ABSTRACT

DWIVEDI, PRAVEK ANIL. Traffic Modelling Framework for Planning of RCUT Intersections (Under the direction of Dr. Billy Williams).

With the advances in science and technology, demand for transportation facilities is increasing dramatically. To meet this demand, there has been development of new forms of transportation facilities across the globe and of all the innovations, one of the widely known concepts is that of Alternative Intersections and Interchanges (AIIs). These modern form of intersections and interchanges termed as AII redirects conventional movements so as to make traffic operation smoother and safer. Of the several designs of AIIs developed, one of the most widely constructed AII is Restricted Crossing U-turns (RCUT) Intersection, also known as "Superstreet". RCUT intersection redirects minor street left and through movement to turn right and then make a U-Turn after travelling some distance downstream to complete desired movement. Major street operations are similar to conventional intersection.

On the basis of Traffic Control strategy adopted, RCUTs are classified into three types; they are: Signalized RCUT, Stop-controlled RCUT and RCUT with merges. There are several factors which govern the design of RCUT such as turning bays, spacing of U-turn crossover, storage bays, design of curb and gutter, intersection control design and similar other. In this thesis, of all the design controls, three critical parameters for RCUT design are studied: U-Turn crossover spacing, length of storage bays and impact to neighboring intersection. Since traffic volumes are one of the most important design inputs, impact of change in traffic volume on these three design parameters is studied. Microscopic analysis was done for the analysis and VISSIM, one of the most famous and prevalent microsimulation tools was used for this. Two types of RCUTs were studied: stop controlled and signalized RCUT and guidelines for optimum design of above mentioned three parameters were developed. For U-turn crossover spacing, based on the data

collected from VISSIM, regression models were developed and relevant equations were derived so as to obtain a spacing value which yields minimum average delay per vehicle corresponding to operating traffic volumes. Similar procedure was adopted for developing guidelines on optimum length of storage bay. To reduce the number of variables, optimum length of storage bays was derived and reported in terms of U-Turn Crossover spacing. For impact to neighboring intersection, based on most common design combinations of RCUT and adjacent intersection, minimum spacing requirements for these design combinations were suggested based on maximum queue lengths obtained by VISSIM simulation.

In last section of the thesis, concluding remarks which can be helpful for consultancies and practicing engineers are listed. Also scope for future research is documented so as to make RCUT design and operations efficient.

Traffic Modelling Framework for Planning of RCUT Intersections

by

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DEDICATION

This thesis is dedicated to my mother

Late Mrs. Harsha Dwivedi

for her valuable lessons, blessings and unconditional sacrifices

BIOGRAPHY

Born and brought up in India, Pravek Dwivedi is Graduate student in CCEE Department, NC State University with a focus on Transportation Systems Engineering. Pravek works at ITRE, NCSU as a Graduate Research Assistant. His research interests lie in the field of Alternative Intersections and Connected-Autonomous Vehicles. Apart from academics, he likes to read poetries, novels and explore ancient Indian literature.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Background

The mode of transportation wherein people and goods are transported through roads is defined as Road Transportation. In this age of population explosion and technological advances, development and management of road transportation facilities is crucial. Road transport helps in carriage of goods and humans from one corner of the globe to another which implicitly as well as explicitly helps in economic development. In essence, road transportation is one of the vital components in today's economy and hence it becomes necessary to study and develop technologies to optimize it.

In today's time wherein population is growing at an exponential rate, demand for road transportation is influenced and it is increasing significantly not only in United States but globally. In 2008 vehicle-miles traveled in US by road transport was 2,976,528 million whereas that in 2018 was 3,240,327 million which is about 8.86% of growth in 10 years (USDOT 2018). With such escalation in demand, it is necessary to not only develop new ones but also optimize existing transportation facilities. Development of completely new transportation infrastructure such as highways, arterials, bridges and similar other requires huge financial investments. As a result, traffic management strategies and efficient design of transportation facilities is crucial to avoid construction of completely new facilities. Conventional traffic management strategies comprise of making an intersection signalized or stop-controlled based on preliminary analysis, adding a lane to accommodate higher number of vehicles, adding a turning bay for safety purposes and similar others. In past couple of decades, United States is witnessing implementation of Alternative Intersections and Interchanges (AIIs) in several states. Alternative Intersections and Interchanges

redirect few movements in comparison to conventional intersection so as to provide safer transportation and reduce delays for vehicles.

1.2 Alternative Intersections and Interchanges

Alternative intersections and interchanges can be defined as intersections which provide unconventional movements by restricting movements, redirecting movements, combining non-conflicting movements and similar other modifications. Alternative intersections and interchanges reduce conflict points by adopting unconventional movements which results in improved safety; improvised design also helps in reducing vehicle delays resulting in enhanced capacity and smoother traffic operations. There are several types of alternative intersections and interchanges, each design has its benefits and limitations. Depending upon project need and available resources, appropriate type of alternative intersection or interchange can be chosen. Benefits and limitations of several alternative intersections and interchanges is summarized in table-1.1 below.

Table 1. 1: Summary of several Alternative Intersection and Interchange designs

AII Design	Advantages	Limitations	Location
MUT	• Improves safety, has 16 conflict points • Fewer signal phases hence reduces delay and lower waiting time • MUT installation costs less than adding a lane for capacity enhancement.	• Performance deteriorates when ratio of minor road volume to total intersection volume exceeds 0.25 • Land acquisition and ROW constrainsts • Minor street left turns are redirected and hence it can lead to driver expectancy issues and higher travel time for those movements	Poplar Tent Road at Derita Road, Concord, N.C.

Table 1.1 (continued): Summary of several Alternative Intersection and Interchange designs

AII Design	Advantages	Limitations	Location
RCUT	• Improves safety, has 18 conflict points • Each direction of major road operates as one-way street resulting in overall capacity enhancement. • Fewer traffic signal phases reduce delay. • RCUT installation costs less than adding a lane for capacity enhancement.	• Performance deteriorates when ratio of minor road volume to total intersection volume exceeds 0.2 • Minor street left and through movements are redirected and hence it can lead to driver confusion and higher travel time for those movements	Highway 9 East at Liberty Church Road, Loris, S.C
Bowtie	• Improves safety, has 20 conflict points. • Roundabouts enable safe pedestrian and bicyclists' movements. • Fewer signal phases and hence lower delays. • Suitable in limited ROW locations • Bowtie installation costs less than adding a lane for capacity enhancement.	• Higher chances of driver confusion as majority of the turning movements are redirected. • Higher delays for left turning vehicles • Placement of roundabouts is challenging • Potential spillback issues at roundabouts	Only proposed, not yet implemented in US
Jughandle	Safe movement of pedestrians and bicyclists on main intersection. Fewer signal phases at main intersection and hence lower delays, reduces overall travel time. Shorter pedestrian crossing distances across mainline.	Land acquisition and ROW constraints Pedestrian conflicts increases along the cross street due to the addition of an additional intersecting approach. Increased travel time for left turns from the arterial Potential for driver confusion	Jackson Avenue & State Highway 23, Pequannock Township, NJ

Table 1.1 (continued): Summary of several Alternative Intersection and Interchange designs

AII Design	Advantages	Limitations	Location
CFI/XDL/DLT	• Spreads total number of conflict points, making intersection safer. • Allows simultaneous movement of protected left turns and opposing through-movements • Better signal coordination possible resulting in lower delays. • Less potential for driver confusion	• Land acquisition and ROW constraints • Left turning vehicles need to pass through two signals resulting in higher delays relatively • Restricts direct access to parcels located in corners of an intersections	State Route 741 (North Springboro Pike) at Austin Boulevard, Miamisburg, Ohio
Quadrant	• Spreads out number of conflict points, making it a safe facility. • Reroutes left turns resulting in fewer signal phases and less waiting time. • Coordination of 3 signalized intersections improves corridor travel times.	• Greater potential for driver confusion and disregard of left turn prohibition at main intersection • Increased travel time for left turning vehicles • ROW constraints; land acquisition is challenging unless a side street exists and it is utilized.	State Route 4 at State Route 4 Bypass/Ross Road, Fairfield, Ohio
Split	• Spreads out conflict points where vehicles and pedestrians may cross paths. • Separates traffic flow on major street resulting in operations with less delay. • Better signal coordination possible on major street as well as minor street improving travel time of entire corridor.	• Greater ROW needs in comparison to other alternatives • High costs of construction and maintenance • Drivers experience multiple stops and hence higher delays of signals are not properly coordinated.	U.S. 1 in Old Town Alexandria, Va.

Table 1.1 (continued): Summary of several Alternative Intersection and Interchange designs

AII Design	Advantages	Limitations	Location
USC	• It eliminates left-turn conflicts with the opposing traffic by crossing both through and left movements to the left side of the road at the four approaches prior to the intersection. • Fewer signal phases and signal coordination can improve mobility of corridor. • Suitable for balanced intersection volumes	• Greater potential for driver confusion as crossovers exist on all four legs of an intersection • Delays during non-peak hours are almost equal to that of peak hours • Insufficient guidance on access management, pedestrian conflicts, construction costs and similar others vital parameters	Only proposed, not yet implemented in US
Roundabout	• Improves safety by enforcing lower speeds and reducing conflict points. • Yield controlled intersection, results in lower delays and shorter queues. • Lower long-term operations and maintenance costs as no signals are installed. • Better aesthetics and landscaping.	• Lower capacity than conventional four-legged signalized intersection • Higher chances of driver confusion in initial years of installation • Lack of signalized pedestrian crossings • Difficult to maneuver heavy vehicles; may run over central island	Hillsborough St. at Pullen Rd, Raleigh, NC.
DXI	• Can handle higher volumes with less delay than conventional intersections. • Suitable for heavy left turns on major street.	• For lower volumes, its performance is similar to conventional intersection • Higher number of stops for pedestrian crossings • Potential for driver confusion is much higher and can arise safety concerns	Only proposed, not yet implemented in US

Table 1.1 (continued): Summary of several Alternative Intersection and Interchange designs

AII Design	Advantages	Limitations	Location
PFI	• Fewer signal phases resulting in lesser delays. • Eliminates permitted left turns making it safer facility than conventional intersection • Has channelizing island for pedestrian refuge	• Inefficient pedestrian and bicycle movements • Greater potential for driver confusion	Only proposed, not yet implemented in US
DDI (Interchange)	• Improves safety, has 18 conflict points • Can operate with 2-phase signals and can handle higher volume of traffic • Easy access to Freeway; does not require crossing of opposite lanes • Cost effective in terms of a retrofit or new interchange construction.	• Access to parcels in neighborhood is challenging • Potential for driver confusion	Poplar Tent Road at I-85, Concord, NC
SPUI (Interchange)	• Requires only one signalized intersection; vehicles cross paths at only one location. • Operates with 3-phase signals hence reduces overall interchange delay • Left turns can be made at higher speeds	• Longer bridge spans resulting in higher construction costs • Pedestrian and bicycle crossings are difficult • Vehicles cross path at single point resulting in greater driver confusion	U.S. 50 (Arlington Boulevard) at Gallows Road, Falls Church, Va.

Table 1.1 (continued): Summary of several Alternative Intersection and Interchange designs

AII Design	Advantages	Limitations	Location
DLT (Interchange)	• Improves safety, has 22 conflict points and spreads conflict points. • Simultaneous movement of protected left turns and opposing through movements; hence can operate with two phase signals. • Better signal coordination is possible allowing traffic to spend less time stopped.	• Land acquisition and ROW constraints • Greater potential for driver confusion	I-35 at East Hopkins Street, San Marcos, Texas
Contra-flow Left (Interchange)	• Reduces potential for rear-end crashes • Operates with 3 signal phases; reduces overall interchange delay. • Smooth and better traffic flow and hence congestion reduces.	• Operationally ineffective when left turn volumes are significantly imbalanced. • Higher costs for bridge construction and maintenance • Potential for wrong way movements caused due to driver confusion	State Route 869 (Sawgrass Expy) at Lyons Rd, Coconut Creek, Fla.
Roundabout (Interchange)	• Reduces potential for right-angle and head-on crashes by reducing number of conflict points. • Eliminates need for traffic signals; traffic can flow in smoothly	• Spreads out in large areas; land acquisition is challenging and can add to cost • Assess to parcels in neighborhood is challenging	US 9 at Troy Schenectady Road, Latham, N.Y.

1.3 Problem Statement

Out of all the AII designs researched and developed, few states have constructed more than one AIIs whereas some states have focused on single or two AIIs. For instance, Jughandles are common in New Jersey, CFIs are common in Utah, MUTs are common in Michigan and similar

others. Similarly, RCUTs or Superstreets are common design in North Carolina and are implemented at several locations. RCUT development is dramatically peaking in NC and United States. Myriad research on RCUTs has been done and is ongoing in field of operations, design and safety. Federal Highway Administration (FHWA) has published informational guide on RCUT intersection and also the latest edition of Highway Capacity Manual (HCM) has procedure for analysis of RCUT. This research aims to contribute to existing guidance on RCUT and hence this research is focused on RCUT intersections.

Restricted Crossing U-turns (RCUTs) is an intersection form wherein minor street left-turns and through movements are redirected to major street right turn; vehicles are then required to make a U-turn downstream to complete desired movements. There are various design elements of RCUT which govern its operation such as spacing of U-turn crossover, intersection control, acceleration and deceleration lanes, signage and markings, distance to neighboring intersection and similar others. Majority of RCUTs are either signalized or stop-controlled, very few RCUTs are merge controlled. Out of all these major and minor factors governing RCUT operation, three vaguely researched so far are: spacing of U-turn crossover, length of storage bays and spacing to neighboring intersections. Spacing of U-turn crossover affects delays of minor street vehicles and hence in turn performance of entire intersection. Length of storage bays govern queue length and queue spillover can cause safety and operational concerns. Spacing of main intersection to neighboring intersection is essential to identify if the RCUT will affect neighboring intersection in terms of causing higher delays, calling in for corridor level modelling. Design of these three parameters for signalized as well as stop-controlled RCUT is dependent of several factors, one major of this being traffic volumes. Several research works have been done to provide guidance on these three parameters but no solid or clear relationship in correlation to traffic volume exists.

This thesis focuses on addressing this and attempts to develop a concrete guidance on these three parameters for signalized as well as stop-controlled RCUT in relation to traffic volumes.

1.4 Research Objectives and Scope

This research work focuses on development of guidelines for design of three parameters i.e. U-turn spacing, length of storage bays and advisable spacing to neighboring intersection for signalized as well as stop-controlled RCUT in correlation to traffic volume. Impact of traffic volume variation on each parameter was observed and deductions were made based on these data obtained. Use of VISSIM, a microsimulation tool has been done to generate output data and mathematical modelling was done to develop relationships between required parameters.

FHWA's Technical brief on RCUT (Bared 2009) explains that RCUTs are most suitable, in terms of traffic volume when ratio of minor street total volume to total intersection volume is less than or equal to 0.20. In this study, this ratio is varied from 0.05 to 0.20 in intervals of 0.05 units and corresponding changes in three design parameters mentioned earlier are observed. Based on these observations, design warrants are developed. Major objectives of this study are outlined as follows:

- Observe effects on three basic parameters of RCUT design: Spacing of U-turn crossover, Length of storage bays and distance to neighboring intersection with variation in traffic volume.
- Develop a relationship between traffic volume variation and required U-turn spacing, length of storage bays and impact to neighboring intersection using VISSIM, a microsimulation tool.
- Primary assumption is that the resulting values will be different for signalized RCUT and stop-controlled RCUT and hence relationships for both are developed independently.
- Develop a planning level advisory based on these relationships so as to make RCUT planning smoother, promote implementation of RCUTs.

1.5 Thesis Organization

This dissertation comprises of an abstract and eight chapters in total. Chapter 1 i.e. Introduction gives an overview of alternative intersections and interchanges along with research objectives and problem statement. Chapter 2 i.e. Literature Review, summarizes research articles, research papers and reports within the scope of this study, emphasizing basically on RCUT design elements and traffic operations. Chapter 3 i.e. Data preparation explains how the data is collected and how has it been cleaned so as to use it for modelling. Chapter 4, titled as Methodology explains the procedure adopted in detail along with the use of VISSIM. Chapter 5 Results and Discussion focuses on summarization of the results obtained and trends relating to it. Chapter 6 i.e. Conclusions and Recommendations, presents the deductions and final conclusions based on analysis' results and mathematical model. This chapter also gives direction for future research. Chapter 7 and 8 are References and Appendices respectively, chapter 7 lists all the research works cited and referred to in this study and chapter 8 contains additional results and tables which can be helpful for detailed review of this thesis.

2. LITERATURE REVIEW

2.1 RCUT Intersection: An Overview

RCUT or Reduced Crossing U-Turn intersection redirects minor street left turn and through movements to further downstream on major road and then do a U-turn to complete desired movement. RCUT intersection has several synonyms, it is also known as Superstreet, J-Turn intersection and Synchronized street intersection.

Concept of RCUT intersection was first published in US in1987 by Richard Kramer (Kramer 1987) and since then, myriad research works has been done on this intersection to understand and quantify safety and operational benefits of RCUT intersection. Number of research articles and research projects confirm that RCUT intersection helps in making intersection safer and reduces delay in comparison to conventional intersection when traffic volume is within the specifications. There are basically three types of RCUT intersections (Hummer, et al. 2014) based on controls:

- Signalized-RCUT: Traffic flow on minor street, major street and U-turn crossovers are controlled by traffic signals. Signals at RCUT provide adequate progression opportunities and can operate with two-phase resulting in lower lost times. Typical signalized RCUT is shown in figure 2.1 below.

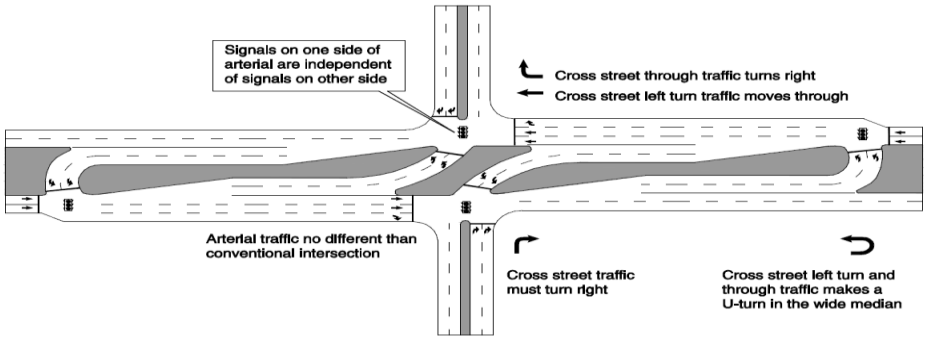


Figure 2. 1: Typical four-legged RCUT intersection

- Stop-controlled RCUT: In this type of RCUTs, traffic flow at major street, minor street and U-turn crossovers are governed by stop control and intersection operates on Gap-Acceptance process. Typical stop-controlled RCUT is shown in figure 2.2 below.

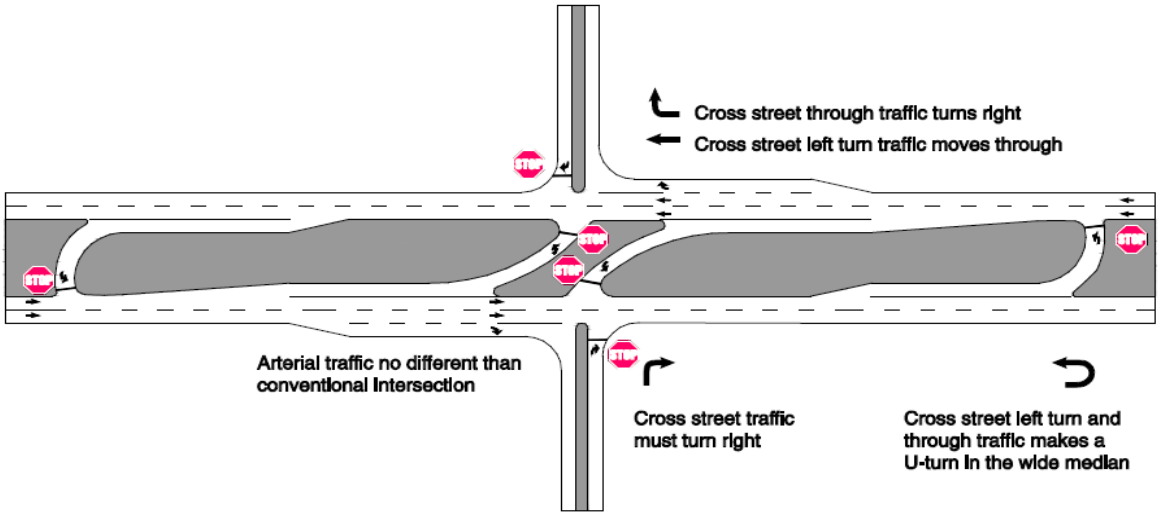


Figure 2. 2: Typical four-legged stop controlled RCUT

- Merge-controlled RCUT: In this type of RCUT, traffic flows are controlled by weaving operation which are governed by yield signs mostly. Hence it is also known as yield-controlled RCUT. Typical merge-controlled RCUT is shown in figure 2.3 below.

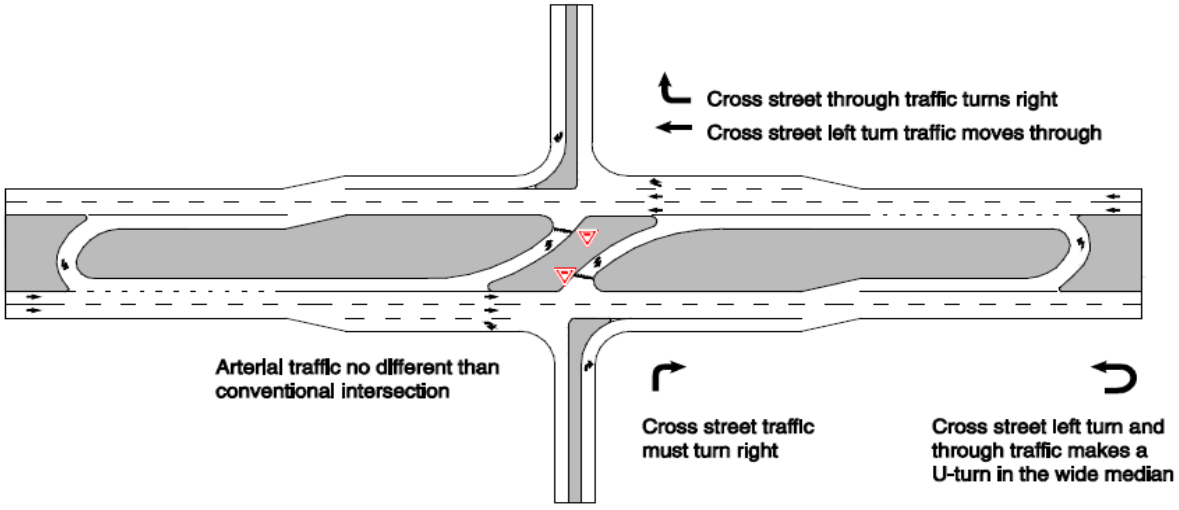


Figure 2. 3: Typical merge controlled four-legged RCUT

Stop-controlled and merge-controlled RCUTs can be termed as unsignalized RCUTs and RCUT with signals is termed as signalized RCUTs. RCUTs with different type of intersection control fails at different traffic volumes. Unsignalized RCUTs can handle lower traffic volumes in comparison with signalized RCUTs. Installation of unsignalized RCUTs at locations with traffic volumes higher than certain limit can cause unreasonably high delays resulting in intersection failure. A nomograph has been developed by FHWA for feasible demands for these two types of RCUTs i.e. signalized and unsignalized; it is shown in figure 2.4 below.

