNED _____

DATE OF SURVEY _____

SURVEY HOURS _____

_____ *

12 HOUR COMBINED VEHICULAR VOLUME _____

* *REGULAR HOURS:* 7:30am.-9:30am. 11:30am.-2:00pm. 2:30pm.-6:00pm. *TOTAL = 8 HOURS*

PEDESTRIAN VOLUME (INCL. ADJ. FACTOR)

PEDESTRIAN TYPE	ZONES				TOTAL
CHILDREN WITH PATROLS					
CHILDREN					
YOUTHS					
ADULTS					
SENIOR CITIZENS					
HANDICAPPED PERSONS					
TOTAL					

TOTAL REQUIRED VOLUME

PEDESTRIAN DELAY >10 SEC.

PEDESTRIAN DELAY	ZONES				TOTAL
CHILDREN WITH PATROLS					
CHILDREN					
YOUTHS					
ADULTS					
SENIOR CITIZENS					
HANDICAPPED PERSONS					
TOTAL					

TOTAL REQUIRED DELAY VOLUME

PERCENT WARRANTED ☐ *WARRANTED* *YES* ☐ *NO* ☐

VOLUME _____ DATE ANALYZED _____

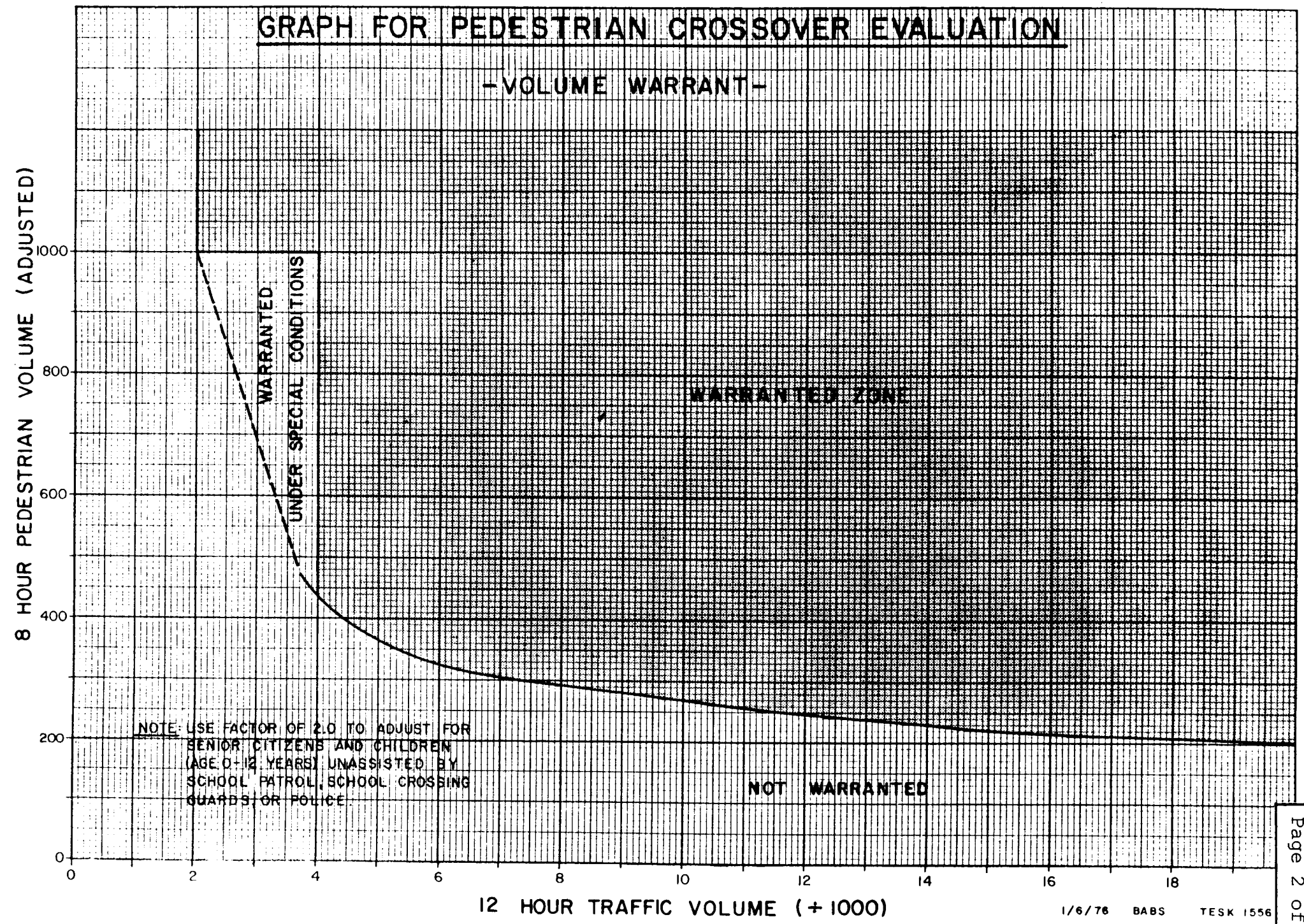
DELAY _____ ANALYZED BY _____