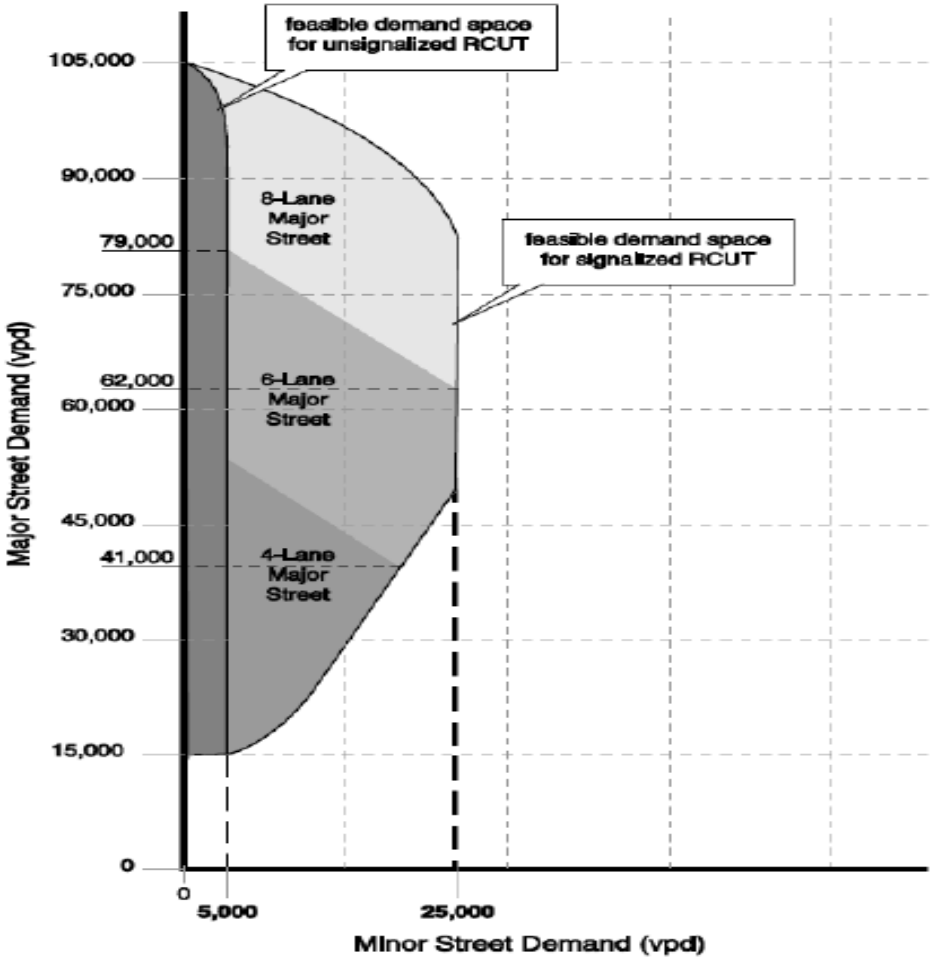


Figure 2. 4: Feasible demands for RCUTs

(Source: (Hummer, et al. 2014)*)*

2.2 Design Elements of an RCUT

There are various minor and major design factors to be considered when RCUT intersection is to be constructed. Broadly these design elements can be classified into three categories described below. Figure 2.5 represents design elements of RCUT.

(a) Main Intersection Design: Design of main intersection includes design of Left turn crossovers also known as J-turn design, minor street right turn design and relevant lane assignment, acceleration lanes on minor street if required and other minor factors such as curb design, gutter design and others.

(b) U-Turn Crossover Design: It is one of the most critical elements of RCUT design. It includes design of crossover spacing, crossover design, U-turn lane design, design of storage bays and acceleration lanes.

(c) Pedestrian and Bicycle Facilities: It includes design of footpaths and bicycle lanes if required. RCUT is typically implemented in sub-urban to rural setting with low to no pedestrian and bicycle traffic and hence it is not a major concern most of the times. If these facilities are required, a conventional Z-crossing is provided with minor changes if required.

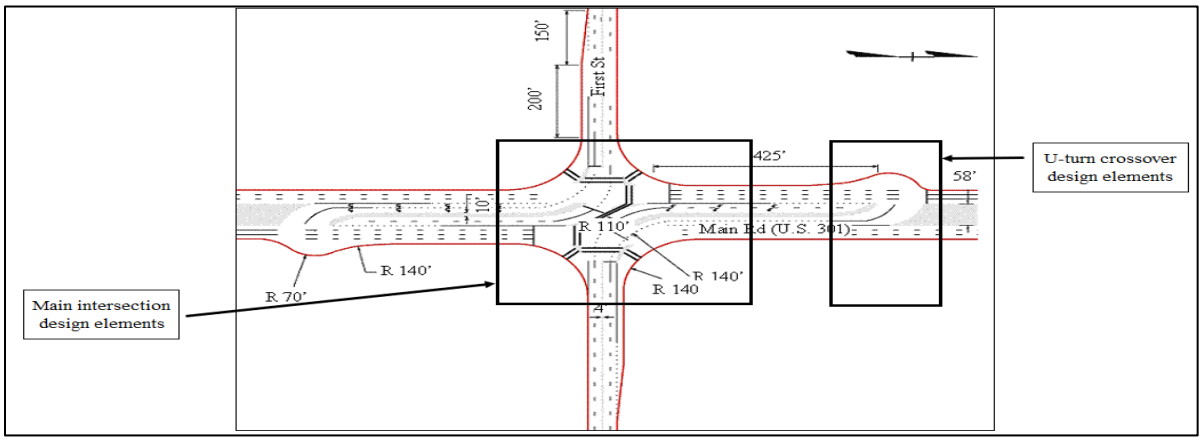


Figure 2. 5: Design elements of RCUT intersection

Of the three main design components described above, in comparison to conventional intersection, U-turn crossover design is the only novel addition to the intersection. Components of main intersection design and pedestrian and bicycle accommodation are similar to conventional intersection design. Hence design of U-turn crossover becomes most critical element of RCUT design and hence this thesis focuses on U-turn crossover design more than other design elements. Next portion of these section summarizes literature review on U-turn crossover design elements.

U-Turn Crossover Spacing

Vehicles from minor street willing to turn left or go straight (through) are redirected to U-turn crossover downstream to make a U-turn and complete desired movement. Higher the distance of U-turn crossovers from main intersection, more distance will the vehicles from minor street have to travel resulting in extended travel times. This may lead to increased delays and hence optimum spacing is necessary for U-turn crossovers.

Documents by FHWA states following for U-Turn crossover spacing (Horn 2016), "Several factors should be considered when selecting the appropriate spacing from a main intersection to a U-turn crossover. Longer spacing between the main intersection and crossovers decreases spillback probabilities, providing more time and space for drivers to maneuver into the proper lane and read and respond to highway signs. Shorter spacing between the main intersection and crossovers translates to shorter driving distances and travel times for the minor street left turn and through vehicle travel times, which are a strong measure of operational effectiveness." Different agencies provide different specifications and restrictions on spacing of U-Turn crossovers. Table 2.1 summarizes guidance given by different agencies for stop controlled as well as signalized RCUT intersections. Less research has been done for merge controlled RCUTs.

Table 2. 1: U-Turn Crossover spacing recommended by several agencies

Agency	Minimum Spacing	Maximum Spacing
AASHTO*	400 ft.	600 ft.
TRB Access Management Manual	660 ft.	1320 ft.
North Carolina DOT	800 ft.	1000 ft.
Michigan DOT	560 ft.	760 ft.
Oregon DOT	990 ft.	1320 ft.
Virginia DOT**	400 ft.	800 ft.
Missouri DOT***	600 ft.	1000 ft.

*For signalized intersection
**For merge controlled it can be up to 2600 ft.
***Specific location to be determined by Capacity Analysis

(Source: (Horn 2016), (VDOT 2019)*)*

Apart from DOTs and other renowned agencies, few papers are also written in this domain to develop some guidance on U-Turn crossover spacing. In (Edara, et al. 2016), use of crash data and crash analysis was done to interpret optimum spacing of U-Turn crossovers. It was observed that RCUTs with spacing between 1000 ft. to 2000 ft. experienced lower crash rates and hence it was recommended for low volume traffic whereas spacing of 2000 ft and higher was recommended for medium to high volume traffic. No specific traffic volume bounds were established and data used for analysis was limited, crash data from only 12 RCUTs were used for analysis; these were the limitations of this study. Another study applied somewhat similar method (Xu, Yang and Chang, Computing the Minimal U-Turn Offset for an Unsignalized Superstreet 2017) i.e. relying on crash statistics to obtain optimal spacing for unsignalized RCUT. It was observed that safety of intersection remained almost constant when the spacing reduced from 1500 ft. to 1100 ft. whereas it became dramatically unsafe i.e. crash rates increased when it was reduced to 700 ft. Driver behavior is also an important component in determining optimal spacing as it impacts safety and operations directly and indirectly. In a paper by (Sun, Qing, et al. 2017), use of driving simulator was done to obtain configurations of U-turn spacing in combination with acceleration and

deceleration lanes. It was observed that for RCUTs with acceleration lanes, spacing of 2000 ft. was optimum whereas for RCUTs with only deceleration lane, spacing of 1000 ft. was adequate.

Of all the studies done in this field to investigate optimal spacing of U-Turn crossovers, one common limitation observed in most of the studies was that none of the studies investigated spacing requirements from operational standpoint. It is necessary to correlate traffic volume with spacing in order to get clear understanding of RCUT operations for a specific traffic volume.

Acceleration-Deceleration Lanes and Storage Bays

Acceleration and Deceleration lanes play vital role in RCUT design to carry out safe weaving maneuver. Vehicles from minor street willing to turn left and go through are bound to perform weaving in RCUT intersection and hence safe design to complete weaving maneuver is important for RCUT intersection. Inadequate length of acceleration and deceleration lanes can lead to unsafe weaving and spillover which causes additional delay.

Lengths of acceleration and deceleration lanes are different for different types of RCUTS. For stop-controlled and signalized RCUT, methodology used for determination of acceleration and deceleration lengths is same and for merge-controlled reasonably long acceleration and deceleration lanes are provided. This study limiting its scope to stop-controlled and signalized RCUT intersections, literature only on these two types of RCUTs are discussed. AASHTO's Green Book (A Policy on Geometric Design of Highways and Streets (The Green Book) 2018) provides guidance on length of acceleration and deceleration lanes based on design speed of highways. Table-2.2 and table-2.3 below describes guidance provided by The Green Book. For guidance relating to referring table, green book must be referred. The guidance provided by The Green Book can be used for determination of lengths of acceleration and deceleration lanes for signalized and stop-controlled RCUT.

Table 2. 2: Guidelines for Determination of Acceleration Length

U.S. Customary									
Acceleration Length, L (ft) for Entrance Curve Design Speed (mph)									
Highway		Stop Condition	15	20	25	30	35	40	45	50
Design Speed, V (mph)	Speed Reached, V_a (mph)	and Initial Speed, V'_a (mph)								
		0	14	18	22	26	30	36	40	44
30	23	180	140	—	—	—	—	—	—	—
35	27	280	220	160	—	—	—	—	—	—
40	31	360	300	270	210	120	—	—	—	—
45	35	560	490	440	380	280	160	—	—	—
50	39	720	660	610	550	450	350	130	—	—
55	43	960	900	810	780	670	550	320	150	—
60	47	1200	1140	1100	1020	910	800	550	420	180
65	50	1410	1350	1310	1220	1120	1000	770	600	370
70	53	1620	1560	1520	1420	1350	1230	1000	820	580
75	55	1790	1730	1630	1580	1510	1420	1160	1040	780

Note: Uniform 50:1 to 70:1 tapers are recommended where lengths of acceleration lanes exceed 1,300 ft.

(Source: (A Policy on Geometric Design of Highways and Streets (The Green Book) 2018)*)*

Table 2. 3: Guidelines for Determination of Deceleration Length

U.S. Customary										
Deceleration Length, L (ft) for Design Speed of Exit Curve V' (mph)										
Highway Design Speed, V (mph)	Speed Reached, V_a (mph)	Stop Condition	15	20	25	30	35	40	45	50
		For Average Running Speed on Exit Curve, V'_a (mph)								
		0	14	18	22	26	30	36	40	44
30	28	235	200	170	140	—	—	—	—	—
35	32	280	250	210	185	150	—	—	—	—
40	36	320	295	265	235	185	155	—	—	—
45	40	385	350	325	295	250	220	—	—	—
50	44	435	405	385	355	315	285	225	175	—
55	48	480	455	440	410	380	350	285	235	—
60	52	530	500	480	460	430	405	350	300	240
65	55	570	540	520	500	470	440	390	340	280
70	58	615	590	570	550	520	490	440	390	340
75	61	660	635	620	600	575	535	490	440	390

(Source: (A Policy on Geometric Design of Highways and Streets (The Green Book) 2018)*)*

In a RCUT intersection, acceleration and deceleration lane are mostly used for merge-controlled RCUT. For signalized and stop-controlled RCUT, storage bays are important component to avoid spillover and carry on smooth operations. For signalized and stop-controlled RCUT intersection, based on 95^{th} percentile queue lengths, appropriate length of storage bays is provided after accounting for variability. For vehicles trying to make a left turn or go through from a minor street, need to go through U-turn crossover and hence need to utilize storage bays as well. For some designs of RCUTs, storage bay is directly connected from minor street whereas for some it provided after some distance downstream. Undoubtedly this causes safety concerns but it also affects total delay for vehicle. This is mostly unexplored; no studies have focused on correlating length of storage bay and delay associated with it. Limited studies have been done to explore length of storage bays for RCUT intersection. At present, engineers provide length of storage bays mostly based on expected queue lengths, appropriate length of storage bays is provided.

Impact to Neighboring Intersection

DOTs for several states in US are encouraging development of Alternative Intersections and out of all the AIIs, RCUT intersections are developing at increased pace. There have been numerous studies on traffic impacts of RCUTs focusing on capacity, safety, delays, and similar other measures of effectiveness (Abou-Senna, Radwan and Abdelwahab 2018), (Haley, et al. 2011), (Hummer, Haley, et al. 2010). Undoubtedly these are important but one of the critical parameters for RCUT Planning is its impact to neighboring intersection. RCUT intersections are usually developed in a corridor and a set of three, four or more RCUTs is usually provided. There are numerous sites in US wherein entire corridor is converted to RCUT corridor rather than converting single conventional intersection to RCUT.

RCUT design involves design of U-Turn Crossover and hence it is necessary to maintain effective spacing from neighboring intersection to avoid overlapping and longer queues resulting in higher delays. There have been impact studies on RCUT but their primary focus has been economic impacts, impacts on resident in neighborhood of RCUT, commuter impacts on businesses and similar others. No study has been done so far which explicitly focuses on impact of RCUT on neighboring intersection and advisable spacing for an RCUT corridor. It is an important parameter and microsimulation can provide significant results which can be helpful for providing some guidelines relating to effective spacing. In this study, through VISSIM modelling, required spacing between a RCUT and a conventional intersection and between two RCUTs has been explored.

2.3 Operational Analysis of RCUT

There have been several studies which did operational analysis of different types of RCUT using different methodologies. A research report in early 2000s studied RCUT intersection and reviewed its operations and design variation (Reid 2004). Several benefits and limitations of RCUT are discussed with a section on challenges encountered for its implementation. In a study done in 2011 (Haley, et al. 2011) three existing signalized superstreets were compared with conventional signalized intersection using VISSIM with various volume levels. It was observed that superstreet outperformed all the conventional intersections and researchers used travel time as primary measure of effectiveness. Another study examined the potential of replacing Two-Way Stop Control (TWSC) and All-Way Stop Control (AWSC) with RCUT intersection on rural highway (Sangster and Adams, Restricted Crossings on Rural Highways 2019). HCM analysis as well as VISSIM models were used for analysis; it was found that it is feasible to replace TWSC and AWSC with RCUT intersection. Researchers suggested that one of the most important

parameters to consider is increase in delays of minor street vehicles in case of higher volumes. It is essential to compare different forms of Alternative Intersections and Interchanges to understand which one performs better of several designs available. In a study by (Abou-Senna, Radwan and Abdelwahab 2018) left-turn movements of RCUT were compared with MUT. It was observed that RCUT showed 52% improvement over MUT in average speeds and 66% in delay savings. In this study, VISSIM models were used for analysis and to obtain results. Another study evaluated RCUT intersection as an alternative to grade separated interchanges (Morello and Sangster 2018). There are instances where a stop-controlled RCUT is to be converted to a signalized one to improve operations and safety. There have been research works in this section, in (Warchol, et al. 2019), warrants for need of signalization considerations were developed based on Gap-acceptance data collected in North Carolina. This paper published several charts to determine 95^{th} percentile queue lengths for different movements for intersections having less than four-legs. These charts, especially the one for U-Turn movements can be useful for decision-making process for RCUT signalization. Based on analysis using VISSIM, it was concluded that though grade separation has better operational benefits than RCUT, RCUT intersection is way more cost effective. A cost-benefit analysis showed that RCUT design is capable of recuperating construction costs within two years, with a 15-year return on investment for Grade-separated Interchanges.

Though each study on RCUT has different objectives, each study agrees to the point that RCUT intersections are beneficial than conventional intersections in terms of operations and safety. Even then there are some issues with RCUT implementation which is a reason why there are few RCUT intersections constructed. There have been few studies to identify obstacles for RCUT construction. In a report (Reid 2004), it was mentioned that some of the obstacles for RCUT implementation are driver expectancy and driver confusion, developing effective signing and

marking plans, enforcement and public awareness. Another study reported that RCUT implementation and AII implementation in general is slowed down as a result of some lingering questions about analysis procedure and design principles (Sangster, Operational Analysis of Alternative Intersections 2015). This thesis tries to address some of these designing principles by developing foundations for operational analysis useful for RCUT planning.

2.4 RCUT: Design Guidance

With the increased implementation of RCUT intersections, it is necessary to develop uniform and concrete design guidance for RCUT intersection. When RCUT is to be constructed, myriad minor and major parameters come into play. Some of the critical elements to consider for design of RCUT intersection are intersection control strategies, design of U-Turn crossovers, design of turning bays and storage bays, pedestrian and bicycle facilities, impact to neighboring intersection, safety considerations and similar others. Several research works have focused on these parameters to optimize RCUT implementation. In (Xu, Yang and Chang, Two-stage model for optimizing traffic signal control plans of signalized Superstreet 2018), intersection control strategies for RCUT were studied to account for unique geometry of superstreets using Mixed-Integer-Linear-Programming (MILP). Model developed in this study can be used effectively for signal progression for heavy through and left-turn movements to avoid queue spillback in RCUT.

Latest edition of HCM ((TRB) 2016) developed a method for analysis of RCUT intersection. HCM uses a parameter termed as “Experienced Travel Time (ETT)” for determining LOS for RCUT intersection. Experienced Travel Time is basically the time taken by vehicle to navigate intersection as a result of rerouting. ETT is basically sum of control delay and EDTT; EDTT is Extra Distance Travel Time which is the time experienced as result of rerouting. Based on this, LOS is calculated. Table 2.4 shows ETT range corresponding to LOS published in HCM.

Table 2. 4: LOS Criteria corresponding to ETT

ETT (s/veh)	Condition: $v/c \leq 1$ and $R_Q \leq 1$ for Every Lane Group	Condition: $v/c > 1$ for Any Lane Group	Condition: $R_Q > 1$ for Any Lane Group
≤10	A	F	F
>10–20	B	F	F
>20–35	C	F	F
>35–55	D	F	F
>55–80	E	F	F
>80	F	F	F

(Source: ((TRB) 2016)*)*

For pedestrian and bicycle facilities in Superstreet, a detailed study was done in (Holzem, et al. 2015) and recommendations of crossing alternatives were developed. Several alternatives for pedestrians such as diagonal cross, median cross, two-stage Barnes Dance, and midblock cross were studied. Also for bicyclists, several crossing options such as bicycle U-turn, bicycle use of the vehicle U-turn, bicycle direct cross, and midblock cross. Options were studied using microsimulation models and conclusions were drawn. Similarly, many studies were done to develop design guidance on some critical parameters for RCUT design. A study useful for decision-making of RCUT planning was not explored and hence this thesis aims to address this research gap.

2.5 Summary of Literature Review

Literature reviewed in this thesis suggests that there have been several studies which explored operational performance and design parameters for different types of RCUTs. Also, some studies analyzed RCUT intersection as a replacement to grade separation, conventional signalized and stop controlled intersections. Though there has been significant research in the field of RCUT operations, three parameters remain relatively unexplored. In this study, these three parameters are studied and a framework for development of comprehensive planning level tool is suggested from

traffic operations standpoint. There are several factors which are to be considered for planning level analysis of RCUT such as U-Turn crossover spacing, Intersection control strategies, pedestrian and bicyclists facilitation, provisions for Right Turn on Red, length of storage bays and similar others. Developing a planning level tool with all the factors considered requires ample of time and resources. This MS thesis limits its analysis to three critical parameters of the lot: U-Turn Crossover Spacing, Length of Storage Bays and Spacing to neighboring intersection.

This study attempts to develop clear relationship between traffic volumes and required spacing of U-Turn crossover, lengths of storage bays and spacing to neighboring intersection. Use of VISSIM, a microsimulation tool has been done for this; detailed methodology is discussed in up-coming chapters.

3. DATA PREPARATION

3.1 Traffic Volume Data

This thesis aims at developing relationships between various design parameters and traffic volumes for a Superstreet; hence it basically involves sensitivity analysis. As a result, there was no need to collect fresh data and hence previously collected data was used for this thesis with some necessary improvisations. Site selected for this project was a corridor on Ocean Hwy E (US 17) located in Leland, North Carolina which has several RCUTs. For isolated RCUT analysis, critical intersection chosen was Lanvale Rd SE / Lanvale Rd NE at Ocean Hwy E with minor modification (discussed below) so as to account for symmetry. Figure 3.1 shows site selected for study.

Figure 3. 1: Site selected for VISSIM Modelling

(Source: (Google Maps n.d.)*)*

For any traffic design project, one of the most basic and most vital input is Turning Movement Counts (TMCs). Hence in this research, use of Turning Movement Counts (TMCs) was done as an input parameter for traffic volumes. In this study, TMC data collected in a research report published by NCDOT was used. For the critical intersection, TMC data used is shown in table 3.1 below.