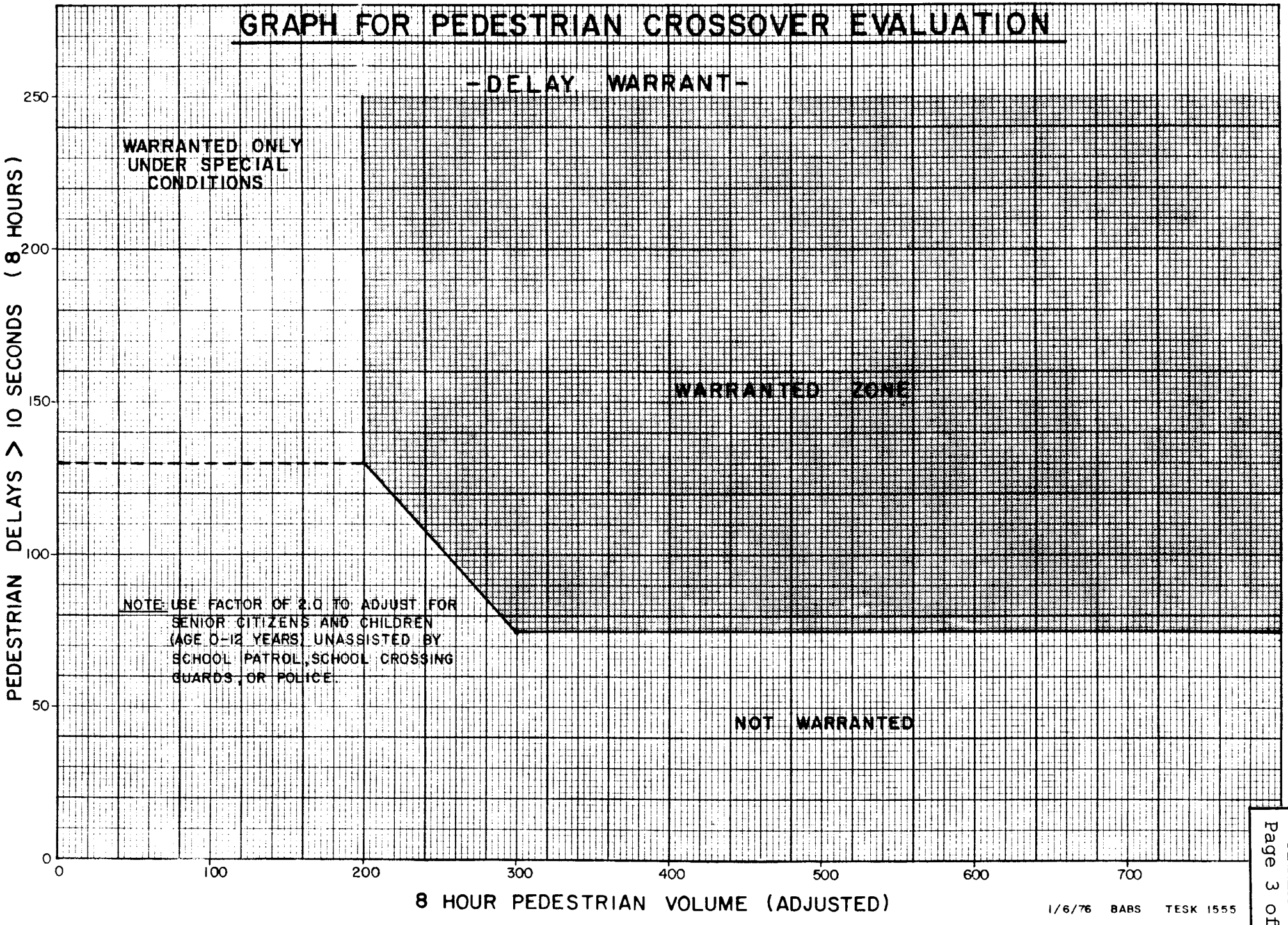
CHECKED BY _____

COMMENTS _____

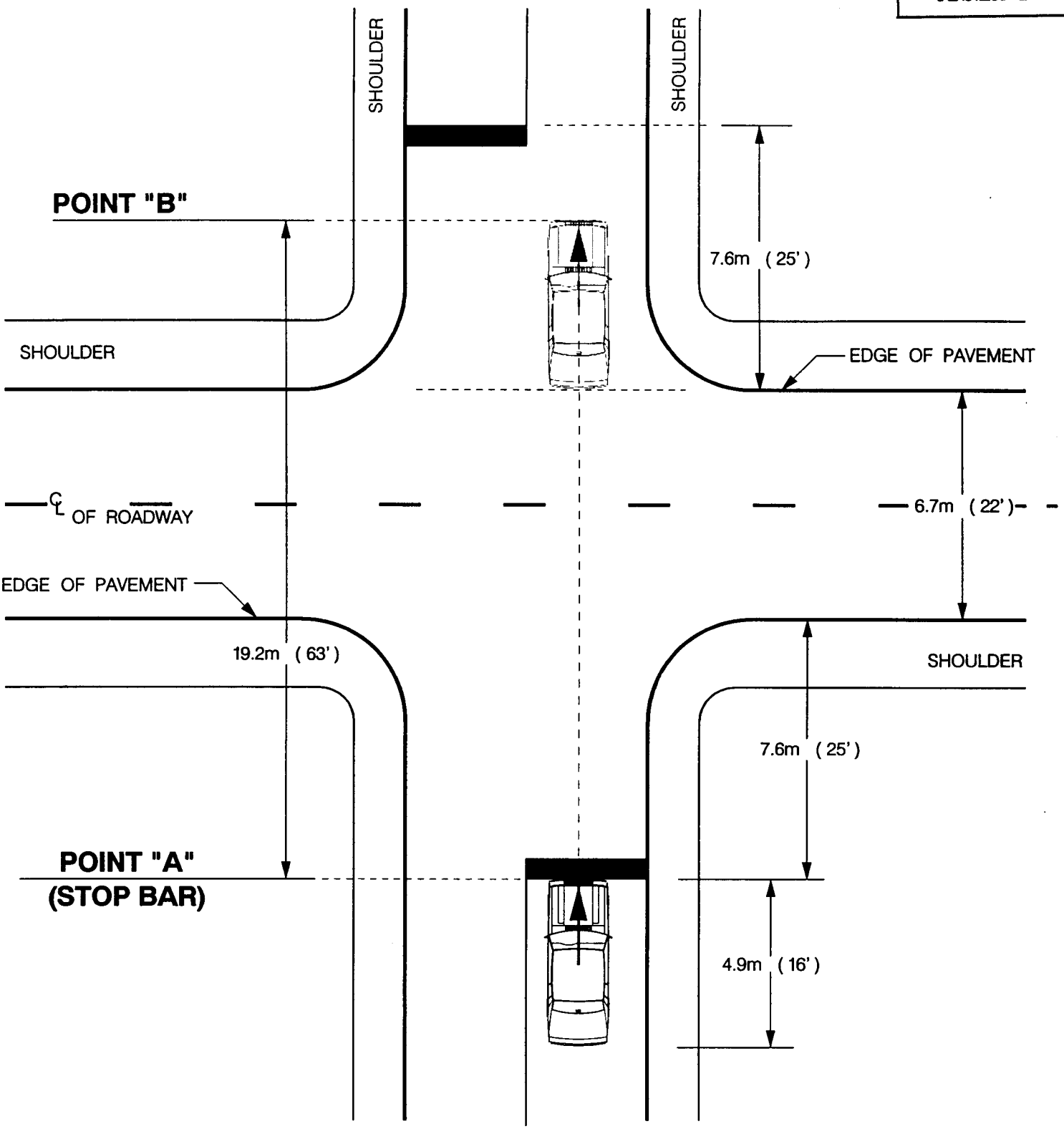
_____

_____


GRAPH FOR PEDESTRIAN CROSSOVER EVALUATION
-VOLUME WARRANT-
8 HOUR PEDESTRIAN VOLUME (ADJUSTED)
1000
800
600
400
200
0
WARRANTED UNDER SPECIAL CONDITIONS
WARRANTED ZONE
NOTE: USE FACTOR OF 2.0 TO ADJUST FOR SENIOR CITIZENS AND CHILDREN (AGE 0-12 YEARS) UNASSISTED BY SCHOOL PATROL, SCHOOL CROSSING GUARDS, OR POLICE.
NOT WARRANTED
0
2
4
6
8
10
12
14
16
18
12 HOUR TRAFFIC VOLUME (+1000)
1/6/76 BABS TESK 1556


GRAPH FOR PEDESTRIAN CROSSOVER EVALUATION
-DELAY WARRANT-
WARRANTED ONLY UNDER SPECIAL CONDITIONS
WARRANTED ZONE
NOT WARRANTED
NOTE: USE FACTOR OF 2.0 TO ADJUST FOR SENIOR CITIZENS AND CHILDREN (AGE 0-12 YEARS) UNASSISTED BY SCHOOL PATROL, SCHOOL CROSSING GUARDS, OR POLICE.