Table 3. 1: Turning Movement Counts for site selected

Direction	Volumes	Approach Volume	Turning Percentage	Road	Street Volume	Int. Volume
WBL	72	423	0.17	Minor Road (Lanvale Rd)	472	3674
WBR	340		0.80			
WBT	11		0.03			
EBL	21	49	0.43			
EBR	18		0.37			
EBT	10		0.20			
NBL	21	1372	0.02	Major Road (Ocean Hwy E)	3202	
NBR	68		0.05			
NBT	1283		0.94			
SBL	19	1830	0.01			
SBR	68		0.04			
SBT	1743		0.95			
Critical Ratio		**0.13**				

As per the guidelines by FHWA (Bared 2009), RCUTs are suitable when minor street traffic is very low in comparison to major street traffic. Quantitatively, RCUTs are most applicable for installation when ratio of minor road total volume to total intersection volume is less than or equal to 0.20; this is termed as critical ratio in this study. For the data in table 5, critical ratio is 472/3674 i.e. 0.13.

This study aims to determine impacts on design parameters with varying traffic; critical ratio being vital parameter for RCUTs, it was varied and TMCs were generated. To account for

growth, total intersection volume was rounded off to 4000 vph and with varying critical ratios, keeping the proportion of vehicles turning same, turning movement counts for each approach was calculated so as to maintain uniformity. Four critical ratios were used for sensitivity analysis: 0.05, 0.10, 0.15 and 0.20. Detailed tabulation of turning movement counts for each critical ratio is shown in Appendix-A.

3.2 Geometric Data

In this study VISSIM was used as analysis tool and hence input of geometric data plays critical role in analysis and results obtained. Geometric data includes number of lanes, speed limit, U-Turn crossover spacing and similar data. Geometric data used in this study was collected using Google Maps (Google Maps n.d.) with the help of street view feature in it. Geometric Data collected is shown in table-3.2 below.

Table 3. 2: Geometric Data for site selected

Approach	Lane Assignment			Speed Limit (mph)	Crossover Spacing (ft)
	LT	RT	Th		
Lanvale Rd (EB)	0	1	0	45	820' on SB
Lanvale Rd (WB)	0	2+1*	0	25	845' on NB
Ocean Hwy E(NB)	1*	1*	2	55	N/A
Ocean Hwy E (SB)	2*	1*	2	55	N/A

*Pocket lanes

Based on the geometric and traffic volume data, a minor geometric modification was done in VISSIM model for critical intersection. As is shown in table 6, Ocean Hwy E has 2 left turn pockets on SB approach and 1 left turn pocket on NB approach. From the turning movement data shown in table 3.1, for SB approach, 0.01% of the vehicles are left turning and for NB approach, 0.02% are left turning. With such lower volumes, single left turning pocket on SB approach would

serve the purpose and hence in VISSIM modelling, SB approach is modeled with one left-turn pocket lane with its length sufficient to ensure that queuing vehicles do not spillover to the through lanes.

Traffic volume data and geometric data discussed above was used as an input in VISSIM model to obtain results. Two types of RCUTs were modeled: Signalized and Stop-Controlled RCUTs to obtain necessary results. Signal timing plans, details about VISSIM modelling and measure of effectiveness is discussed in next section i.e. Methodology.

4. METHODOLOGY

4.1 VISSIM Modelling: Overview

In this research, impacts on RCUT design parameters were observed by varying traffic in terms of turning movement counts. For this purpose, widely used and accepted microsimulation tool, VISSIM was used; VISSIM 10.0 was used to do the analysis. Primary purpose of this research was to develop relationships between design parameters of RCUT intersection and also to understand the impact of RCUT on neighboring intersection calling in for corridor level modelling. An intersection next to RCUT is most of the times either of the two: Conventional four-legged intersection or another RCUT. In rare cases, other forms of alternative intersections such as MUT, CFI and similar others are placed next to RCUTs. This is usually not advisable as it can cause higher amount of driver confusion leading to safety concerns. Hence this research is limited to exploring impact of RCUT on neighboring four-legged intersection and RCUT. Broadly, three types of VISSIM models were developed:

1. Isolated RCUT i.e. critical intersection to study impact of traffic on design parameters
2. Four-legged intersection adjacent to RCUT
3. RCUT placed adjacent to RCUT

In this three VISSIM models, TMC datasets explained in detail in chapter 3 were used to determine impacts of traffic variation on RCUT intersection. VISSIM model developed was aimed to replicate existing geometry, for this the geometric data collected using google maps was used as input. VISSIM modelling consists of number of inputs such as links, desired speed decisions, reduced speed areas, vehicle inputs and several other inputs so as to replicate exact driving scenario. VISSIM models developed for each of the three cases is discussed in detail in later sections of this chapter.

Isolated VISSIM model was used for determining relationship of U-turn spacing and storage bay lengths with respect to traffic. Hence variation in U-turn spacing and storage bay lengths was also necessary. Based on literature review it was observed that various research works have suggested crossover spacing for RCUT ranging from minimum of 400 ft. to maximum of 1000 ft; few articles suggests excessively high lengths of 1300-1400 ft. Hence in this research 6 sets with varying crossover spacing were constructed; crossover spacing was varied as: 500 ft, 600 ft, 700 ft, 800 ft, 900 ft, 1000 ft. It is described in chart form below.

Similarly, for storage bays, different sets were developed. It was observed that in many states and especially in NC, optimum crossover spacing of 800 ft is practiced for RCUTs with variation in length of storage bays. As a result, keeping crossover spacing as 800 ft, length of storage bays was varied to simulate different sets of traffic volumes and develop relationships. Length of storage bays was varied in different ratios as a function of crossover spacing. If the crossover spacing is represented by 'U', five sets with varying length of storage bays developed were: 0.2U, 0.4U, 0.6U, 0.8U, 1.0U. This was done particularly to see if there is any form of correlation between U-Turn crossover spacing and length of storage bays. This procedure was adopted so as to reduce the number of design parameters for RCUT planning. If there exists a relationship, for the planning of RCUT, on the basis of U-Turn crossover spacing, length of storage bays can be obtained. For this study, U-Turn crossover spacing was kept constant as 800 ft. for variation in length of storage bays. In essence, 5 sets of lengths of storage bays were studied. This were: 0.2U (800*0.2 = 160 ft.), 0.4U (800*0.4 = 320 ft.), 0.6U (800*0.6 = 480 ft.), 0.8U (800*0.8 = 640 ft.), 1.0U (800*1.0 = 800 ft.). After simulation results, it was observed that there is no strong and simple relationship existing between U-Turn Crossover Spacing and length of storage bays. Summary of different models developed in VISSIM is shown in chart below.

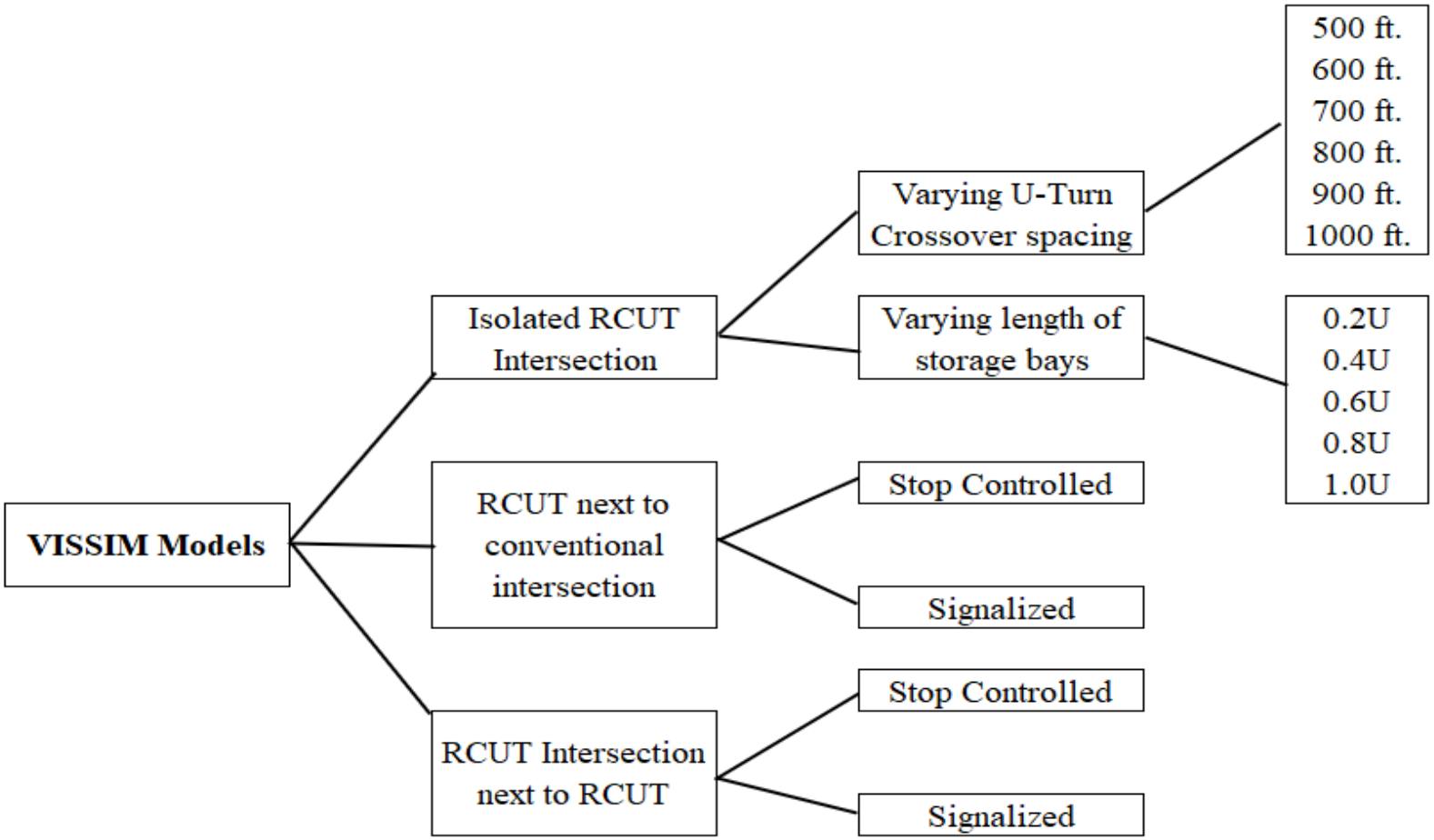


Figure 4. 1 Summary of VISSIM Models Developed

4.2 VISSIM Model for Isolated Intersection

a. Signalized Isolated RCUT Intersection

For signalized RCUT, geometry was similar to the geometry discussed in section 4.1 and listed in table 3.2. Apart from geometry, there are several inputs which are critical to develop consistent VISSIM model. Table 4.1 discusses each VISSIM attributes and corresponding procedure adopted. Figure 4.1 shows coded VISSIM network for signalized isolated RCUT Intersection.

Table 4. 1: VISSIM Procedures adopted coding Signalized Isolated RCUT

VISSIM Attributes	Coding procedures adopted
Links	Links were coded based on existing geometry and each geometric property was maintained similar to that in the field e.g. Number of lanes, turning pockets etc.
Desired Speed Decisions	For each approach, desired speed decisions were coded at the beginning of each leg based on posted speed limits. These were similar to speed limits mentioned in table-6
Reduced Speed Areas	Reduced speed areas were provided for each turning movement and speed distribution of 25 kmph (15 mph) for cars and 20 kmph (12.5 mph) for trucks was used. Similar speed distribution was coded for U-turn crossovers.
Signal Heads	For signalized RCUTs, signal heads were placed at main intersection and at U-Turn crossovers. It is similar to that shown in figure 1
Signal Controller	To operate signals as per a defined phasing and green time, a coordinated signal program was used; signal timing plans are discussed in detail in further sections.
Signal Program	Detailed discussion in upcoming section
Vehicle Inputs	Volumes generated in dataset-1 to 4 shown in appendix were used as input for critical intersection. Additional vehicle inputs can also be found in appendix.
Vehicle Routes	Static vehicle routing was used and vehicles were routed similar to how a typical RCUT operates by redirecting through and left movements of minor road.
Warm-up and Cool down period	Warm-up period: 900 seconds (15 mins) Cool-down period: 900 seconds (15 mins)
Simulation time	Each simulation run was of 90 minutes or 1.5 hours
Simulation Runs	For each TMC dataset, 5 simulation runs were done and average of those results were reported. Results were generated in bins of 900 seconds or 15 minutes
Evaluation type	Node evaluation

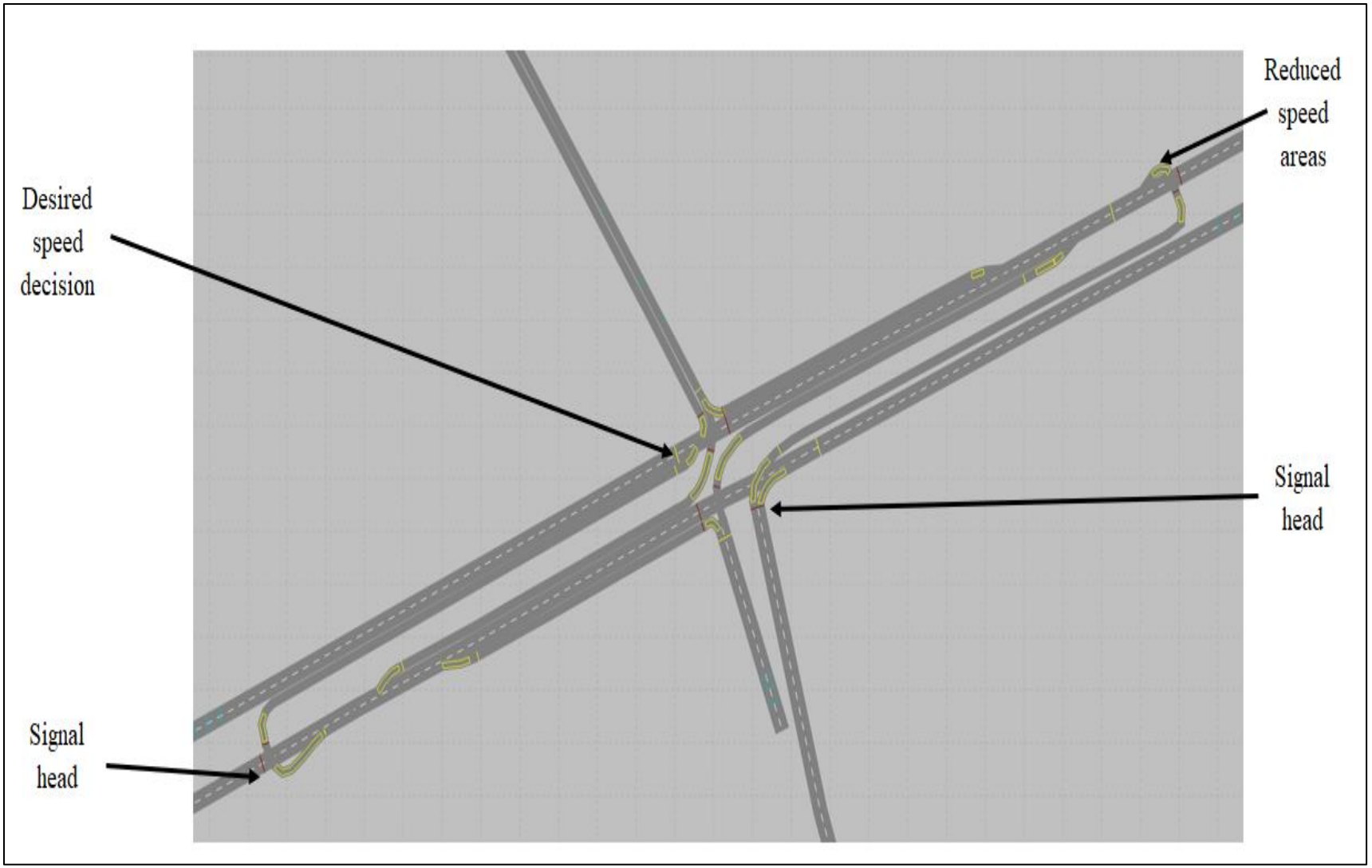


Figure 4. 2: Signalized RCUT

b. Stop-Controlled Isolated RCUT Intersection:

Table-4.2 shown below describes procedures adopted for modelling stop controlled RCUT in VISSIM and figure 4.2 shows final network.

Table 4. 2: VISSIM Procedures adopted for coding Stop-controlled Isolated RCUT

VISSIM Attributes	Coding procedures adopted
Links	Links were coded based on existing geometry and each geometric property was maintained similar to that in the field e.g. Number of lanes, turning pockets etc.
Desired Speed Decisions	For each approach, desired speed decisions were coded at the beginning of each leg based on posted speed limits. These were similar to speed limits mentioned in table-6
Reduced Speed Areas	Reduced speed areas were provided for each turning movement and speed distribution of 25 kmph (15 mph) for cars and 20 kmph (12.5 mph) for trucks was used. Similar speed distribution was coded for U-turn crossovers.
Conflict Areas	Conflict areas were determined and priorities were set similar to how a typical RCUT operates. It was used only for stop-controlled RCUTs
Priority Rules	Normal priority rules relevant for RCUT were used such as minor street vehicles yield to major street through movements and similar others. It was used only for stop-controlled RCUTs
Stop signs	Stop signs were allocated for turning movements at main intersection and U-turn crossover similar to that shown in figure 2
Vehicle Inputs	Volumes generated in dataset-1 to 4 shown in appendix were used as input for critical intersection. Additional vehicle inputs can also be found in appendix.
Vehicle Routes	Static vehicle routing was used and vehicles were routed similar to how a typical RCUT operates by redirecting through and left movements of minor road.
Warm-up and Cool down period	Warm-up period: 900 seconds (15 mins) Cool-down period: 900 seconds (15 mins)
Simulation time	Each simulation run was of 90 minutes or 1.5 hours
Simulation Runs	For each TMC dataset, 5 simulation runs were done and average of those results were reported. Results were generated in bins of 900 seconds or 15 minutes
Evaluation type	Node evaluation

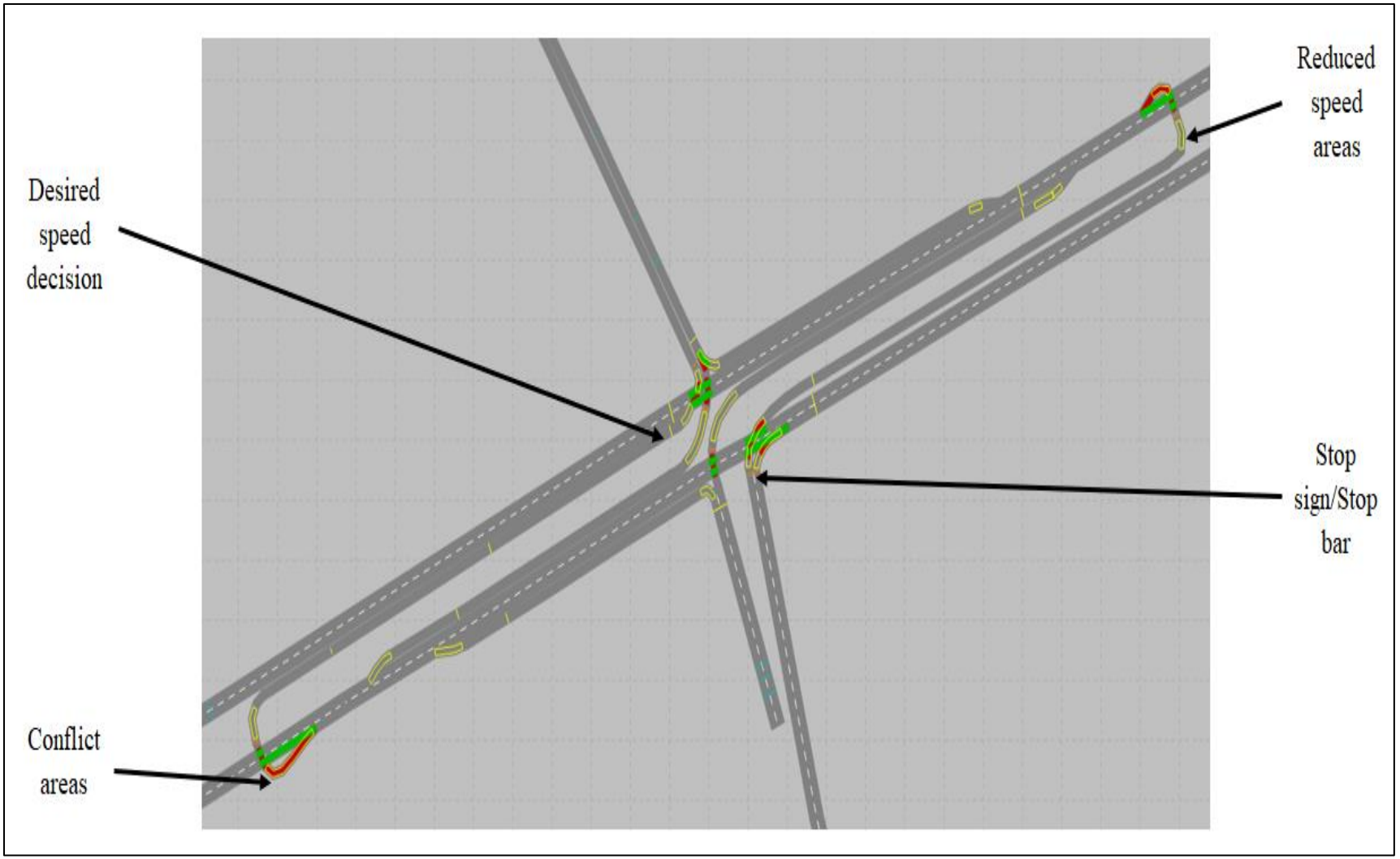


Figure 4. 3: Stop Controlled RCUT

4.3 RCUT Network: Four-legged intersection next to RCUT

For RCUT Network, a hypothetical four-legged conventional intersection was coded. Geometrics of this intersection is shown in table 4.3 below.

Table 4. 3: Geometrics of Conventional 4-legged intersection

Approach	Lane Assignment			Speed Limit (mph)
	LT	RT	Th	
EB	0	1**	0	45
WB	1	2*	0	25
NB	1	1	2	55
SB	1	1	2	55

**Shared Left, Right and Through lane
*Shared lane (through and right)

Volumes similar to existing volume shown in table 3.1 were used. 2 sets were coded: RCUT operating as signalized RCUT and RCUT operating as stop controlled RCUT. VISSIM coding procedure was similar to that shown in table 4.1 and 4.2. VISSIM model is shown in figure 4.4. Four-legged intersection was operating as signalized intersection all the time. For each of the case, fixed time signal plans were adopted. A typical four-phase signal were developed for this hypothetical intersection. Calculations were performed based on HCM methodology. Signal timing plans for RCUT are discussed in section 4.5; Signal timing plans for four-legged intersection is shown in figure 4.3 below.

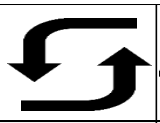
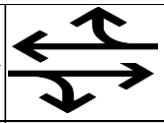
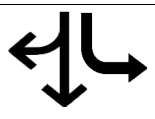
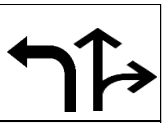
Phasing and splits for 4-legged intersection				
Phase	A	B	C	D
Green (s)	16	75	12	22
Yellow (s)	4	6	5	5
Red (s)	2	4	2	2
Cycle Length	155 seconds			

Figure 4. 4: Phasing plans and Splits for 4-legged intersection

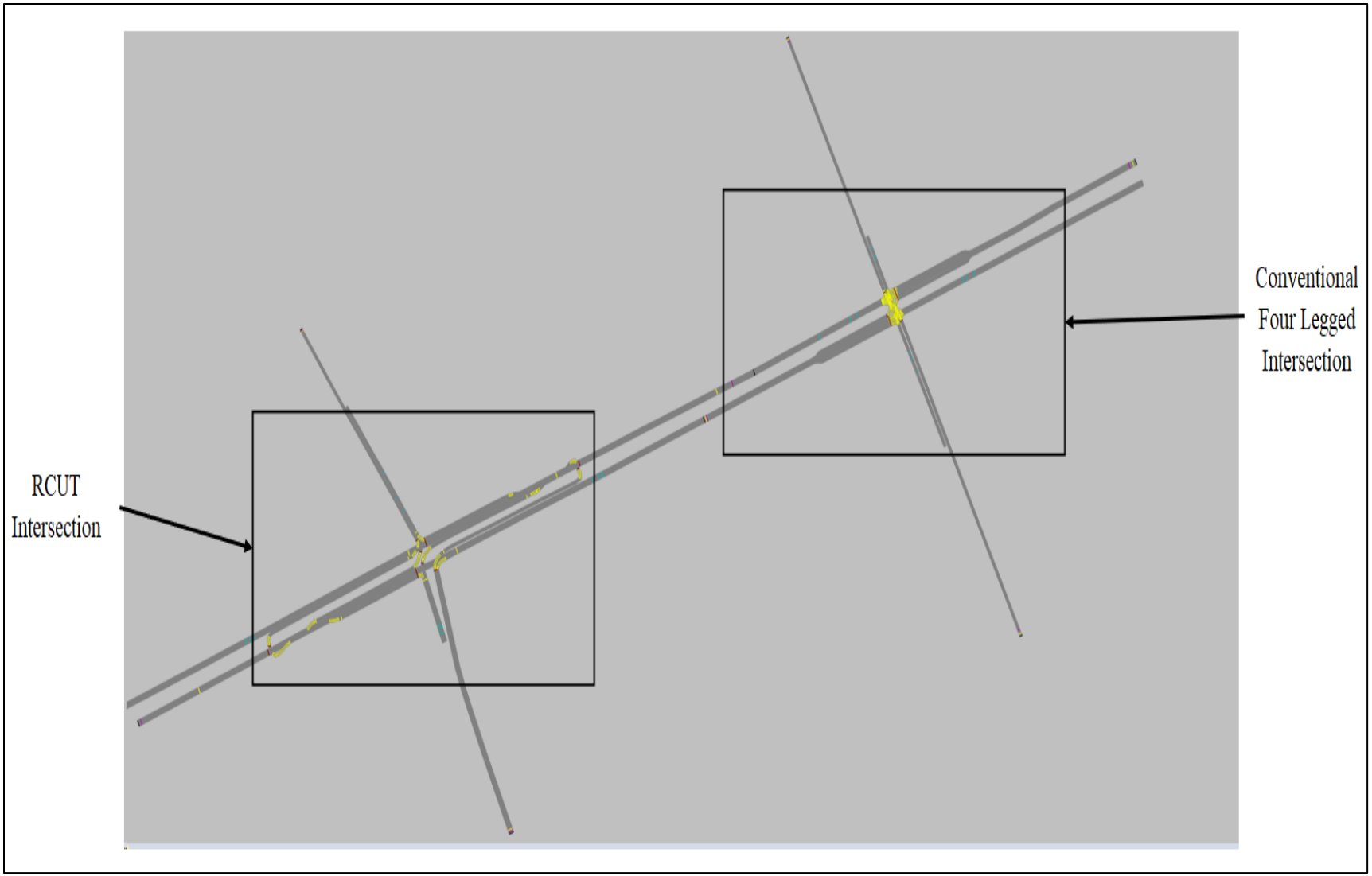


Figure 4. 5: RCUT Corridor: Four-legged intersection next to RCUT

4.4 RCUT Network: RCUT Intersection next to RCUT:

Both the RCUTs were coded similarly; in accordance with the procedures described in table 4.1 and 4.2. Critical RCUT was operating as signalized and stop-controlled whereas other RCUT is operating as signalized itself. Signal timing plans are discussed in section 4.5. Coded VISSIM network is shown in figure 4.5 below.

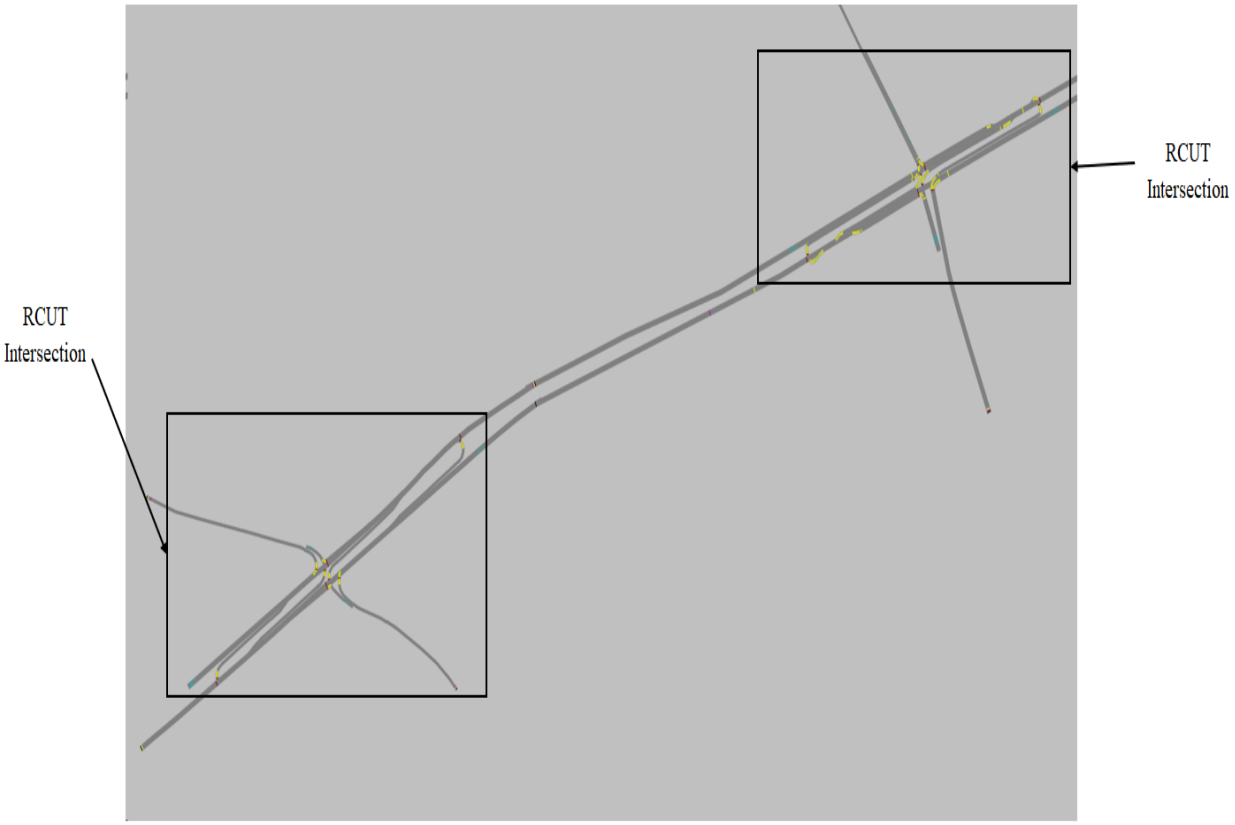


Figure 4. 6: RCUT Corridor: RCUT next to RCUT

4.5 Intersection Control

Two types of RCUTs based on traffic control devices installed were studied in this thesis: Signalized RCUTs and Stop-Controlled RCUTs. This section of the thesis explains in detail how the signals were designed and what all parameters were considered. Also, some of the

terminologies associated with stop controls such as critical gap, follow-up time and similar others are discussed here. Signal heads and stop signs were installed in a RCUT intersection as per the guidelines of FHWA'S RCUT guide. It is similar to figure 2.1 for signalized RCUT and figure 2.2 for stop controlled RCUT.

For analysis of signalized RCUTs, signal timing plans were developed manually based on HCM methodology ((TRB) 2016). 2-phase signals, typical for RCUT intersection were used and the signals at main intersection and U-Turn crossovers were coordinated so as to minimize delay and carry out smooth operations. Phasing diagram for signals used is depicted in figure 4.6 below.

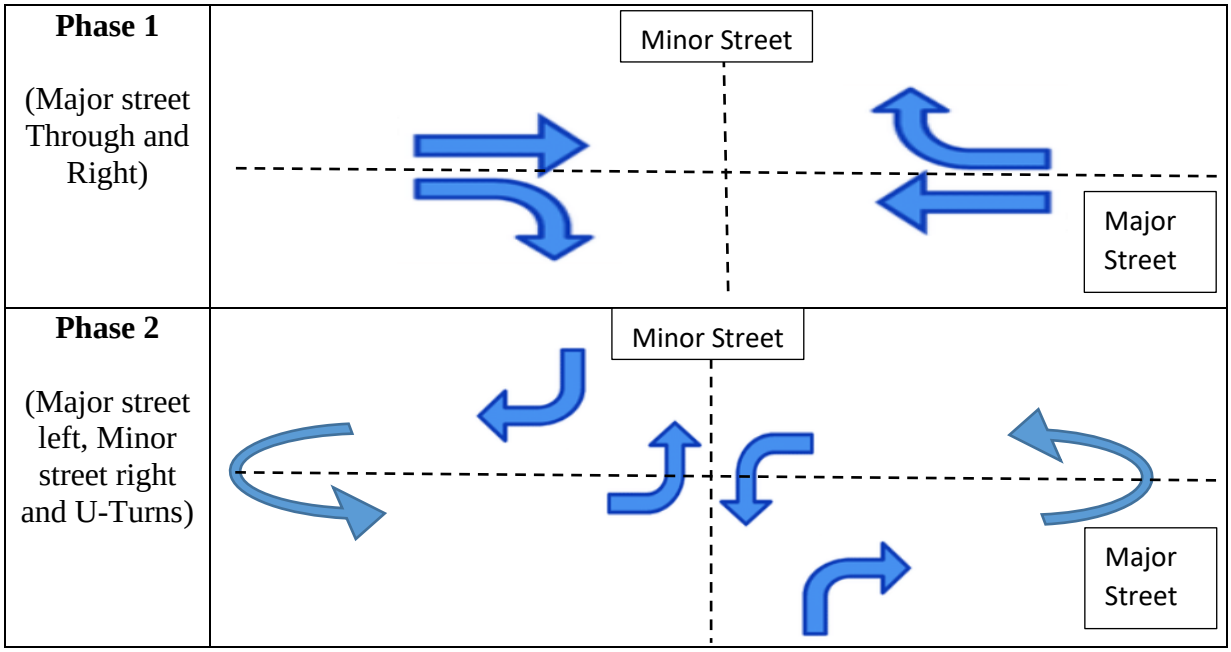


Figure 4. 7: Phasing diagram for signalized intersections

Based on HCM methodology ((TRB) 2016), assuming saturation flow for respective turning lanes, signal timings were calculated and cycle length of 109s, 112s, 116s and 118s was obtained corresponding to critical ratio of 0.05, 0.10, 0.15 and 0.20. Based on four datasets, volumes were varied in this study and hence it is necessary to consider them for signal timing

design. After computing signal timings with volume variation, feasible cycle lengths of 120 seconds were obtained which was appropriate for each geometry and each volume dataset. For lower critical ratios where the cycle lengths calculated were less than 120 s, extra green time was allotted to the major street and splits were adjusted accordingly. Table 4.4 describes values for all the relevant parameters computed.

Table 4. 4: Splits for Signals installed on RCUT

Phase	Green interval	Yellow interval	Red interval	Cycle Length
Phase-1	73 s	6 s	2 s	**120 s**
Phase-2	34 s	3 s	2 s	

As it is evident from table 4.4 and figure 4.3, signal timing plans for RCUT and Four-legged intersection were quite different. They were operating under different cycle lengths and hence were not coordinated. In this research, worst case scenario for guidance on minimum spacing was explored. If the signals were coordinated, there would have been significant change in minimum spacing advisory developed.

For the stop controlled RCUT, most critical factors are critical gap and follow-up time. RCUT intersections being completely modern form of intersection, no literature or study computing critical gap and follow-up headway of four-legged RCUT intersection was found. Also, this study mainly deals with developing relationships between various design parameters for RCUT intersection and traffic demand. As a result, default values provided by VISSIM 10.0 was used. It was checked in the simulation if it produced feasible results or not and it worked fine with default values. Hence default values provided by VISSIM were used for stop-controlled RCUTs. Another important parameter for stop-controlled RCUT is the priorities in case of conflicts. Table 4.5 shown below explains in detail all the conflicts in RCUT and corresponding priorities assigned in VISSIM model.

Table 4. 5: Priority rules for Stop-controlled RCUT

Conflicts	Priority
Major street throughs conflicting with minor street right turns	Minor street right turns waits for a gap in major street traffic stream
U-Turn traffic conflicting with Major street Through	U-Turn vehicles waits for a gap in major street traffic stream
Major street left turns conflicting with major street (opposite direction) through traffic	Through movements are prioritized and left turning vehicle wait until a gap in traffic stream

4.6 Measure of Effectiveness

This thesis is focused on exploring several design parameters and hence for each design control, different measure of effectiveness was chosen. For developing relationship between traffic demand and several design parameters of an RCUT, different measure of effectiveness is required for each design parameter. For developing relationship between optimum crossover spacing and traffic demand, average delay per vehicle was used as measure of effectiveness. VISSIM defines total vehicle delay as average delay per vehicle and this was obtained using nodal evaluation. For each movement in RCUT with different crossover spacing, vehicle delays were computed and correlated traffic demand so as to develop mathematical relationships. In RCUT, redirecting minor street movements has an explicit effect on major street delays and in turn can impact total intersection delay as well. Hence this was also used as measure of effectiveness.

For the turning bays though vehicle delay being one of the performance measures, it is not most efficient measure of effectiveness. As a result, queue lengths were used as performance measure for storage bays. Queue counters were used for calculating queue lengths on storage bays. VISSIM computes queue length from the start of location where queue counter is placed to the end of link. It was ensured that the queue lengths calculated were accurate and precise. Also, for corridor level modelling, queue counters were used as measure of effectiveness. Vehicle queues at main intersection of RCUT were computed and this was correlated with the spacing between

RCUT and neighboring intersection. Measure of effectiveness can be understood more deeply in Section 5 i.e. Results and Discussion.

5. RESULTS AND DISCUSSION

5.1 Overview:

There are several design parameters involved in RCUT Planning, this thesis focuses on three factors wherein limited guidance is available. These three factors are: U-Turn Crossover spacing, Length of Storage bays and impact to neighboring intersection. For analyzing U-Turn crossover spacing, average vehicle delays and total intersection delays were used. For recommended minimum length of storage bays, queue lengths and average vehicle delays were used. For impact to neighboring intersection and minimum distance to reduce impacts, use of queue length was done as measure of effectiveness. Graphical representation shown below summarizes this. Results shown in this section are average results over 5 runs; individual results of each run are shown in Appendix-D below in List of Appendices.

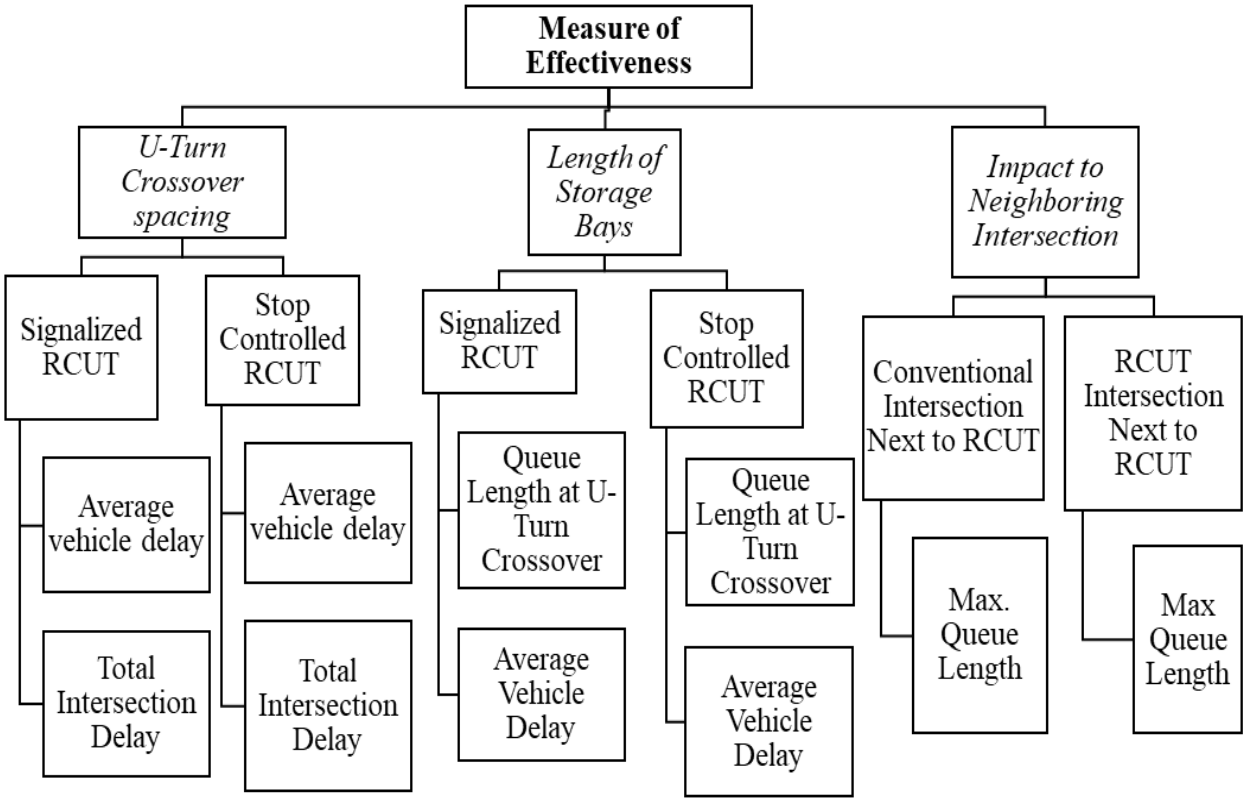


Figure 5. 1 Overview of Measure of Effectiveness for different parameters

5.2 U-Turn Crossover Spacing

a. Signalized RCUT.

For signalized RCUTs, delay per vehicle averaged over all the vehicles in network was reported for each of the six set of U-Turn spacing from 500 ft. to 1000 ft. For each set of spacing, delay per vehicle was plotted against critical ratio i.e. minor street volume to total intersection volume. These data points were found to follow exponential distribution and hence relevant fits were done; R^2 for each data fits were calculated and reported. Tabulated value of delay per vehicle for each U-Turn spacing corresponding to each critical ratio is shown in table 5.1. Regression curves are shown in figure 5.1. Also, for some projects, instead of average delay per vehicle, delay for specific movement i.e. minor street left, major street right and similar others is more important. For this purpose, delay for each movement, for each spacing value corresponding to critical ratio is documented in Appendix-B and Appendix-C.

Table 5. 1: Average Intersection Delay associated with Signalized RCUT

Critical Ratio	**Delay per vehicle (seconds)**					
	500 ft.	**600 ft.**	**700 ft.**	**800 ft.**	**900 ft.**	**1000 ft.**
0.05	100.58	102.41	105.28	113.69	110.92	109.46
0.1	138.87	104.47	108.69	109.75	114.82	122.07
0.15	119.07	111.18	137.75	121.3	186.38	217.14
0.2	194.6	186.17	204.85	202.66	216.58	238.98

Figure 5. 2: Plots for Average Delay/vehicle with different Spacing for Signalized RCUT

When planning for an RCUT intersection, as explained earlier, determining optimum spacing plays an important role; these plots can play important role from the viewpoint of traffic

operations. Based on traffic demand, critical ratio can be easily calculated and then these graphs can be used to determine optimal U-Turn spacing based on delay minimization. Though for some of the U-turn spacing, not highly precise but fairly precise values in the range of 0.70 are obtained; relevant graphs can still be used for comparative analysis. Table 5.2 shows relevant equations which can be used for forward and backward interpolation.

Table 5. 2: Equations for Computing Average delay per vehicle for Signalized RCUT

Spacing	Equation for delay per vehicle
500 ft.	y = 84.966 e^(3.6523x)
600 ft.	y = 76.716 e^(3.7106x)
700 ft.	y = 76.687 e^(4.4678x)
800 ft.	y = 83.664 e^(3.6684x)
900 ft.	y = 80.762 e^(4.9837x)
1000 ft.	y = 78.231 e^(5.8368x)

y = Delay per vehicle
x = Critical Ratio

b. Stop-Controlled RCUTs

Similar to Signalized RCUTs, for stop-controlled RCUTs regression models for delay per vehicle for each spacing corresponding to critical ratio was developed. Table 5.3 represents delay per vehicle averaged over total vehicles in network and figure 5.2 shows plots developed from regression modelling. For stop-controlled RCUTs exponential distribution was fitted as well.