PEDESTRIAN DELAYS > 10 SECONDS (8 HOURS)
0
50
100
150
200
250
0
100
200
300
400
500
600
700
8 HOUR PEDESTRIAN VOLUME (ADJUSTED)
1/6/76 BABS TESK 1555

ANNEX B



DIAGRAMMATIC SKETCH OF TYPICAL RURAL INTERSECTION

FIGURE 1

Ottawa-Carleton

MOBILITY SERVICES

Environment &Transportation Department

Drawn By	Checked By	Approved By	Scale	Date	
E.P.	H.L.D.	J.A.F.	N. T. S.	JANUARY 1998	M98001-F1

B 2.03 INSTALLATION WARRANTS FOR TRAFFIC CONTROL SIGNALS

The warrants for traffic signals have been developed for two types of conditions: Restricted Flow Conditions (Roads with operating speeds less than 70 km/h) and Free Flow Conditions (Roads with operating speeds greater than or equal to 70 km/h). This division is necessary due to the different operating characteristics which exist under each condition.

Restricted Flow Conditions are those which are normally encountered in urban areas where the traffic volumes approach or exceed the practical working capacity of the roadway.

Free Flow Conditions are those which are normally encountered in rural areas. The basic limitation on vehicle operation lies with the driver himself. However, the Ministry also recognizes that the driving characteristics in small communities are different than those in larger urban areas. Therefore, these conditions will be used for an intersection within the built-up area of a community having a population of less than 10 000 and outside the commuting influence of a large urban centre, even if the operating speed is less than 70 km/h.

The installation of traffic control signals at any location will be justified and will probably prove beneficial when any one of the following warrants, vehicular volume, vehicular delay, accident or pedestrian, is completely satisfied. These warrants are summarized on the traffic signal warrant sheet Section B 2.03.07. Section B 2.03.08 is the work sheet that will be used in calculating the compliance of the warrants. In the application of these warrants the following principles must be observed:

1. Only vehicles entering the intersection – whether they turn right, go straight through or turn left – should be considered. If the right turns are channelized by means of physical islands, they are not considered to enter the intersection and therefore should not be included in any warrant calculations

2. Right turns are not considered as traffic crossing the artery, therefore, they should be deleted from the combined pedestrian and vehicle volume in the Delay to Cross Traffic Warrant. In one-way street systems left turns from a one-way street into another one-way street should be treated similar to right turns and should also be deleted from this warrant

3. The minimum warrant values for the volume on the major street are for two-lane, two-way roadways. Vehicle volume warrants for multi-lane roadways having four or more moving lanes on the major street should be 25% higher. Two-lane, two-way roadways with exclusive left turn lanes are not classified as multi-lane roadways.

4. In applying warrant 1 (Minimum Vehicular Volume) for 'T' intersections, the warrant values for the minor street should be increased by 50%

5. When applying warrant 2.B, the crossing volume consists of:

   (1) Total left turns from both the minor street approaches and the highest through volume from the minor street

   (2) 50% of the heavier left turn traffic movement from the major street when **both** of the following two criteria are met:

      (a) The left turn volume is greater than 120 vehicles per hour.

      (b) The total of the left turn volume plus the opposing volume is greater than 720 vehicles per hour.

   (3) The number of pedestrians crossing the major street

6. When applying warrant 2 (Delay to Cross Traffic) for the minor street, the through volume used could be from one approach during some hours and from the opposite approach during other hours.

B 2.03.01 Minimum Vehicular Volume Warrant Restricted Flow

Total vehicular volume entering the intersection from all approaches must be at least 720 vehicles per hour for each of the heaviest eight hours of an average day, and;

Total vehicular volume entering the intersection from the minor street must be at least 170 vehicles per hour for each of the same eight hours.

Free Flow

Total vehicular volume entering the intersection from all approaches must be at least 480 vehicles per hour for each of the heaviest eight hours of an average day.

Total vehicular volume entering the intersection from the minor street must be at least 120 vehicles for each of the same eight hours.

B 2.03.02 Delay to Cross Traffic Warrant

Restricted Flow

At an intersection operating under restricted flow conditions, the vehicular volume entering the intersection from the major street approaches must be at least 720 vehicles per hour for each of the heaviest eight hours of an average day, and;

The combined vehicle (crossing volume only) and pedestrian volume crossing the major street must be at least 75 units per hour for each of the same eight hours.

Free Flow

At an intersection operating under free flow conditions, the vehicular volume entering the intersection from the major street approaches must be at least 480 vehicles per hour for each of the heaviest eight hours of an average day, and;

The combined vehicle (crossing volume only) and pedestrian volume crossing the major street must be at least 50 units per hour for each of the same eight hours.

B 2.03.03 Accident Hazard

While an accident situation alone seldom justifies signal control, the installation of traffic control signals may be warranted when every one of the following conditions is satisfied:

1. Five or more reported accidents of types preventable by traffic control signals have occurred per 12 month period averaged over 36 consecutive months, each accident involving personal injury or property damage which appears to be serious enough to be reported by the police

2. Adequate trial of less restrictive remedies with satisfactory observance and enforcement have failed to reduce accident frequency

3. There exists a volume of vehicular and pedestrian traffic not less than 80% of the requirements specified in the Minimum Vehicular Volume Warrant, or the Delay to Cross Traffic warrant.

Preventable accidents are those involving traffic which under signalized conditions would move on completely separate phases. Less restrictive measures, which would be tried before signals are installed, include the improvement of control or warning signs, installation of flashing beacons, the provision of safety or channelizing islands, the improvement of street lighting, and the prohibition of parking and/or turns.