Table 5. 3: Average Intersection Delay associated with Stop-controlled RCUT

Critical Ratio	Delay per vehicle (seconds)					
	500	600	700	800	900	1000
0.05	7.09	7.32	8.17	7.83	7.46	7.57
0.1	12.9	12.93	12.69	12.61	12.44	12.65
0.15	20.55	26.2	23.23	22.31	27.13	24.45
0.2	112.2	113.43	120.09	106.69	122.5	111.62

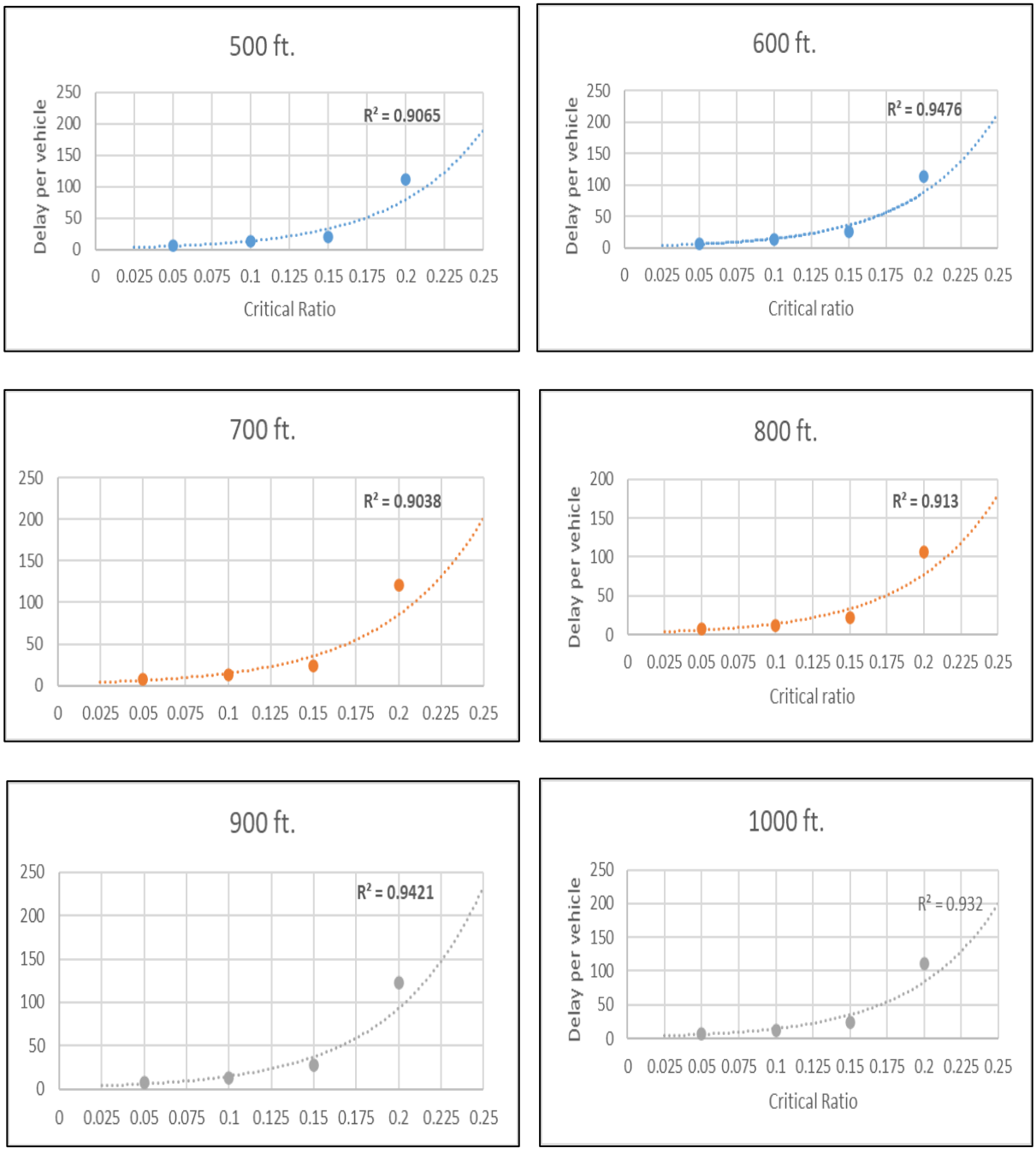


Figure 5. 3: Plots for Average Delay/vehicle with different Spacing for Stop-controlled RCUT

Table 5.4 shows relevant equations which can be used for forward and backward interpolation

Table 5. 4: Equations for Computing Average delay/vehicle for Stop-controlled RCUT

Spacing	Equation for Delay per vehicle
500	y = 2.4041 e^(17.501x)
600	y = 2.4714 e^(17.856x)
700	y = 2.6558 e^(17.336x)
800	y = 2.6919 e^(16.813x)
900	y = 2.3773 e^(18.351x)
1000	y = 2.5484 e^(17.463x)

y = Delay per vehicle (s)
x = Critical Ratio

5.3 Length of Storage Bays

a. Signalized RCUT

Storage bays mainly affect minor street left and through movements in terms of delays. As a result, length of storage bay is usually calculated based on the expected number of vehicle arrivals. In this research, an attempt was made to calculate length of storage bay as a function of U-Turn crossover spacing. Length of crossover spacing was kept constant as 800 ft. which is most widely accepted and then 5 different lengths of storage bays were attached to it. If 'U' is termed as Crossover spacing, 5 sets of lengths for storage bays used were: 0.2U, 0.4U, 0.6U, 0.8U, 1.0U. Maximum queue lengths for each critical ratio was calculated based on simulation and it was found that for the highest critical ratio of 0.2 i.e. maximum traffic volume, length of storage bay equal to 0.2U i.e. 0.2*800 = 160 ft. was sufficient to accommodate all the queues. Queue length results are shown in table 5.5 below.

Table 5. 5: Maximum Queue Length results for Signalized RCUT

Critical Ratio	Max Queue Length (ft)	
	EB-UT	WB-UT
0.05	51.73	79.32
0.1	75.89	126.51
0.15	54.69	128.32
0.2	103.29	152.59

To understand the relationships better, correlation coefficient was computed between these lengths of storage bays and Minor street lefts and through movements. For some critical ratios, strong correlation was observed whereas for some fair correlation was observed. Significant correlation was found between delays for minor street movements and length of storage bays. Results are shown in table 5.6 below.

Table 5. 6: Correlation Coefficients and its Interpretation for Signalized RCUT

Critical Ratio	Minor Street Through		Minor Street Left	
	Correlation Coefficient	Interpretation	Correlation Coefficient	Interpretation
0.05	0.48	Low	0.19	Very Low
0.1	0.66	Moderate	0.65	Moderate
0.15	0.5	Moderate	0.92	Very High
0.2	0.76	High	0.81	High

Main aim of developing such peculiar relationship was to ensure that in cases where crossover spacing varies, some guidance on optimum length of storage bays is available. Vehicle delays for minor street through and minor street left turn movements were plotted against 5 sets of length of storage bays developed. This was done for all the four critical ratios used across this research: 0.05, 0.10, 0.15, 0.20. Since different traffic volumes requires different lengths of storage bays, developing regression model can result into inconsistent results. Hence only simple bar charts were plotted. Table 5.7 shows values of average delay per vehicle for minor street through and minor street left turn movements. Relevant plots are shown in figure 5.3 below.

Table 5. 7: Delay results for Signalized RCUT corresponding to varying Length of storage bay

Critical Ratio	Delay per vehicle (seconds)					
	Movements	0.2 U	0.4 U	0.6 U	0.8 U	1.0 U
0.05	Minor St. Through	173.31	156.76	198.69	158.88	206.83
	Minor St. Left	223.62	238.69	257.02	238.64	230.89
0.1	Minor St. Through	187.67	166.08	153.38	204.06	237.12
	Minor St. Left	228.32	247.55	235.01	244.53	247.8
0.15	Minor St. Through	213.04	247.85	232.29	289.14	207.02
	Minor St. Left	181.59	199.08	189.67	221.26	237.93
0.2	Minor St. Through	272.97	274.02	304.6	359.64	867.43
	Minor St. Left	317.61	338.69	350.2	435.59	927.21

Highlighted values are lowest for each category

Plots shown in figure 5.4 can be used for identifying length of storage bay which causes minimal delay for minor street movements. This is recommended as optimal length of storage bays in terms of U-Turn crossover spacing in table 5.8 shown below. As it is evident from plots and table 5.7, some lengths produce lower delays for minor street left turns whereas some produces lower delays for minor street through movement. For some critical ratios, the lengths obtained are same whereas for some it is different. It is recommended that optimal length can be chosen based on the engineering judgement and prioritizing the movement which has higher correlation coefficient shown in table 5.6.

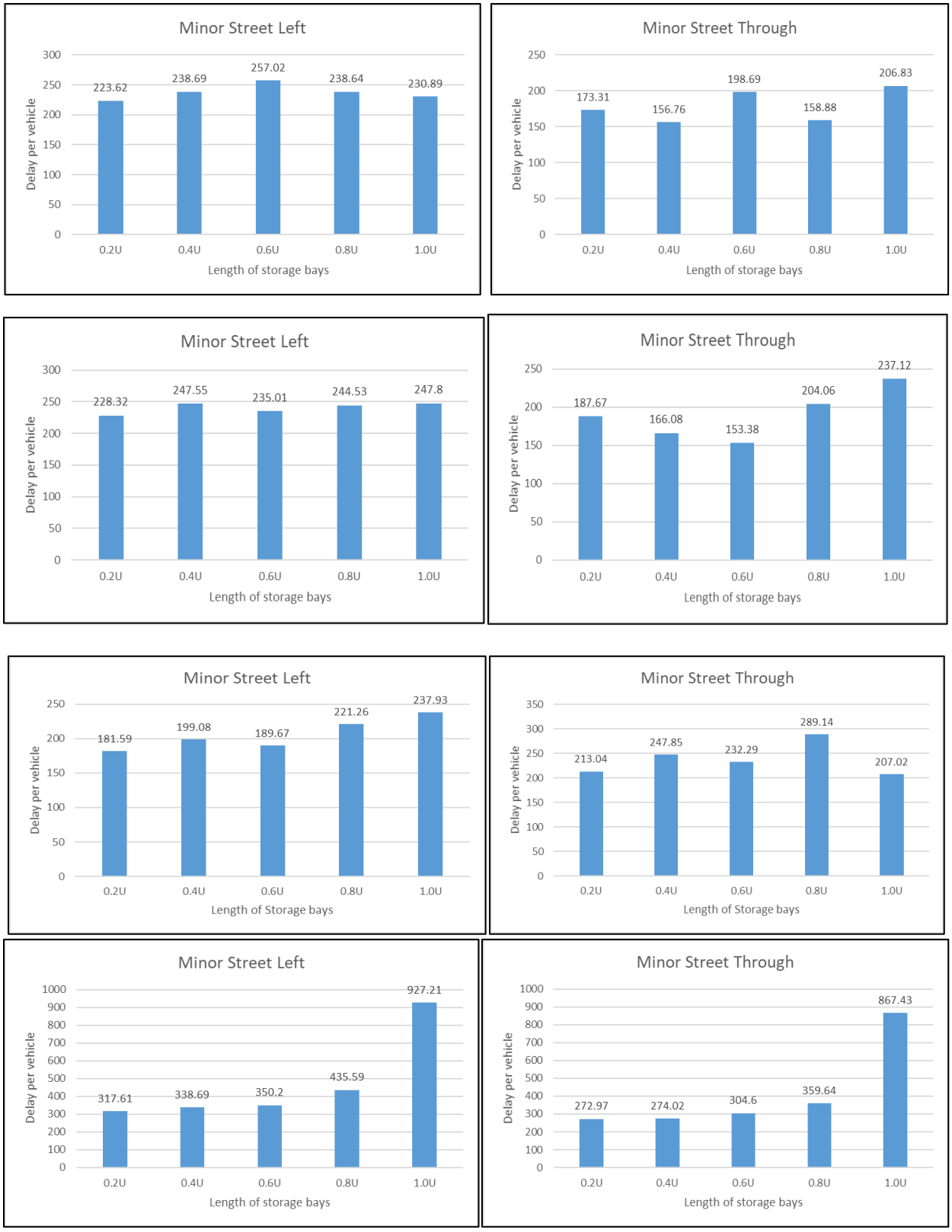


Figure 5. 4: Delay for Minor Street Lefts and Throughs for varying Lengths of Storage Bays for Signalized RCUT

Table 5. 8: Minimum requirement length of Storage Bays for Signalized RCUT

Critical Ratio	Proposed minimum length of Storage Bay	
	Minor Street through	Minor street left
0.05	0.4 U	0.2 U
0.1	0.6 U	0.2 U
0.15	1.0 U	0.2 U
0.2	0.2 U	0.2 U

U = U-turn crossover spacing

b. Stop-Controlled RCUT

For stop-controlled RCUTs, procedure similar to that of signalized RCUTs was adopted to get insights about optimum length of storage bays. 5 sets of similar lengths: 0.2U, 0.4U, 0.6U, 0.8U and 1.0U was used to obtain guidance on optimum length for storage bay. Similar trend as signalized intersection was observed, queue lengths were such that storage bay of 160 ft or 0.2U was able to accommodate all the queues. Queue length results are shown in table 5.9 below and table 5.10 shows correlation coefficients for minor street through and minor street left turning movements. Table 5.11 then shows delays for minor street through and minor street left turns.

Table 5. 9: Queue Length results for Stop Controlled RCUT

Critical Ratio	Max Queue Length (ft)	
	EB-UT	WB-UT
0.05	25.32	26.13
0.1	27.03	75.32
0.15	52.19	79.41
0.2	77.92	129.34

Table 5. 10: Correlation Coefficients and its Interpretation for Stop-controlled RCUT

Critical Ratio	Minor Street Through		Minor Street Left	
	Correlation Coefficient	Interpretation	Correlation Coefficient	Interpretation
0.05	0.86	High	0.61	Moderate
0.1	0.55	Moderate	0.38	Low
0.15	0.32	Low	0.95	Very High
0.2	0.34	Low	0.28	Very low

Table 5. 11: Delay results for Stop-controlled RCUT corresponding to varying Length of storage bay

Critical Ratio	Delay per vehicle (seconds)					
	Movements	0.2 U	0.4 U	0.6 U	0.8 U	1.0 U
0.05	Minor St. Through	119.03	125.15	123.33	127.83	145.68
	Minor St. Left	109.43	135.5	142.41	141.56	132.32
0.1	Minor St. Through	139.97	141.83	151.61	135.36	128.22
	Minor St. Left	128.2	155.72	163.55	154.04	145.18
0.15	Minor St. Through	104.55	130.2	111.23	112.59	123.87
	Minor St. Left	108.29	111.37	113.12	115.54	115.23
0.2	Minor St. Through	230.69	614.92	304.39	323.85	529.81
	Minor St. Left	221.5	615.76	291.49	302.4	529.4

Highlighted values are lowest for each category

Graphs shown below in figure 5.4 explains further delays corresponding to different lengths of storage bays for each critical ratio.

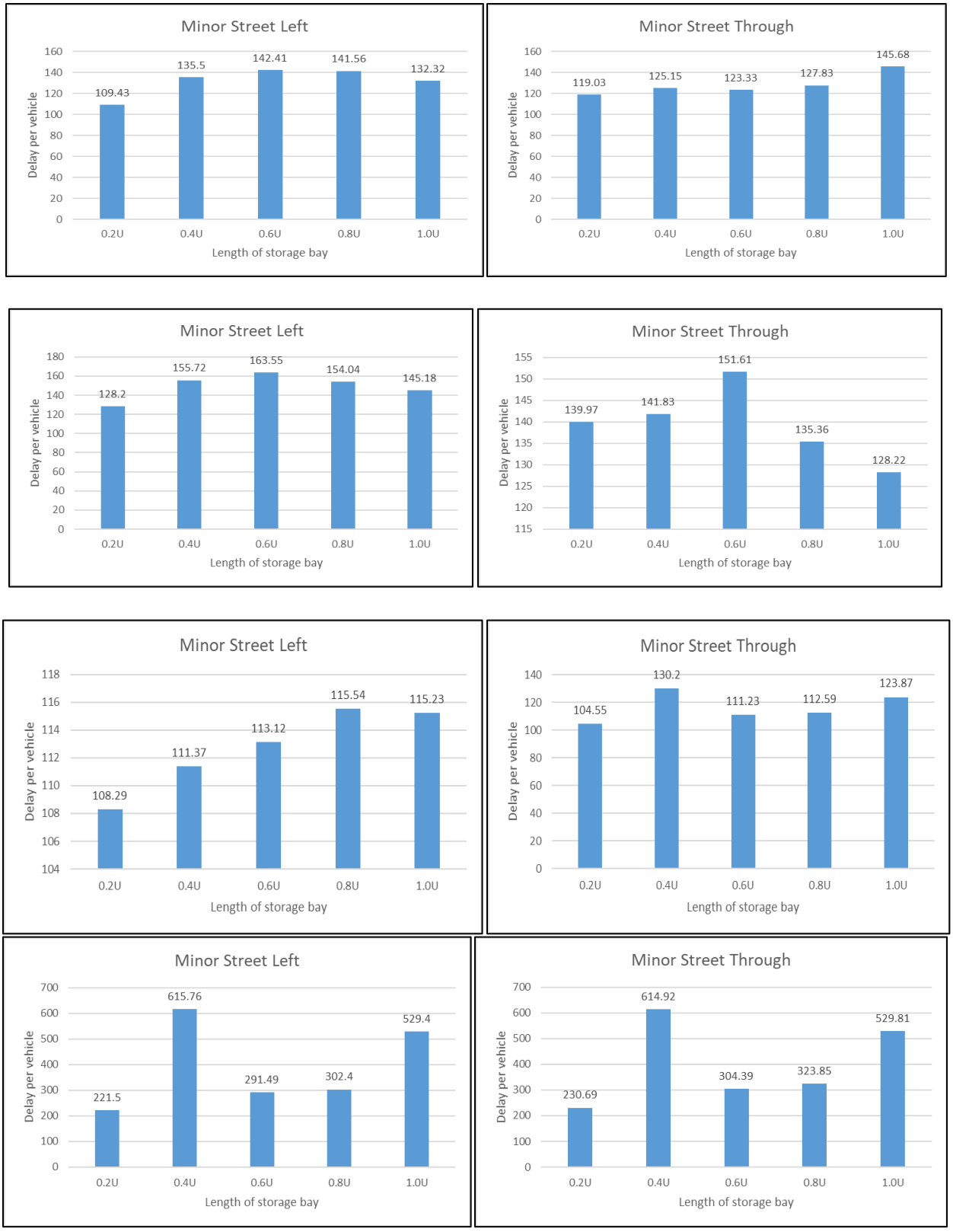


Figure 5. 5: Delay for Minor Street Lefts and Throughs for varying Lengths of Storage Bays for Stop-controlled RCUT

Based on minimal delay, table 5.12 shows advisable length of storage bay for each critical ratio.

Table 5. 12: Recommended length of Storage Bays for Stop-controlled RCUT

Critical Ratio	Proposed Minimum length of storage bays	
	Minor Street through	Minor street left
0.05	0.2 U	0.2 U
0.1	1.0 U	0.2 U
0.15	0.2 U	0.2 U
0.2	0.2 U	0.2 U

U = U-turn crossover spacing

5.4 Impact to Neighboring Intersection

a. Conventional Intersection Next to RCUT

It is critical to understand required spacing between a RCUT and conventional four-legged intersection to avoid spillover and higher delays. There can be different spacing available for a stop controlled RCUT as well as signalized RCUT and hence two sets one with signalized RCUT and one with stop-controlled RCUT were simulated to obtain relevant results. Distance from Main intersection at RCUT and four-legged intersection was varied and 5 sets of spacings were tested: 0.2 mi, 0.4 mi, 0.6 mi, 0.8 mi and 1.0 mi. Figure 5.5 shown below explains more clearly distances varied. For the RCUT, U-Turn crossover spacing was 800 ft.

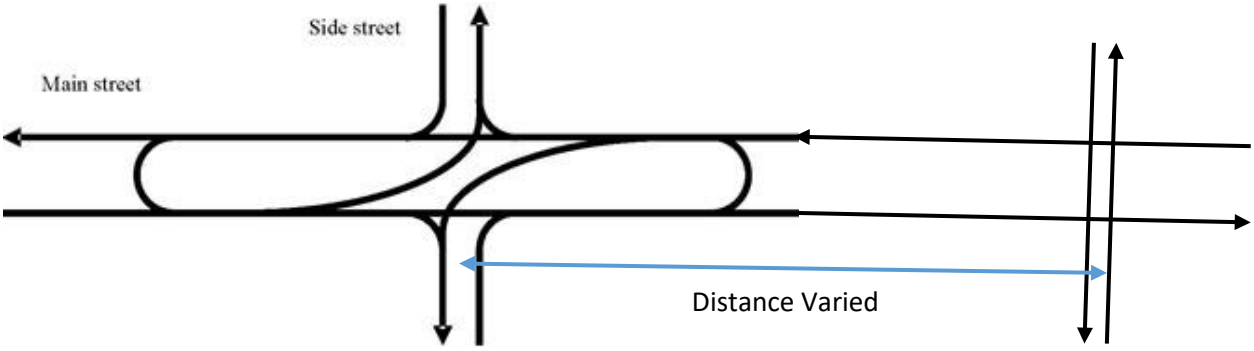


Figure 5. 6: Schematic of Spacing variation for RCUT Network-RCUT next to 4-legged intersection

Maximum queue lengths were collected using queue counters and it was compared with respect to available spacing to estimate if queues spillover or not. Maximum queue lengths were collected at different locations for different cases. Next sections explain in detail how results were collected for each type of RCUT and values associated with it.

Signalized RCUT next to Conventional Intersection:

Maximum queue lengths were collected at two primary locations represented by thick red lines shown in figure 5.6 below and the relevant calculations were done to check if spillover has occurred or not. Results are shown in table 5.13 below.

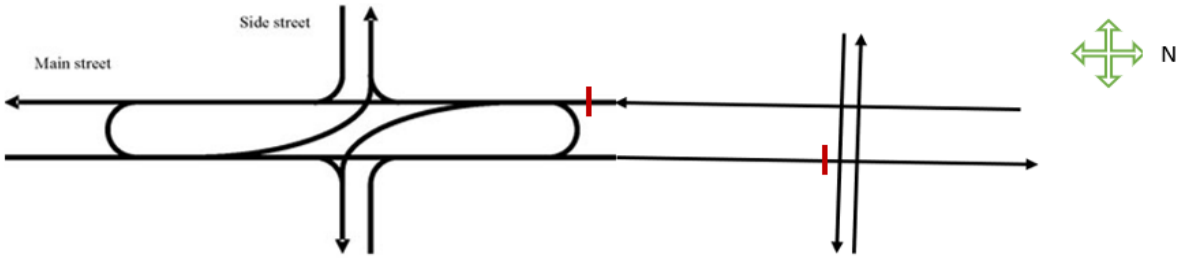


Figure 5. 7: Placement of Queue counters for Queue Length data collection for Signalized RCUT next to 4-legged intersection

Table 5. 13: Queue Length results and Spillover Analysis for RCUT Network- Signalized RCUT next to 4-legged intersection

Spacing			**Maximum Queue lengths (ft)**		**Spillover analysis**	
			RCUT	**Intersection**		
Overall spacing (mi)	**Overall spacing (ft)**	**Effective spacing (ft)**	**SB**	**NB**	**Difference NB (Spacing-Queue length)**	**Difference SB (Spacing-Queue length)**
0.2	1056	256	380.64	976.03	-720.03	-124.64
0.4	2112	1312	834.63	749.97	562.03	477.37
0.6	3168	2368	854.57	737.90	1630.10	1513.43
0.8	4224	3424	903.97	739.74	2684.26	2520.03
1.0	5280	4480	898.26	705.36	3774.64	3581.74

In table 5.13, effective spacing is calculated as the spacing available after reducing U-Turn crossover spacing i.e. 800 ft so as to measure actual queues occurring at RCUT which will spillover at the four-legged intersection and vice versa. As it is evident, for a spacing of 0.2 miles between main intersection of RCUT to four-legged intersection, there is significant spillover on RCUT as well as the conventional intersection. Whereas for 0.4 miles, there is reasonable space available (shown by difference in the table) which can accommodate roughly 18-20 vehicles per signal cycle. Depending upon traffic volumes and using this table, appropriate spacing can be chosen. On common grounds, minimum spacing of 0.35 miles is necessary.

Stop Controlled RCUT next to Conventional RCUT

For stop controlled RCUT, priority is given to major street vehicles and vehicle on minor street wait for a gap greater than critical gap to enter traffic stream. Similar procedures happen at U-Turn crossover. Vehicles waiting for U-Turn waits and forms queues until a critical gap to enter traffic stream. As a result, measuring queues at major street of RCUT near U-Turn crossover makes no sense since those vehicles will not be queuing rather vehicles trying to make a U-Turn forms queues. As a result, queue counters for this case were placed at stop bar of U-Turn crossover for RCUT and since four-legged intersection is signalized, queue counter is placed at similar location as previous one. Placement of queue counters is explained more clearly in figure 5.7; queue counters are shown represented by thick red lines.

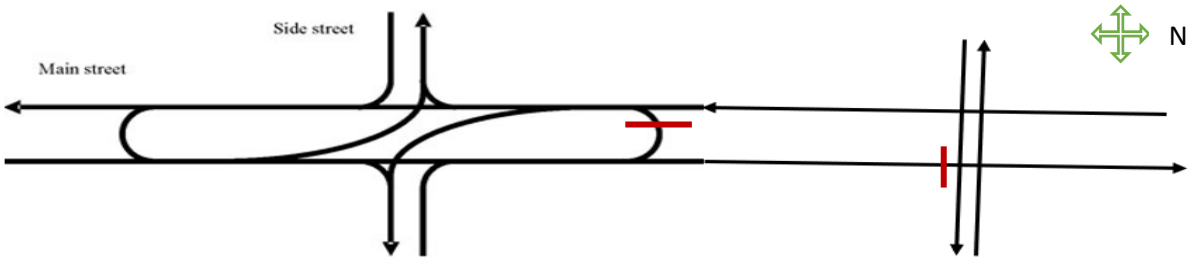


Figure 5. 8: Placement of Queue counters for Queue Length data collection for Stop-controlled RCUT next to 4-legged intersection

Spillover analysis for four-legged intersection is similar to the previous case whereas for RCUT, spillover is calculated by deducing maximum queue lengths from length of storage bays i.e. 800 ft. Results are shown in table 5.14.

Table 5. 14: Queue Length results and Spillover Analysis for RCUT Network- Stop-controlled RCUT next to 4-legged intersection

Spacing in miles	Spacing (ft)		Maximum Queue lengths		Spillover analysis	
			RCUT	Intersection		
	Overall spacing	Effective spacing	WB-UT	NB	Difference: WB-UT (Storage bay-Queue length)	Difference SB (Spacing-Queue length)
0.2	1056	256	78.42	852.96	721.58	-465.58
0.4	2112	1312	77.77	655.70	722.23	589.77
0.6	3168	2368	80.82	729.21	719.18	1648.82
0.8	4224	3424	70.62	634.45	729.38	2694.62
1	5280	4480	76.29	678.89	723.71	3756.29

As it is evident from the results, there is significant spillover at the four-legged intersection and vehicle queues are affect operations at RCUT whereas there is no spillover from storage bays. Thus, it is not advisable to have spacing of 0.2 miles between four-legged intersection and stop controlled RCUT as well. Though with some changes in signal timing plans, there can be reduction in queues but it is likely that queues might spillover. As a result, it is advisable to have minimum spacing of 0.25 miles when stop-controlled RCUT is placed next to 4-legged signalized intersection.

b. RCUT Intersection next to RCUT Intersection

It is a common practice to construct RCUT corridors rather than constructing a single RCUT intersection. With this. It becomes critical to develop optimum spacing requirements

between two RCUTs. Two identical RCUTs with U-Turn crossover spacing as 800 ft were coded and distance between their main intersection was varied in four sets: 0.4 mi, 0.6 mi, 0.8 mi and 1.0 mi. Distance variation is explained more clearly in figure 5.8 shown below.

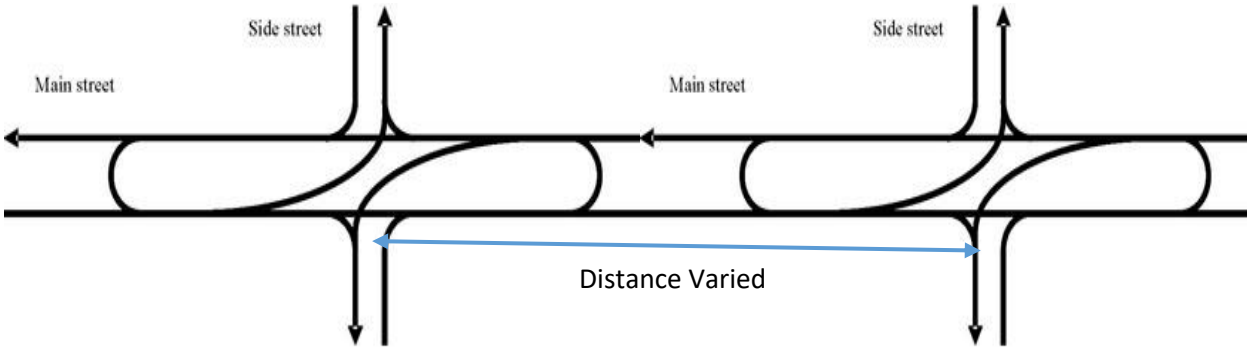


Figure 5. 9: Schematic of Spacing variation for RCUT Network-RCUT next to RCUT

For the RCUT corridor, one of the RCUT referred to as critical RCUT intersection was modelled as signalized-RCUT and stop-controlled RCUT whereas second RCUT was operating as signalized RCUT for both the cases. Detailed data collection procedure and results obtained are shown in next sections.

Signalized RCUT next to Signalized RCUT:

For these types of RCUTs, maximum queue lengths were collected using queue counters. Queue lengths were collected on major street at the stop bar just before U-turn crossovers. Placement of queue counters is shown in figure 5.9 below and relevant results are shown in table-5.15 below the figure.

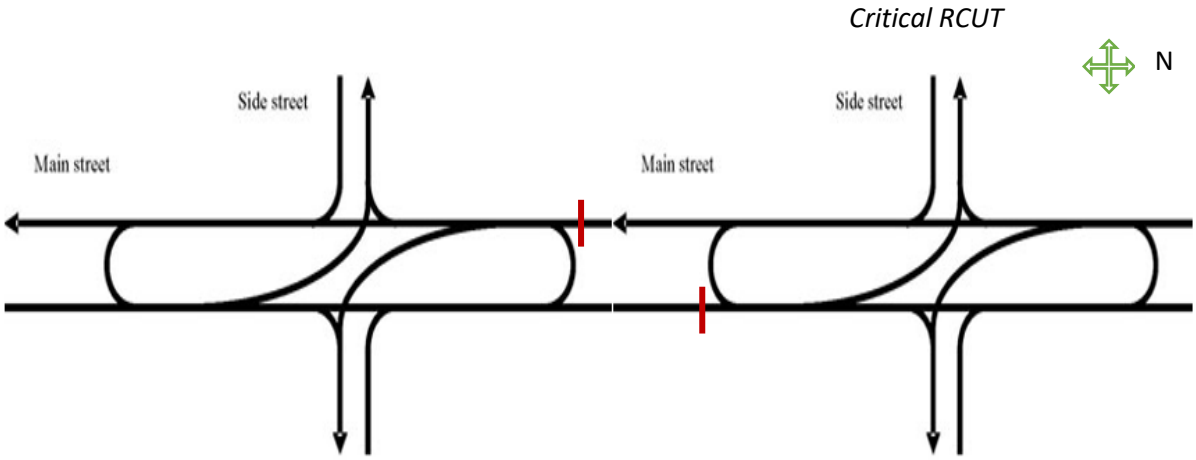


Figure 5. 10: Placement of Queue counters for Queue Length data collection for Signalized RCUT next to Signalized RCUT

Table 5. 15: Queue Length results and Spillover Analysis for RCUT Network- Signalized RCUT next to Signalized RCUT

Spacing in miles	Spacing (ft)		Maximum Queue lengths (ft)		Spillover analysis	
	Overall spacing	Effective spacing	RCUT-Critical	RCUT	Difference NB (Spacing-Queue length)	Difference SB (Spacing-Queue length)
			NB	SB		
0.4	2112	1312	122.74	319.31	1189.26	992.69
0.6	3168	2368	102.37	476.06	2265.63	1891.94
0.8	4224	3424	63.04	638.12	3360.96	2785.88
1	5280	4480	47.10	725.50	4432.90	3754.50

As it is evident from analysis, spacing of 0.4 mi is more than sufficient for NB but for SB, difference is really small and hence there are chances of spillover. It is likely that reason for it is difference in traffic volume for NB and SB. To have smoother operations, it is advisable to have minimum spacing of 0.4 miles and to account for variability, spacing of 0.45 mi is recommended when two RCUTs placed adjacent to each other are signalized.

Signalized RCUT next to Stop Controlled RCUT

Similar to above mentioned methodology, for stop-controlled RCUT, queue counter was placed at stop bar of U-Turn crossover. For signalized RCUT, queue counters were placed at the conventional position. Placement of queue counters is explained in detail in figure 5.10 below.

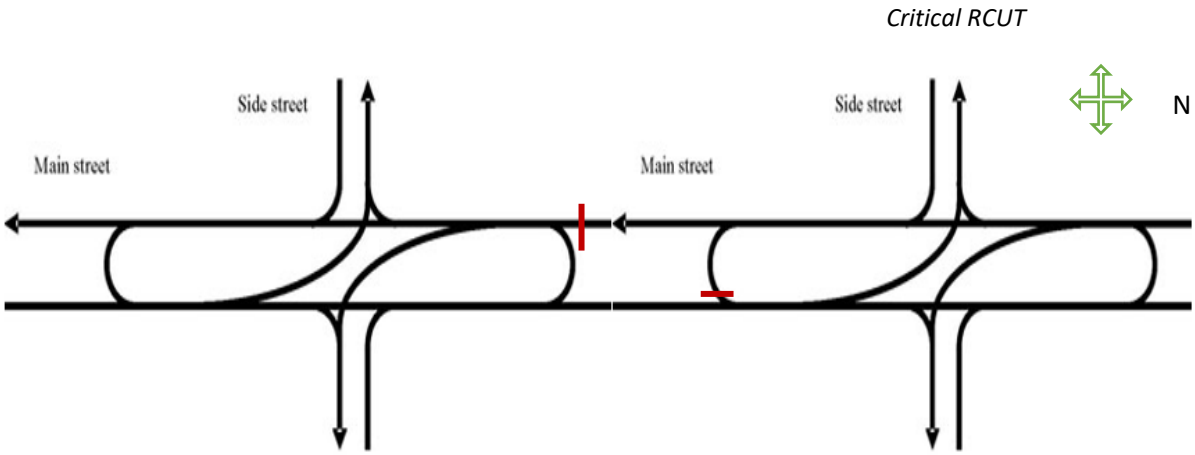


Figure 5. 11: Placement of Queue counters for Queue Length data collection for Signalized RCUT next to Stop-controlled RCUT

Queue length results and spillover analysis is shown in table 5.16 below.

Table 5. 16: Queue Length results and Spillover Analysis for RCUT Network- Signalized RCUT next to Stop-controlled RCUT

Spacing in miles	Spacing (ft)		Maximum Queue lengths		Spillover analysis	
	Overall spacing	Effective spacing	RCUT-Critical EB-UT	RCUT SB	Difference (Storage bay-Queue length)	Difference SB (Spacing-Queue length)
0.4	2112	1312	42.78	77.08	757.22	554.78
0.6	3168	2368	43.73	65.66	756.27	1611.73
0.8	4224	3424	41.81	77.34	758.19	2665.81
1	5280	4480	46.32	149.37	753.68	3726.32

As it is evident from the result, there was no spillover observed for spacing of 0.4 mi; extra length of approximately 0.05 mi is left unutilized. Hence minimum spacing of 0.35 miles is advisable if the U-Turn crossovers do not overlap. One of the most important observation is that for the pair: stop-controlled RCUT and signalized RCUT, lesser spacing is sufficient in comparison to the network wherein both RCUTs are signalized. Table 5.17 shown below summarizes minimum and recommended spacing for each combination.

Table 5. 17: Spacing guidelines for different combinations of RCUT and adjacent intersection

Design Combination	Minimum spacing proposed
Signalized RCUT adjacent to signalized 4-legged conventional intersection	1850 ft. (0.35 mi)
Stop controlled RCUT adjacent to signalized 4-legged conventional intersection	1320 ft. (0.25 mi)
Signalized RCUT adjacent to Signalized RCUT	2115 ft. (0.4 mi)
Signalized RCUT adjacent to Stop-controlled RCUT	1850 ft. (0.35 mi)

Note: For combination of RCUT adjacent to RCUT, it must be checked that U-turns of both the RCUTs do not overlap

5.5 Statistical Inferences

Based on the results collected using VISSIM simulation, some critical deductions can be made based on change is values. For signalized RCUT, percentage change in delay with change in critical ratio was calculated. This was done to observe the trend in changes over the variation in critical ratio. In table 5.18, percentage change in delay is reported and figure 5.11 represents corresponding plot for signalized RCUT. Similar procedure was adopted for stop-controlled RCUT to draw some conclusion on change in delays. For stop-controlled RCUT, table 5.19 and figure 5.12 shows relevant calculations.

Table 5. 18 Percentage change in Delay with change in Critical Ratio (Signalized RCUT)

Change in critical Ratio	Percentage change (w.r.t. previous value)					
	500 ft.	600 ft.	700 ft.	800 ft.	900 ft.	1000 ft.
0.05-0.10	38.07%	2.01%	3.24%	-3.47%	3.52%	11.52%
0.10-0.15	-14.26%	6.42%	26.74%	10.52%	62.32%	77.88%
0.15-0.20	63.43%	67.45%	48.71%	67.07%	16.20%	10.06%

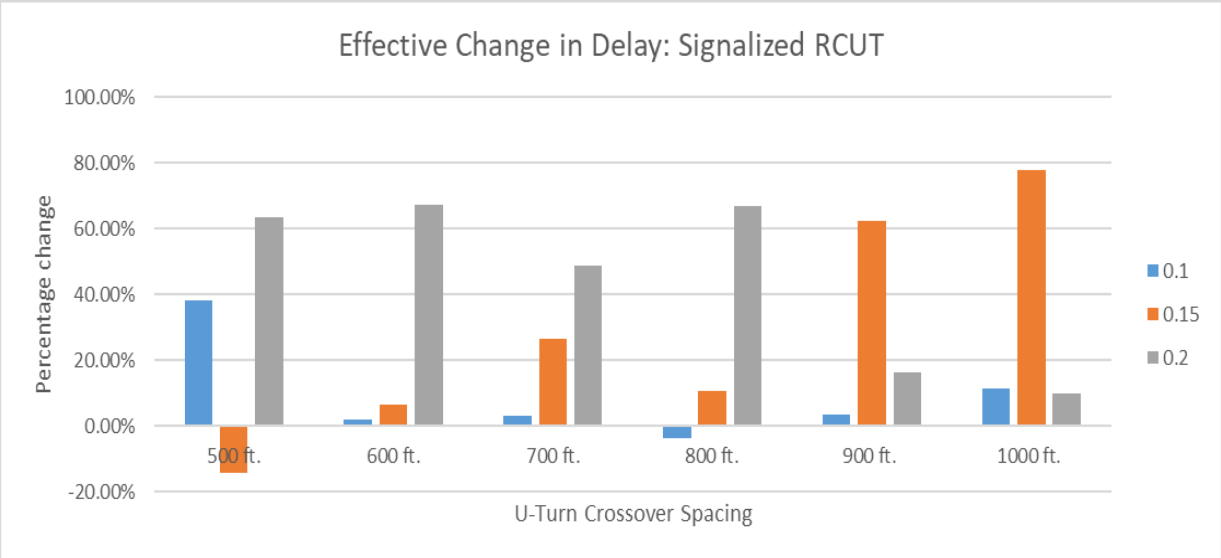


Figure 5. 12: Percentage Change in Delay with variation in Critical Ratio for Signalized RCUT

Table 5. 19 Percentage change in Delay with change in Critical Ratio (Stop-controlled RCUT)

Chane in critical Ratio	Percentage Change (w.r.t. previous value)					
	500 ft.	600 ft.	700 ft.	800 ft.	900 ft.	1000 ft.
0.05-0.10	81.95%	76.64%	55.32%	61.05%	66.76%	67.11%
0.10-0.15	59.30%	102.63%	83.06%	76.92%	118.09%	93.28%
0.15-0.20	445.99%	332.94%	416.96%	378.22%	351.53%	356.52%

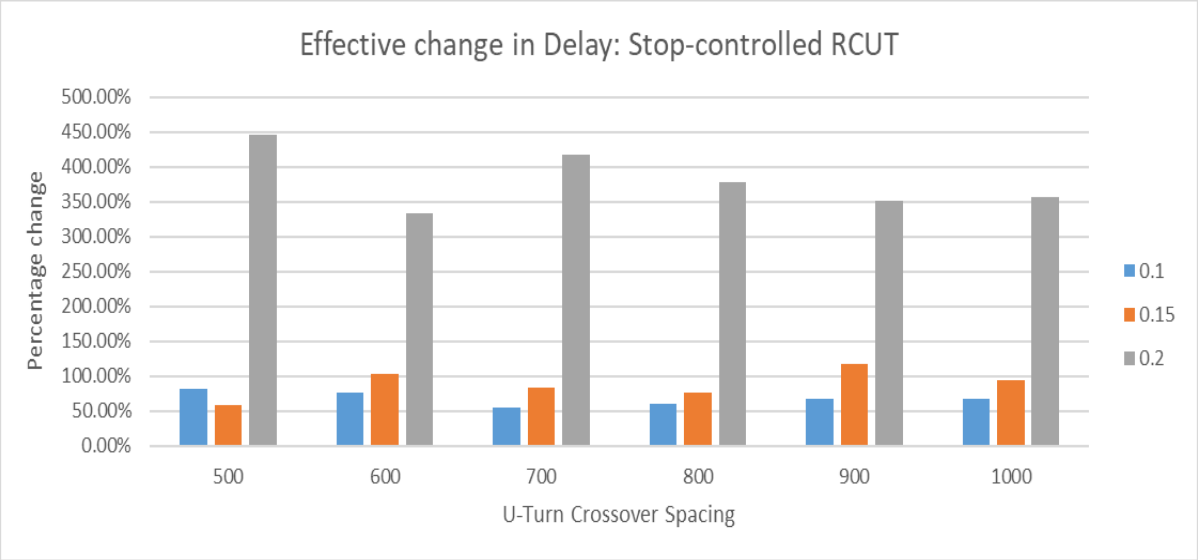


Figure 5. 13 Percentage Change in Delay with variation in Critical Ratio for Stop-controlled RCUT

As it is evident from the plots 5.11 and 5.12, the percentage change in delay per vehicle follows different trend for signalized RCUT and stop-controlled RCUT. For signalized RCUT, biggest jump in delay is observed when critical ratio changes from 0.15 to 0.20 for U-turn crossover spacing from 500 ft. to 800 ft. On the other side, when the U-Turn crossover spacing of 900 ft. and 1000 ft. is provided, highest jump in delay is observed when critical ratio increases from 0.1 to 0.15. This is an interesting observation because the general expectation is that with the increase in critical ratio, delay will increase in uniform proportion with consistency but for signalized RCUT with U-Turn crossover spacing of 900 ft. and 1000 ft., some anomalies are observed. This can be attributed to the spurious results expected in microsimulation runs over number of signal cycles. On the other hand, for stop-controlled RCUT a consistent trend is observed. Percentage change in delay is highest for change in critical ratio from 0.15 to 0.20. Some irregularities for RCUT with U-Turn crossover spacing of 500 ft. are observed. Percentage change

in delay is higher for transition in critical ratio from 0.05 to 0.1 than that for 0.1 to 0.15. This is not observed in any other spacing.

For length of storage bays, as it is evident in table 5.6 for signalized RCUT and 5.10 for stop-controlled RCUT, there are some pairs which are strongly correlated whereas there are some pairs which are not correlated. In this research, an attempt was made to see if the length of storage bays can be correlated with U-Turn crossover spacing along with an objective of delay minimization. The delay results are helpful in determining the minimum length of storage bays required for RCUT design but correlation results are not comprehensively conclusive. Based on correlation results, it can be said that there is no solid relationship existent between U-Turn crossover spacing and length of storage bays. It is not advisable to report length of storage bays as a linear function of U-Turn crossover spacing, some other function maybe good fit.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

This thesis focused on performing Planning-level analysis for RCUT and develop guidance on three basic parameters critical for RCUT design. These three parameters are: U-Turn Crossover spacing, Length of Storage Bays and Impact to neighboring intersection and relevant advisable spacing. Use of VISSIM was done for modelling and very basic inputs i.e. geometry and turning movement counts were used to derive some useful relationships. Major conclusions of this study are documented as follows:

- Significant change in Average delay per vehicle occurs with variation in U-Turn crossover spacing and critical ratio- a parameter used to define traffic volume. There is an optimum value for U-Turn crossover spacing which gives lowest delay for a given volumes of traffic defined by critical ratio.
- Even if coordinated signals are installed in RCUT, it is unreasonable to assume that higher the U-Turn crossover spacing, lower the delays. Analysis for average delay per vehicle is necessary for determining optimum spacing of U-turn Crossovers from main intersection.
- For different types of traffic control devices, there can be different recommended spacing for U-turn crossovers. For stop-controlled RCUT usually lower values of crossover spacing is suitable than that for signalized RCUT.
- Equations shown in table 5.2 for signalized RCUTs and table 5.4 for stop-controlled RCUTs must be used to determine optimum spacing for U-turn crossovers. These equations are obtained after appropriate statistical data fitting to the data output obtained by VISSIM simulations.

- Conventional method for designing storage bay for RCUT involves queuing data collection and based on 95th percentile queue length, appropriate length of storage bay is provided after accounting for variability. Undoubtedly this process is important but another important factor to consider is delays associated with it.
- It was confirmed in this study that for some levels of traffic for RCUT, average delays per vehicle for minor street lefts and minor street throughs are related to lengths of storage bays provided.
- Length of storage bay as a function of U-turn crossover spacing was obtained and based on lengths for which minimum delays were obtained, appropriate lengths of storage bay was recommended. Different lengths of storage bays were obtained for different levels of traffic and for different types of traffic control devices used.
- Recommended lengths of storage bays for signalized RCUT and stop-controlled RCUT are reported in table 5.8 and table 5.12 respectively. It has different values for minor street left turns and minor street through movement; based on traffic volumes and correlation coefficients computed, appropriate values must be selected.
- It is a common practice to develop a set of conventional intersections into RCUT Corridor rather than constructing a single RCUT intersection. Usually, RCUT has another RCUT or a conventional signalized 4-legged intersection adjacent to it. Hence, it is essential to developing guidelines for minimum spacing requirements between two intersections.
- Based on VISSIM simulations and maximum queue length results obtained from it, different spacing requirements for different combinations were obtained. These recommendations are purely based on maximum queue length results and there has been no attempt to minimize delays.

- It was found that when a conventional 4-legged signalized intersection is adjacent to RCUT, minimum spacing of 0.35 mi and 0.25 mi is required for signalized and stop-controlled RCUT respectively. This distance is measured from main intersection of RCUT to four-legged intersection.
- For the combination of signalized RCUT adjacent to another signalized RCUT, minimum spacing of 0.4 mi and that for signalized RCUT adjacent to stop-controlled RCUT is 0.35 mi. Though the minimum spacing recommended is well above the overlapping limits, it should be ensured that U-turns for both the RCUTs do not overlap. This distance is measured from main intersection of both the RCUTs.
- Combination of two stop controlled RCUTs adjacent to each other is rare and if such a corridor is designed, queuing on major street will not be a major concern since it is mostly free flowing. Hence this case is not considered in this study. To account for variability, additional spacing of 0.05 mi should be added to minimum spacing requirements mentioned above.