The installation of traffic signals will seldom be justified on the accident warrant alone and it should be remembered that their operation may even increase the intersection accident rate due to rear-end collisions, etc., caused directly or indirecty by the signal operation.

B 2.03.04 Combination Warrant

Signals may occasionally be justified where no one warrant is satisfied, but two or more are satisfied to the extent of 80% or more of the stated values, particularly if other important factors are present such as a:

1. Sudden change from rural conditions to those of an urban business district

2. Extreme width of roadway which pedestrians must cross

3. Predominance of small children or handicapped pedestrians such as blind, aged or crippled adults who need to cross the roadway

B2.03.07

MINIMUM REQUIREMENTS FOR INSTALLATION OF TRAFFIC SIGNALS FOR TWO LANE ROADWAYS

LOCATION _____ AT _____

MUNICIPALITY _____ DATE OF SURVEY _____

	WARRANT		DESCRIPTION	MINIMUM REQUIREMENT FOR TWO-LANE ROADWAYS: FREE FLOW, OPERATING SPEED GREATER THAN OR EQUAL TO 70 km/h	MINIMUM REQUIREMENT FOR TWO-LANE ROADWAYS: RESTRICTED FLOW, OPERATING SPEED LESS THAN 70 km/h	COMPLIANCE: SECTIONAL %	COMPLIANCE: ③ ENTIRE %
INTERSECTION	1. MINIMUM VEHICULAR VOLUME	①A	Vehicle Volume, All Approaches for Each of the Heaviest 8 Hours of an Average Day, and	480	720		
		④B	Vehicle Volume, Along Minor Streets for Each of the Same 8 Hours	120	170		
	2. DELAY TO CROSS TRAFFIC	①A	Vehicle Volume, Along Major Street for Each of the Heaviest 8 Hours of an Average Day, and	480	720		
		②B	Combined Vehicle and Pedestrian Volume Crossing the Major Street for Each of the Same 8 Hours	50	75		
	3. ACCIDENT HAZARD	A	Total Reported Accidents of Types Susceptible to Correction by a Traffic Signal, per 12 Month Period Averaged Over a 36 Month Period, and	5			
		B	Adequate Trial of Less Restrictive Remedies, Where Satisfactory Observance and Enforcement Have Failed to Reduce the Number of Accidents, and	YES ☐ NO ☐			
		C	Fulfillment of Either of the Above Warrants (Minimum Vehicular Volume or Delay to Cross Traffic) to the Extent of 80% or More.	YES ☐ NO ☐			
	4. COMBINATION WARRANT		Two or More of the Above Warrants (1, 2 or 3) Satisfied to the Extent of 80% or More.	YES ☐ NO ☐			
~~MID-BLOCK~~	~~5. MINIMUM PEDESTRIAN VOLUME~~	~~A~~	~~Pedestrian Volume Crossing the Major Street Average per Hour for the Heaviest 8 Hours of an Average Day, and~~	~~120~~	~~240~~		
		~~①B~~	~~Vehicle Volume Along Major Street Average Per Hour for the Same 8 Hours.~~	~~290~~	~~575~~		

NOTES:

① Vehicle Volume Warrants (1A), (2A) and (5B) for Roadways Having Two or More Moving Lanes in one Direction Should Be 25% Higher Than Values Given Above.

② For Definition of Crossing Volume Refer to Note ④ on the Signal Warrant Analysis Form B2.03.08

③ The Lowest Sectional Percentage Governs the Entire Warrant.

④ For "T" Intersections the Values for Warrant (1B) Should Be Increased by 50%

B.2.03.08 TRAFFIC SIGNAL WARRANT ANALYSIS FORM FOR INTERSECTION CONTROL.

Minimum warrants for installation of traffic signals for roadways with two or more lanes.

Major street.....;MULTI LANE YES ☐ NO ☐
Minor street.....