6.2 Limitations of the Study

- In the analysis to develop guidelines on minimum spacing requirements for various design combinations, hypothetical four-legged intersection was operating as signalized intersection in all the cases. The signals for this four-legged intersection and RCUT were not coordinated and were operating at different cycle lengths. Since worst case was studied in this research, signals were not coordinated. Significant changes in guidance developed is expected with intersections operating under coordinated signals.

- In this study, total intersection volume was kept constant as 4000 vph and the volume on each approach was varied in accordance with the critical ratio. In essence, total congestion level was constant for intersection whereas that for each approach was varying.
- The data reported in this study is the average of 5 runs which in basically the average of 150 signal cycles (3600*5/120). Since it is a common practice to report average of all the microsimulation runs, it hides the variability and anomalies caused in final result.
- For the analysis on length of storage bays, an attempt was made to relate it with U-Turn crossover spacing. U-Turn crossover spacing of 800 ft. was used to establish the relationship but since there was no significant relationship, other spacings were not explored. It is quite possible that for some spacing of U-Turn crossovers, length of storage bays is strongly correlated.
- Results are completely based on microsimulation results, a macroscopic analysis must be performed to get better insights into the conclusions of this research and to bolster the results.

6.3 Recommendations for Future Research

There are several strong assumptions taken into consideration for this study. For further optimizing planning and design of RCUTs, these areas must be explored and researched on. Some of the recommendations for future research on RCUT is as follows:

- In this study, guidance on several less-researched parameters for RCUT design was developed from traffic operations standpoint. A study from traffic safety standpoint must be conducted to evaluate design recommendations documented in this study.
- Pre-timed signals were used for each phase of this study wherever signals were to be installed. With the wide range of vehicle detection and signal optimization techniques evolving, there is

a broad scope of optimizing RCUT operations. Some of the technologies such as Actuated signals, ATSPM, Adaptive signal systems and similar others must be explored.

- In this study, the output results obtained using VISSIM simulations were fitted using exponential distribution. Two distributions- exponential and simple linear regression were fitted and the one with better fit i.e. exponential distribution was reported. There is a scope for better fit using different distributions such as power function, moving average, polynomial and others.
- RCUT being most common design in sub-urban to rural areas, this study assumed that there is negligible pedestrian and bicycle traffic. However, it is not the case for each site, there is low to moderate pedestrian and bicycle traffic at some RCUT intersections. Hence it is critical to study how does the U-turn spacing guidelines and recommended lengths of storage bays affect non-motorized traffic.
- Several important design parameters were studied in this research work and relevant guidelines were developed. This study did foundational analysis from traffic operations standpoint for RCUT Planning. To further promote efficient traffic operations, it is advisable to develop a comprehensive planning level tool for RCUT Planning by expanding the scope of research to several parameters such as recommended length of storage bays and distance from neighboring intersection, design of left turn bays, scope for reverse RCUT, signal coordination strategies with neighboring intersection and its effect on spacing from adjacent intersection, varying the level of congestion in total, variation in heavy vehicles percentage and its impacts on design.

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8. APPENDICES

Appendix A: Turning Movement Counts

- Turning Movement counts corresponding to each critical ratio:

Direction	Volumes	Approach Volume	Percent	Street	Street Volume	Int. Volume
WBL	31	179	17%	Minor Street	200	4000
WBR	144		80%			
WBT	5		3%			
EBL	9	21	43%			
EBR	8		37%			
EBT	4		20%			
NBL	25	1628	2%	Major Street	3800	
NBR	81		5%			
NBT	1523		94%			
SBL	23	2172	1%			
SBR	81		4%			
SBT	2068		95%			
Critical Ratio			**0.05**			

Direction	Volumes	Approach Volume	Percent	Street	Street Volume	Int. Volume
WBL	61	358	17%	Minor Street	400	4000
WBR	288		80%			
WBT	9		3%			
EBL	18	42	43%			
EBR	15		37%			
EBT	8		20%			
NBL	24	1543	2%	Major Street	3600	
NBR	76		5%			
NBT	1443		94%			
SBL	21	2057	1%			
SBR	76		4%			
SBT	1960		95%			
Critical Ratio			**0.10**			

Direction	Volumes	Approach Volume	Percent	Street	Street Volume	Int. Volume
WBL	92	538	17%	Minor Street	600	4000
WBR	432		80%			
WBT	14		3%			
EBL	27	62	43%			
EBR	23		37%			
EBT	13		20%			
NBL	22	1457	2%	Major Street	3400	
NBR	72		5%			
NBT	1362		94%			
SBL	20	1943	1%			
SBR	72		4%			
SBT	1851		95%			
Critical Ratio			**0.15**			

Direction	Volumes	Approach Volume	Percent	Street	Street Volume	Int. Volume
WBL	122	717	17%	Minor Street	800	4000
WBR	576		80%			
WBT	19		3%			
EBL	36	83	43%			
EBR	31		37%			
EBT	17		20%			
NBL	21	1371	2%	Major Street	3200	
NBR	68		5%			
NBT	1282		94%			
SBL	19	1829	1%			
SBR	68		4%			
SBT	1742		95%			
Critical Ratio			**0.20**			

Appendix B: VISSIM Results- Average Delay/vehicle for Varying U-Turn Crossover

- Movement-wise delay for Signalized RCUT

Movements		Delay in seconds corresponding to U-Turn Crossover Spacing					
Critical Ratio = 0.05		**500 ft.**	**600 ft**	**700 ft.**	**800 ft.**	**900 ft.**	**1000 ft.**
Minor Street Movements (1)	**E-N**	152.32	146.944	157.21	151.88	175.19	204.26
	E-S	207.698	210.257	220.12	230.89	240.97	252.18
	E-W	224.588	167.023	169.72	195.13	203.74	202.75
Major Street Movements (1)	**N-S**	96.7316	99.2675	101.49	116	109.47	104.02
	N-E	212.258	180.05	169.43	186.55	187.93	152
	N-W	111.528	87.0199	80.12	89.71	86.53	92.13
Minor Street Movements (2)	**W-N**	185.039	242.495	235.6	224.28	160.08	205.36
	W-S	125.666	161.228	138.61	129.32	117.24	115.79
	W-E	200.817	163.554	178.57	206.83	238.84	199.52
Major Street Movements (2)	**S-N**	93.6886	96.3031	99.85	103.78	102.12	101.59
	S-E	95.4784	91.9164	101.45	115.14	101.75	114.62
	S-W	226.193	215.885	209.47	89.14	202.68	243.24

Movements		Delay in seconds corresponding to U-Turn Crossover Spacing					
Critical Ratio = 0.10		**500 ft.**	**600 ft.**	**700 ft.**	**800 ft.**	**900 ft.**	**1000 ft.**
Minor Street Movements (1)	**E-N**	187.107	157.96	174.64	164.53	209.95	332.18
	E-S	191.352	228.9	242.05	247.8	243.13	288.06
	E-W	203.402	162.82	195.38	174.04	178.01	272.84
Major Street Movements (1)	**N-S**	86.2851	95.31	98.35	101.41	104.36	101.5
	N-E	171.503	172.18	188.06	171.92	215.79	191.37
	N-W	87.8615	79.14	83.2	85.31	80.04	99.62
Minor Street Movements (2)	**W-N**	204.613	237.58	214.25	198.53	169.98	234.7
	W-S	146.344	159.61	121.73	136.06	174.57	185.08
	W-E	185.702	167.55	203.39	237.12	168.44	268.92
Major Street Movements (2)	**S-N**	91.3151	96.11	98.38	102.57	100.92	98.58
	S-E	89.9716	107.3	107.12	104.09	107.76	97.63
	S-W	246.419	222.69	234.88	75.58	224.27	231.95

Movements		Delay in seconds corresponding to U-Turn Crossover Spacing					
Critical Ratio = 0.15		**500 ft.**	**600 ft.**	**700 ft.**	**800 ft.**	**900 ft.**	**1000 ft.**
Minor Street Movements (1)	**E-N**	292.376	229.305	387.248	258.02	805.99	1303.46
	E-S	268.379	235.346	412.35	267.53	836.5	1377.67
	E-W	245.323	197.692	429.881	207.02	767.95	1209.73
Major Street Movements (1)	**N-S**	149.988	88.5294	96.542	97.91	99.47	101.926
	N-E	166.303	190.074	209.458	170.98	169.09	166.29
	N-W	109.621	81.6593	89.458	82.47	76.32	95.928
Minor Street Movements (2)	**W-N**	91.7362	238.265	211.784	237.93	178.61	220.758
	W-S	100.419	118.959	136.984	139.92	174.49	190.968
	W-E	250.031	195.027	195.61	164.13	164.09	213.332
Major Street Movements (2)	**S-N**	88.0225	89.0924	94.568	96.62	98.2	98.78
	S-E	218.058	100.327	100.46	104.05	106.83	108.956
	S-W	93.4784	219.318	236.656	83.55	220.03	220.846

Movements		Delay in seconds corresponding to U-Turn Crossover Spacing					
Critical Ratio = 0.20		**500 ft.**	**600 ft.**	**700 ft.**	**800 ft.**	**900 ft.**	**1000 ft.**
Minor Street Movements (1)	**E-N**	829.931	695.56	839.78	766.11	997.03	1436.47
	E-S	936.351	783.71	988.07	927.21	1079.04	1450.52
	E-W	868.229	830.7	957.79	867.43	1116.2	1466.81
Major Street Movements (1)	**N-S**	141.024	85.95	92.41	92.17	99.28	101
	N-E	195.194	192.97	181.46	198.43	187.42	211.45
	N-W	73.543	70.28	75.24	73.01	81.63	87.09
Minor Street Movements (2)	**W-N**	89.9357	213.08	212.41	192.47	179.98	236.38
	W-S	95.1111	143.09	130.7	149.72	187.97	175.22
	W-E	255.519	171.55	167.47	205.83	177.27	256.77
Major Street Movements (2)	**S-N**	86.8679	91.88	95.2	95.95	98.87	95.2
	S-E	200.623	97.62	106.22	92.58	108	105.94
	S-W	92.1432	223.29	276.6	88.02	215.52	247.73

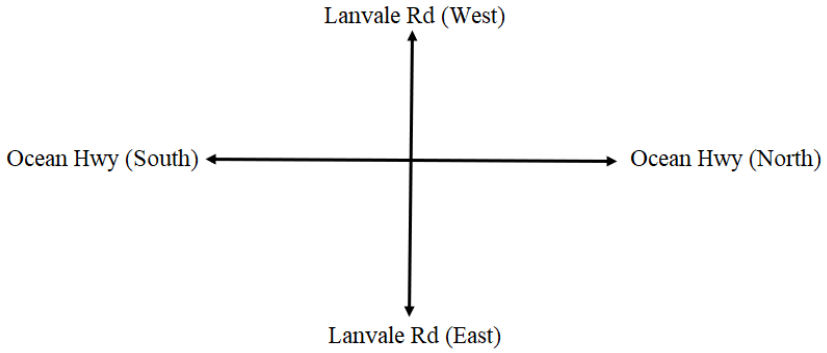
- Movement-wise delay for Stop-Controlled RCUT

Movements		Delay in seconds corresponding to U-Turn Crossover Spacing					
Critical Ratio = 0.05		**500 ft.**	**600 ft.**	**700 ft.**	**800 ft.**	**900 ft.**	**1000 ft.**
Minor Street Movements (1)	E-N	35.24	37.54	34.61	34.87	36.24	34.47
	E-S	141.98	142.47	148.28	132.32	126.99	133.23
	E-W	182.94	126.36	123.57	145.68	130.11	137.95
Minor Street Movements (2)	W-S	4.08	3.72	4.56	4.09	4.26	4.49
	W-E	56.18	46.13	46.51	58.52	46.6	45.76
	W-N	4.4	4.61	3.21	3.11	2.67	2.66
Major Street Movements (1)	S-N	100.99	122.26	142.88	132.48	125.27	121.62
	S-E	57.58	53.78	96.87	71.9	64.53	69.11
	S-W	108.04	103.72	149.65	142.05	108.45	113.19
Major Street Movements (2)	N-S	3.16	4.28	4.26	4.37	4.27	4.15
	N-W	3.45	3.17	3.15	3.14	1.01	3.94
	N-E	44.54	72.3	79.21	89.84	75.31	66.85

Movements		Delay in seconds corresponding to U-Turn Crossover Spacing					
Critical Ratio = 0.10		**500 ft.**	**600 ft.**	**700 ft.**	**800 ft.**	**900 ft.**	**1000 ft.**
Minor Street Movements (1)	E-N	53.29	51.6	46.69	46.23	50.23	47.81
	E-S	146.44	154.18	147.23	137.57	140.39	136.1
	E-W	143.08	150.91	160.19	132.35	127.28	135.65
Minor Street Movements (2)	W-S	5.15	3.96	4.45	4.43	4.71	5
	W-E	46.1	47.19	48.43	61.93	56.37	44.18
	W-N	4.83	5.01	3.29	3.91	2.5	3.32
Major Street Movements (1)	S-N	97.97	123.31	136.5	124.66	121.23	124.33
	S-E	71.18	71.38	68.23	75.02	77.87	73.2
	S-W	94.16	120.16	108.84	106.93	111.77	127.85
Major Street Movements (2)	N-S	4.99	6.58	6.02	6.59	6.33	6.29
	N-W	3.88	3.5	3.28	3.97	1.1	4.1
	N-E	53.61	65.9	84.23	76.23	60.33	71.32

Movements		Delay in seconds corresponding to U-Turn Crossover Spacing					
Critical Ratio = 0.15		**500 ft.**	**600 ft.**	**700 ft.**	**800 ft.**	**900 ft.**	**1000 ft.**
Minor Street Movements (1)	E-N	86.51	123.08	104.37	92.36	134.15	108.44
	E-S	169.11	181.55	176.04	167.41	166.24	168.62
	E-W	181.46	199.87	182.5	158.83	173.6	175.91
Minor Street Movements (2)	W-S	5.45	4.62	4.68	5.01	5.56	5.5
	W-E	46.76	46.58	43.93	61.39	48.88	51.59
	W-N	4.94	4.84	3.07	4.11	4.02	3.93
Major Street Movements (1)	S-N	92.51	119.83	129.17	115.23	131.19	124.47
	S-E	69.88	71.22	70.05	81.28	76.64	66.64
	S-W	91.41	121.49	132.89	123.87	106.3	125.52
Major Street Movements (2)	N-S	6.03	8.9	7.73	8.21	8.39	8.02
	N-W	3.65	3.07	3.02	3.75	0.84	4.12
	N-E	54.34	74.64	74.84	78.68	67.77	66.52

Movements		Delay in seconds corresponding to U-Turn Crossover Spacing					
Critical Ratio = 0.20		**500 ft.**	**600 ft.**	**700 ft.**	**800 ft.**	**900 ft.**	**1000 ft.**
Minor Street Movements (1)	E-N	662.18	678.41	720.75	628.18	748.07	664.51
	E-S	557.62	571.72	608.55	529.4	606.99	547.63
	E-W	558.44	584.4	570.61	529.81	613.26	552.8
Minor Street Movements (2)	W-S	74.85	4.14	4.89	4.57	5.27	5.72
	W-E	101.14	45.94	48.74	59.8	53.02	48.03
	W-N	2	4.34	3.29	3.77	3.1	3.37
Major Street Movements (1)	S-N	7.84	116.9	134.05	117.81	132.18	115.83
	S-E	3.84	73.62	73.76	67.62	72.61	70.87
	S-W	44.91	124.56	128.32	113.29	113.65	116.72
Major Street Movements (2)	N-S	5.64	10.64	8.86	9.63	8.86	8.89
	N-E	47.27	3.51	2.99	4.27	1.25	4.1
	N-W	4.47	56.18	70.92	76.85	58.59	59.4



Appendix C: VISSIM Results- Average Delay/vehicle for Varying Storage Bays

- Movement-wise delay for Signalized RCUT

Movements		Delay in seconds corresponding to Varying Length of Storage Bay				
Critical Ratio = 0.05		**0.2U**	**0.4U**	**0.6U**	**0.8U**	**1.0U**
Minor Street Movement (1)	E-N	140.1	136.65	140.92	154.94	151.88
	E-S	223.62	238.69	257.02	238.64	230.89
	E-W	210.86	217.91	177.88	219.52	195.13
Major Street Movement (1)	N-S	113.2	111.68	120.36	111.09	116
	N-E	179.47	222.14	213.92	215.42	186.55
	N-W	88.76	87.83	94.76	92.36	89.71
Minor Street Movement (2)	W-N	195.62	229.61	219.18	190.24	224.28
	W-S	153.16	139.12	147.14	172.3	129.32
	W-E	173.31	156.76	198.69	158.88	206.83
Major Street Movement (2)	S-N	104.69	103.37	105.89	103.41	103.78
	S-E	111.54	108.47	118.63	111.93	89.14
	S-W	88.24	87.56	92.6	97.39	113.69

Movements		Delay in seconds corresponding to Varying Length of Storage Bay				
Critical Ratio = 0.10		**0.2U**	**0.4U**	**0.6U**	**0.8U**	**1.0U**
Minor Street Movement (1)	E-N	153.04	147.32	148.62	169.27	164.53
	E-S	228.32	247.55	235.01	244.53	247.8
	E-W	207.54	177.81	220.91	216.67	174.04
Major Street Movement (1)	N-S	104.2	99.35	110.38	100.72	101.41
	N-E	202.34	176.93	209.96	153.46	171.92
	N-W	90.36	83.94	85.68	77.86	85.31
Minor Street Movement (2)	W-N	198.18	234.02	188	207.48	198.53
	W-S	121.73	132.14	124.03	165.76	136.06
	W-E	187.67	166.08	153.38	204.06	237.12
Major Street Movement (2)	S-N	100.55	104.58	101.73	103.79	102.57
	S-E	106.12	104.75	103.85	107.58	75.58
	S-W	95.03	75.06	83.45	86.1	109.75

Movements		Delay in seconds corresponding to Varying Length of Storage Bay				
Critical Ratio = 0.15		**0.2U**	**0.4U**	**0.6U**	**0.8U**	**1.0U**
Minor Street Movement (1)	E-N	162.95	164.53	157.86	180.95	258.02
	E-S	265.27	271.49	263.14	308.53	267.53
	E-W	213.04	247.85	232.29	289.14	207.02
Major Street Movement (1)	N-S	98.25	99.59	100.23	97.33	97.91
	N-E	174.99	184.97	176.59	194.31	170.98
	N-W	82.53	85.32	82.22	84.51	82.47
Minor Street Movement (2)	W-N	181.59	199.08	189.67	221.26	237.93
	W-S	126.55	114.83	145.98	141.26	139.92
	W-E	188.15	191.95	163.83	192.78	164.13
Major Street Movement (2)	S-N	99.05	97.51	99.12	95.44	96.62
	S-E	110.41	103.5	109.04	101.43	83.55
	S-W	65.16	77.15	83.99	91.94	121.3

Movements		Delay in seconds corresponding to Varying Length of Storage Bay				
Critical Ratio = 0.20		**0.2U**	**0.4U**	**0.6U**	**0.8U**	**1.0U**
Minor Street Movement (1)	E-N	182.55	183.89	183.35	240.83	766.11
	E-S	317.61	338.69	350.2	435.59	927.21
	E-W	272.97	274.02	304.6	359.64	867.43
Major Street Movement (1)	N-S	94.41	96.33	93.68	95.03	92.17
	N-E	194.11	201.46	196.24	189.43	198.43
	N-W	79.49	77.22	75.23	77.58	73.01
Minor Street Movement (2)	W-N	176.78	209.6	184.62	207.56	192.47
	W-S	135.84	154.48	148.19	153.24	149.72
	W-E	173.62	192.61	217.39	218.85	205.83
Major Street Movement (2)	S-N	96.3	98.67	96.46	97.5	95.95
	S-E	107.42	101.23	101.8	102.12	88.02
	S-W	74.25	80.22	75.73	77.36	202.66

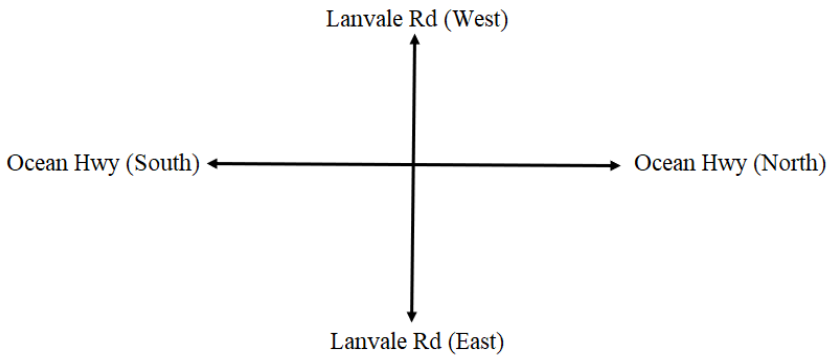
- Movement-wise delay for Stop-Controlled RCUT

Movements		Delay in seconds corresponding to Varying Length of Storage Bay				
Critical Ratio = 0.05		**0.2U**	**0.4U**	**0.6U**	**0.8U**	**1.0U**
Minor Street Movements (1)	E-N	43.93	42.82	44.34	43.16	34.87
	E-S	109.43	135.5	142.41	141.56	132.32
	E-W	119.03	125.15	123.33	127.83	145.68
Major Street Movements (1)	N-S	3.93	4.28	4.73	4.19	4.09
	N-E	59.63	60.59	58.8	61.98	58.52
	N-E	4.8	3.72	3.14	3.42	3.11
Minor Street Movements (2)	W-N	116.24	125.85	110.81	124.22	132.48
	W-S	83.27	77.06	76.54	76.49	71.9
	W-E	112.12	109.11	156.56	195.72	142.05
Major Street Movements (2)	S-N	6.42	5.75	5.9	5.56	4.37
	S-W	3.17	3.85	3.4	4.08	3.14
	S-W	77.9	91.14	92.11	103.76	89.84

Movements		Delay in seconds corresponding to Varying Length of Storage Bay				
Critical Ratio = 0.10		**0.2U**	**0.4U**	**0.6U**	**0.8U**	**1.0U**
Minor Street Movements (1)	E-N	49.89	55.62	51.49	51.9	49.56
	E-S	128.2	155.72	163.55	154.04	145.18
	E-W	139.97	141.83	151.61	135.36	128.22
Major Street Movements (1)	N-S	4.97	5.11	4.82	5.08	4.41
	N-E	58.78	63.57	69.43	61.72	63.79
	N-E	5.55	4.58	3.34	3.85	3.09
Minor Street Movements (2)	W-N	110.76	112.99	126.54	115.38	114.8
	W-S	72.05	62.86	62.6	63.48	88.59
	W-E	117.76	94.15	121.28	125.06	98.12
Major Street Movements (2)	S-N	9.81	9.76	9.51	9.16	6.65
	S-W	3.84	3.66	3.53	3.69	3.79
	S-W	84.27	80.32	80.46	80.28	79.43