FREE FLOW CONDITIONS (RURAL) ☐
RESTRICTED FLOW CONDITIONS (URBAN) ☐

Street Name				
Channelized	NB	SB	EB	WB
Turns				

WARRANT 1 – MINIMUM VEHICULAR VOLUME

100 % SATISFIED – YES ☐ NO ☐
80 % SATISFIED – YES ☐ NO ☐

APPROACH LANES	MINIMUM REQUIREMENTS (80 % SHOWN IN BRACKETS) 1		2 or MORE		PERCENTAGE WARRANT HOUR ENDING									
FLOW CONDITION	FREE FLOW ☐	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☐									TOTAL ACROSS	SECTIONAL PERCENT
A. ALL APPROACHES	480 (385)	720 (575)	600 (480)	900 (720)										
	100% FULFILLED													
	80% FULFILLED													
	ACTUAL % IF BELOW 80% VALUE													
												TOTAL DOWN		÷8=
B. MINOR STREET BOTH APPROACHES	120* (95)*	170* (135)*	120* (95)*	170* (135)*									TOTAL ACROSS	SECTIONAL PERCENT
	100% FULFILLED													
	80% FULFILLED													
	ACTUAL % IF BELOW 80% VALUE													
												TOTAL DOWN		÷8=

*FOR 'T' INTERSECTIONS THESE VALUES SHOULD BE INCREASED BY 50%
T - INTERSECTION YES ☐ NO ☐

WARRANT 2 – DELAY TO CROSS TRAFFIC

100 % SATISFIED – YES ☐ NO ☐
80 % SATISFIED – YES ☐ NO ☐

APPROACH LANES	MINIMUM REQUIREMENTS (80 % SHOWN IN BRACKETS) 1		2 or MORE		PERCENTAGE WARRANT HOUR ENDING									
FLOW CONDITION	FREE FLOW ☐	RESTR. FLOW ☐	FREE FLOW ☐	RESTR. FLOW ☐									TOTAL ACROSS	SECTIONAL PERCENT
A. MAJOR STREET BOTH APPROACHES	480 (385)	720 (575)	600 (480)	900 (720)										
	100% FULFILLED													
	80% FULFILLED													
	ACTUAL % IF BELOW 80% VALUE													
												TOTAL DOWN		÷8=
B. TRAFFIC CROSSING MAJOR STREET	50 (40)	75 (60)	50 (40)	75 (60)									TOTAL ACROSS	SECTIONAL PERCENT
	100% FULFILLED													
	80% FULFILLED													
	ACTUAL % IF BELOW 80% VALUE													
												TOTAL DOWN		÷8=

Warrent 3 - Reported Accidents				
Year	19	19	19	ANNUAL AVG.
Total				
Preventable				

100 % SATISFIED - YES ☐ NO ☐
80 % SATISFIED - YES ☐ NO ☐

A. Reportable accidents within a 12 month period averaged over 36 consecutive months susceptible to correction by a traffic signal.		
WARRANT VALUE	AVERAGE ANNUAL PREVENTABLE	FULFILLED
5	.....	.....%
B. Adequate trial of less restrictive remedies has failed to reduce accident frequency.		100% 0% - Yes ☐ No ☐
C. Either Warrant 1 (Minimum Vehicular Volume) or Warrant 2 (Delay to Cross Traffic) satisfied 80% or more.		100% 0% - Yes ☐ No ☐

WARRANT 4 - COMBINATION WARRANT

SATISFIED - YES ☐ NO ☐

Used if no warrant satisfied 100%

REQUIREMENT	WARRANT SATISFIED 80% OR MORE	FULFILLED
Two Warrants Satisfied 80%	Warrant 1 - Minimum Vehicular Volume - Yes ☐ No ☐ Warrant 2 - Delay to Cross Traffic - Yes ☐ No ☐ Warrant 3 - Accident Experience - Yes ☐ No ☐	- Yes ☐ No ☐

CONCLUSION: TRAFFIC SIGNALS WARRANTED - YES ☐ NO ☐