Movements		Delay in seconds corresponding to Varying Length of Storage Bay				
Critical Ratio = 0.15		**0.2U**	**0.4U**	**0.6U**	**0.8U**	**1.0U**
Minor Street Movements (1)	E-N	82.14	103.97	66.65	69.01	92.36
	E-S	168.37	250.36	192.65	199.99	167.41
	E-W	160.67	221.35	194.78	187.91	158.83
Major Street Movements (1)	N-S	5.35	5.51	5.87	5.23	5.01
	N-E	56.47	61.79	59.06	63.46	61.39
	N-E	6.24	3.9	4.1	4.27	4.11
Minor Street Movements (2)	W-N	108.29	111.37	113.12	115.54	115.23
	W-S	71.66	82.36	74.25	72.59	81.28
	W-E	104.55	130.2	111.23	112.59	123.87
Major Street Movements (2)	S-N	15.68	13.75	13.42	11.99	8.21
	S-W	3.7	4.16	4.18	3.75	3.75
	S-W	70.09	85.84	79.91	76.53	78.68

Movements		Delay in seconds corresponding to Varying Length of Storage Bay				
Critical Ratio = 0.20		**0.2U**	**0.4U**	**0.6U**	**0.8U**	**1.0U**
Minor Street Movements (1)	E-N	132.8	477.47	125.01	127.2	628.18
	E-S	221.5	615.76	291.49	302.4	529.4
	E-W	230.69	614.92	304.39	323.85	529.81
Major Street Movements (1)	N-S	6.14	5.7	5.99	5.59	4.57
	N-E	60.02	65.23	65.57	58.88	59.8
	N-E	6.04	4.04	3.8	3.87	3.77
Minor Street Movements (2)	W-N	117.16	112.6	126.22	118.41	117.81
	W-S	65.62	72.7	69.85	65.63	67.62
	W-E	126.65	115.45	106.84	124.47	113.29
Major Street Movements (2)	S-N	18.96	17.46	17.27	15.41	9.63
	S-W	4.04	4.34	4.24	3.62	4.27
	S-W	74.75	73.01	79.74	68.51	76.85



- Appendix-D- Individual Results of 5 Runs for Each Cases

➢ Signalized RCUT-500 ft. U-Turn Crossover Spacing- Critical Ratio- 0.05

Run-1	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
29	900-1800	E-N	11.34	45.04	46	40.94	35.55	0.8
29	900-1800	E-S	11.34	45.04	7	68.92	55.19	2
29	900-1800	E-W	11.34	45.04	0			
29	900-1800	N-S	56.94	229.42	495	22.47	13.35	0.51
29	900-1800	N-E	56.94	229.42	6	29.48	20.11	1
29	900-1800	N-W	56.94	229.42	22	34.76	24.8	0.82
29	900-1800	W-N	0.73	6.15	2	25.25	12.23	1
29	900-1800	W-S	0.73	6.15	2	27.85	24.69	0.5
29	900-1800	W-E	0.73	6.15	1	72.26	60.52	2
29	900-1800	S-N	41.71	212.4	372	22.49	13.05	0.52
29	900-1800	S-E	41.71	212.4	23	22.01	14.17	0.57
29	900-1800	S-W	41.71	212.4	6	74.05	59.65	1.83
29	900-1800	Total	27.68	229.42	982	24.37	15.24	0.56
29	1800-2700	E-N	7.34	39.12	30	31.96	27.43	0.63
29	1800-2700	E-S	7.34	39.12	7	35.56	24.28	1.43
29	1800-2700	E-W	7.34	39.12	1	2.45	0	0
29	1800-2700	N-S	100.52	313.64	515	25.84	15.69	0.58
29	1800-2700	N-E	100.52	313.64	7	37.52	27.81	1.14
29	1800-2700	N-W	100.52	313.64	27	34.99	25.32	0.78
29	1800-2700	W-N	0.69	13.25	1	51.23	32.9	2
29	1800-2700	W-S	0.69	13.25	3	8.43	5.9	0.33
29	1800-2700	W-E	0.69	13.25	0			
29	1800-2700	S-N	33.4	140.9	389	24.37	13.78	0.59
29	1800-2700	S-E	33.4	140.9	18	18.01	10.5	0.61
29	1800-2700	S-W	33.4	140.9	4	45.74	34.11	1.5
29	1800-2700	Total	35.48	313.64	1002	25.74	15.66	0.6
29	2700-3600	E-N	10.4	50.39	42	37.12	31.66	0.79
29	2700-3600	E-S	10.4	50.39	6	50.17	39.12	1.67
29	2700-3600	E-W	10.4	50.39	0			
29	2700-3600	N-S	53.95	197	489	20.94	11.48	0.52
29	2700-3600	N-E	53.95	197	9	56.44	41.28	1.78
29	2700-3600	N-W	53.95	197	20	20.09	12.74	0.55
29	2700-3600	W-N	0.94	12.98	2	58.48	40.04	2
29	2700-3600	W-S	0.94	12.98	4	12.08	9.73	0.25
29	2700-3600	W-E	0.94	12.98	2	48.55	39.35	1.5
29	2700-3600	S-N	39.73	164.45	379	24.14	14.63	0.58
29	2700-3600	S-E	39.73	164.45	20	26.71	17.87	0.7
29	2700-3600	S-W	39.73	164.45	6	48.9	35.5	1.33
29	2700-3600	Total	26.25	197	979	23.75	14.42	0.58
29	3600-4500	E-N	14.62	56.17	42	45.72	39.75	0.83
29	3600-4500	E-S	14.62	56.17	10	50.97	39.52	1.5
29	3600-4500	E-W	14.62	56.17	0			
29	3600-4500	N-S	105.03	351.53	548	25.65	16.16	0.55
29	3600-4500	N-E	105.03	351.53	1	95.94	79.5	2
29	3600-4500	N-W	105.03	351.53	24	31.42	23.18	0.71
29	3600-4500	W-N	0.16	6.7	2	31.56	14.42	1.5
29	3600-4500	W-S	0.16	6.7	0			
29	3600-4500	W-E	0.16	6.7	1	1.28	0	0
29	3600-4500	S-N	36.62	145.26	399	24.76	14.45	0.61
29	3600-4500	S-E	36.62	145.26	21	22.22	13.16	0.62
29	3600-4500	S-W	36.62	145.26	3	49.91	37.42	1.33
29	3600-4500	Total	39.11	351.53	1051	26.55	16.88	0.6

Run-2	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
30	900-1800	E-N	8.481152	32.810766	35	36.790927	32.123605	0.714286
30	900-1800	E-S	8.481152	32.810766	9	57.539519	43.453744	2
30	900-1800	E-W	8.481152	32.810766	1	30.167698	19.181495	1
30	900-1800	N-S	88.01791	295.492237	512	24.731831	15.627286	0.519531
30	900-1800	N-E	88.01791	295.492237	8	59.041166	45.547526	1.75
30	900-1800	N-W	88.01791	295.492237	20	24.496767	16.514359	0.6
30	900-1800	W-N	0.532647	6.611522	1	75.703552	57.175155	2
30	900-1800	W-S	0.532647	6.611522	0			
30	900-1800	W-E	0.532647	6.611522	1	18.717713	6.967562	2
30	900-1800	S-N	30.68947	147.491875	339	22.927806	13.390402	0.551622
30	900-1800	S-E	30.68947	147.491875	15	21.525371	12.278786	0.733333
30	900-1800	S-W	30.68947	147.491875	4	80.529264	65.386164	1.75
30	900-1800	Total	31.9303	295.492237	945	25.367845	16.168936	0.57672
30	1800-2700	E-N	7.101609	33.437046	21	37.024506	32.116265	0.761905
30	1800-2700	E-S	7.101609	33.437046	10	61.068136	50.035582	1.7
30	1800-2700	E-W	7.101609	33.437046	2	3.015197	0	0
30	1800-2700	N-S	68.60186	306.797427	516	23.746979	14.108826	0.532946
30	1800-2700	N-E	68.60186	306.797427	5	58.45444	44.196456	1.6
30	1800-2700	N-W	68.60186	306.797427	21	35.681573	27.330405	0.809524
30	1800-2700	W-N	0.915611	6.538577	2	35.350776	17.068271	2
30	1800-2700	W-S	0.915611	6.538577	0			
30	1800-2700	W-E	0.915611	6.538577	2	72.214956	59.873666	2
30	1800-2700	S-N	32.27261	162.643989	399	23.161052	13.177412	0.536341
30	1800-2700	S-E	32.27261	162.643989	20	21.613405	13.737721	0.6
30	1800-2700	S-W	32.27261	162.643989	7	47.771348	36.717665	1.285714
30	1800-2700	Total	27.22292	306.797427	1005	24.78837	15.117733	0.573134
30	2700-3600	E-N	7.639481	32.226097	39	33.929602	29.34998	0.641026
30	2700-3600	E-S	7.639481	32.226097	6	42.505173	30.488122	1.666667
30	2700-3600	E-W	7.639481	32.226097	0			
30	2700-3600	N-S	89.34687	299.893065	513	24.399352	15.306633	0.499025
30	2700-3600	N-E	89.34687	299.893065	5	52.318124	40.64739	1.4
30	2700-3600	N-W	89.34687	299.893065	16	31.937293	23.565145	0.6875
30	2700-3600	W-N	1.508036	13.54912	2	88.570528	69.87406	2
30	2700-3600	W-S	1.508036	13.54912	3	56.541373	50.858517	1
30	2700-3600	W-E	1.508036	13.54912	1	1.944098	0	0
30	2700-3600	S-N	32.09192	174.438612	364	22.290775	12.279328	0.535714
30	2700-3600	S-E	32.09192	174.438612	18	22.292815	14.147453	0.555556
30	2700-3600	S-W	32.09192	174.438612	6	71.593002	56.125848	1.833333
30	2700-3600	Total	32.64658	299.893065	973	24.831573	15.532958	0.546763
30	3600-4500	E-N	8.154277	26.409359	33	31.240116	26.448803	0.69697
30	3600-4500	E-S	8.154277	26.409359	11	65.169712	52.650805	1.636364
30	3600-4500	E-W	8.154277	26.409359	1	102.156461	89.96017	2
30	3600-4500	N-S	96.42558	334.042856	519	24.63069	14.969319	0.543353
30	3600-4500	N-E	96.42558	334.042856	3	61.560367	46.244607	1.666667
30	3600-4500	N-W	96.42558	334.042856	27	26.95093	19.034566	0.666667
30	3600-4500	W-N	1.748934	19.033814	5	57.681305	44.391181	1.2
30	3600-4500	W-S	1.748934	19.033814	3	20.368484	15.634343	0.666667
30	3600-4500	W-E	1.748934	19.033814	0			
30	3600-4500	S-N	32.43713	133.5822	394	23.459436	13.317456	0.573604
30	3600-4500	S-E	32.43713	133.5822	18	27.924094	19.188272	0.722222
30	3600-4500	S-W	32.43713	133.5822	8	41.217607	31.304983	1.125
30	3600-4500	Total	34.69148	334.042856	1022	25.411483	15.729392	0.590998

Run-3	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
31	900-1800	E-N	10.04086	37.725964	41	38.12553	32.750949	0.731707
31	900-1800	E-S	10.04086	37.725964	10	33.270516	23.983916	1.3
31	900-1800	E-W	10.04086	37.725964	3	21.070358	12.504219	1
31	900-1800	N-S	132.6163	357.202482	522	26.626985	17.131135	0.492337
31	900-1800	N-E	132.6163	357.202482	1	83.071759	66.787303	2
31	900-1800	N-W	132.6163	357.202482	25	27.353676	19.732806	0.56
31	900-1800	W-N	0.817547	12.559504	2	25.597424	9.694205	1.5
31	900-1800	W-S	0.817547	12.559504	1	80.586452	74.323663	1
31	900-1800	W-E	0.817547	12.559504	1	52.062839	40.017811	2
31	900-1800	S-N	31.60056	142.98828	350	21.679516	12.076024	0.54
31	900-1800	S-E	31.60056	142.98828	17	20.675716	13.705481	0.588235
31	900-1800	S-W	31.60056	142.98828	7	69.831712	53.219431	1.857143
31	900-1800	Total	43.76881	357.202482	980	25.752293	16.416906	0.547959
31	1800-2700	E-N	14.19321	43.111687	42	46.705552	41.221534	0.785714
31	1800-2700	E-S	14.19321	43.111687	9	61.741586	50.453529	1.666667
31	1800-2700	E-W	14.19321	43.111687	1	24.153394	12.072932	2
31	1800-2700	N-S	81.96288	357.678307	515	25.098408	15.275782	0.545631
31	1800-2700	N-E	81.96288	357.678307	2	94.693058	78.213385	2
31	1800-2700	N-W	81.96288	357.678307	16	32.900849	24.59317	0.8125
31	1800-2700	W-N	0.64926	6.634646	0			
31	1800-2700	W-S	0.64926	6.634646	1	32.450668	26.280984	1
31	1800-2700	W-E	0.64926	6.634646	1	92.079188	79.813568	2
31	1800-2700	S-N	42.78405	155.135756	417	25.492661	14.842707	0.613909
31	1800-2700	S-E	42.78405	155.135756	22	26.028181	16.479764	0.772727
31	1800-2700	S-W	42.78405	155.135756	6	64.540264	51.665087	1.666667
31	1800-2700	Total	34.89735	357.678307	1032	27.032725	17.037261	0.614341
31	2700-3600	E-N	8.531379	51.822238	40	36.045237	31.318133	0.7
31	2700-3600	E-S	8.531379	51.822238	7	39.860613	26.987641	1.857143
31	2700-3600	E-W	8.531379	51.822238	1	97.161141	85.361605	2
31	2700-3600	N-S	61.02034	218.677567	474	25.147049	15.364852	0.559072
31	2700-3600	N-E	61.02034	218.677567	5	21.980867	13.230619	1
31	2700-3600	N-W	61.02034	218.677567	13	23.098785	16.265332	0.538462
31	2700-3600	W-N	0.790993	6.580394	2	19.726639	9.450541	1
31	2700-3600	W-S	0.790993	6.580394	2	31.846753	28.640064	0.5
31	2700-3600	W-E	0.790993	6.580394	1	71.181909	59.461958	2
31	2700-3600	S-N	40.69271	189.801266	385	23.296467	13.982169	0.558442
31	2700-3600	S-E	40.69271	189.801266	18	23.308191	15.401145	0.611111
31	2700-3600	S-W	40.69271	189.801266	5	60.036879	47.382343	1.6
31	2700-3600	Total	27.75886	218.677567	953	25.195262	15.866163	0.586569
31	3600-4500	E-N	7.173216	55.931428	31	25.603189	21.008138	0.677419
31	3600-4500	E-S	7.173216	55.931428	6	39.887265	29.981646	1.333333
31	3600-4500	E-W	7.173216	55.931428	1	100.742483	90.102735	2
31	3600-4500	N-S	68.2658	264.481408	527	24.145684	14.498599	0.555977
31	3600-4500	N-E	68.2658	264.481408	4	64.919042	50.747536	1.75
31	3600-4500	N-W	68.2658	264.481408	15	27.371736	18.688536	0.733333
31	3600-4500	W-N	1.348242	11.655871	3	63.936011	50.993164	1.333333
31	3600-4500	W-S	1.348242	11.655871	0			
31	3600-4500	W-E	1.348242	11.655871	2	61.058226	48.644741	2
31	3600-4500	S-N	43.00338	187.604956	421	24.013337	13.984912	0.567696
31	3600-4500	S-E	43.00338	187.604956	20	26.359247	17.890089	0.7
31	3600-4500	S-W	43.00338	187.604956	4	64.273675	52.969779	1.5
31	3600-4500	Total	29.94766	264.481408	1034	24.89034	15.234935	0.588975

Run-4	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
32	900-1800	E-N	9.086994	38.785798	33	39.001896	33.593863	0.818182
32	900-1800	E-S	9.086994	38.785798	7	62.686261	50.067902	1.857143
32	900-1800	E-W	9.086994	38.785798	1	9.300926	0	0
32	900-1800	N-S	73.34518	283.332091	528	23.149221	13.95725	0.498106
32	900-1800	N-E	73.34518	283.332091	4	83.387639	67.213987	2
32	900-1800	N-W	73.34518	283.332091	23	19.945389	13.757087	0.521739
32	900-1800	W-N	0.608408	6.53068	2	48.108907	38.463491	1
32	900-1800	W-S	0.608408	6.53068	3	13.677283	7.858375	1
32	900-1800	W-E	0.608408	6.53068	0			
32	900-1800	S-N	39.64122	157.199119	390	22.777564	13.081198	0.594872
32	900-1800	S-E	39.64122	157.199119	21	30.267894	22.28248	0.666667
32	900-1800	S-W	39.64122	157.199119	11	50.023837	38.112387	1.545455
32	900-1800	Total	30.67045	283.332091	1023	24.395541	15.154553	0.577713
32	1800-2700	E-N	8.772082	52.622919	31	39.143739	33.467752	0.774194
32	1800-2700	E-S	8.772082	52.622919	11	41.84229	31.300257	1.272727
32	1800-2700	E-W	8.772082	52.622919	3	71.149231	61.709	1.333333
32	1800-2700	N-S	64.23248	226.249505	538	23.010568	13.465086	0.537175
32	1800-2700	N-E	64.23248	226.249505	6	53.7681	39.700999	1.666667
32	1800-2700	N-W	64.23248	226.249505	13	18.287272	11.841403	0.538462
32	1800-2700	W-N	0.959794	6.639822	2	60.634333	45.211788	1.5
32	1800-2700	W-S	0.959794	6.639822	3	0.88115	0	0
32	1800-2700	W-E	0.959794	6.639822	1	84.521077	72.397947	2
32	1800-2700	S-N	27.63943	134.181883	370	22.767649	13.111484	0.540541
32	1800-2700	S-E	27.63943	134.181883	20	16.596837	9.606875	0.5
32	1800-2700	S-W	27.63943	134.181883	5	36.029628	28.541098	1
32	1800-2700	Total	25.40095	226.249505	1003	23.900045	14.508678	0.566301
32	2700-3600	E-N	10.41498	55.008266	40	38.160498	32.410603	0.825
32	2700-3600	E-S	10.41498	55.008266	8	60.604876	48.218932	1.625
32	2700-3600	E-W	10.41498	55.008266	1	36.577099	24.81161	2
32	2700-3600	N-S	46.10821	183.917759	487	20.792413	11.782434	0.523614
32	2700-3600	N-E	46.10821	183.917759	5	52.993439	41.65427	1.4
32	2700-3600	N-W	46.10821	183.917759	17	31.318299	23.126391	0.764706
32	2700-3600	W-N	2.148102	26.154895	3	55.41153	41.984618	1.333333
32	2700-3600	W-S	2.148102	26.154895	5	44.891354	39.30789	0.8
32	2700-3600	W-E	2.148102	26.154895	0			
32	2700-3600	S-N	35.22163	148.130118	380	21.889859	12.384945	0.536842
32	2700-3600	S-E	35.22163	148.130118	11	19.771442	11.580131	0.636364
32	2700-3600	S-W	35.22163	148.130118	10	64.057782	50.939882	1.6
32	2700-3600	Total	23.47323	183.917759	967	23.307157	14.179944	0.577042
32	3600-4500	E-N	8.44295	31.649361	30	36.321752	31.870658	0.633333
32	3600-4500	E-S	8.44295	31.649361	10	58.58518	46.443811	1.8
32	3600-4500	E-W	8.44295	31.649361	0			
32	3600-4500	N-S	121.2895	284.8872	559	28.6572	18.554192	0.568873
32	3600-4500	N-E	121.2895	284.8872	2	14.15922	8.8067	0.5
32	3600-4500	N-W	121.2895	284.8872	22	31.447205	23.342537	0.681818
32	3600-4500	W-N	0.714958	6.768176	1	53.573612	35.019761	2
32	3600-4500	W-S	0.714958	6.768176	2	50.708859	44.432389	1
32	3600-4500	W-E	0.714958	6.768176	0			
32	3600-4500	S-N	38.98648	187.884711	381	25.362452	15.152455	0.595801
32	3600-4500	S-E	38.98648	187.884711	17	29.75719	19.576143	0.882353
32	3600-4500	S-W	38.98648	187.884711	8	44.124697	33.568599	1.375
32	3600-4500	Total	42.35846	284.8872	1032	28.189914	18.238191	0.608527

Run-5	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
33	900-1800	E-N	10.58824	50.163733	38	45.10936	39.189586	0.842105
33	900-1800	E-S	10.58824	50.163733	6	55.681299	44.43937	1.333333
33	900-1800	E-W	10.58824	50.163733	0			
33	900-1800	N-S	63.83349	240.219157	530	22.282012	13.04299	0.49434
33	900-1800	N-E	63.83349	240.219157	3	24.547356	18.065559	0.666667
33	900-1800	N-W	63.83349	240.219157	18	34.513655	25.019673	0.833333
33	900-1800	W-N	0.512337	6.457242	0			
33	900-1800	W-S	0.512337	6.457242	2	47.330793	41.746532	1
33	900-1800	W-E	0.512337	6.457242	0			
33	900-1800	S-N	30.71327	162.993682	328	22.556705	12.950173	0.52439
33	900-1800	S-E	30.71327	162.993682	17	24.555295	15.380861	0.705882
33	900-1800	S-W	30.71327	162.993682	9	68.588751	52.872599	1.777778
33	900-1800	Total	26.41183	240.219157	951	24.269818	14.975451	0.547844
33	1800-2700	E-N	10.71504	45.350602	35	43.859507	38.65078	0.771429
33	1800-2700	E-S	10.71504	45.350602	6	54.534297	44.057817	1.666667
33	1800-2700	E-W	10.71504	45.350602	0			
33	1800-2700	N-S	88.74115	302.760414	525	26.132005	15.981228	0.56
33	1800-2700	N-E	88.74115	302.760414	7	55.396802	41.278047	1.714286
33	1800-2700	N-W	88.74115	302.760414	28	26.974061	19.078458	0.642857
33	1800-2700	W-N	0.362325	13.88464	2	1.458722	0	0
33	1800-2700	W-S	0.362325	13.88464	0			
33	1800-2700	W-E	0.362325	13.88464	0			
33	1800-2700	S-N	48.63089	206.89929	430	24.45953	14.043992	0.597674
33	1800-2700	S-E	48.63089	206.89929	18	31.933172	22.204943	0.833333
33	1800-2700	S-W	48.63089	206.89929	4	37.983221	26.79198	1.25
33	1800-2700	Total	37.11235	302.760414	1055	26.513638	16.470318	0.604739
33	2700-3600	E-N	11.40147	69.48112	39	45.651466	39.932543	0.820513
33	2700-3600	E-S	11.40147	69.48112	5	44.072113	35.491143	1.2
33	2700-3600	E-W	11.40147	69.48112	1	99.558217	87.699288	2
33	2700-3600	N-S	61.9081	245.697377	500	22.017398	12.683281	0.5
33	2700-3600	N-E	61.9081	245.697377	7	39.797391	28.166171	1.285714
33	2700-3600	N-W	61.9081	245.697377	15	15.118725	9.79622	0.4
33	2700-3600	W-N	1.141145	12.958586	3	57.234709	38.325743	2
33	2700-3600	W-S	1.141145	12.958586	2	31.352273	27.94073	0.5
33	2700-3600	W-E	1.141145	12.958586	3	34.437035	21.551839	2
33	2700-3600	S-N	34.23117	136.110781	361	22.951887	13.409058	0.554017
33	2700-3600	S-E	34.23117	136.110781	20	24.093685	17.066745	0.5
33	2700-3600	S-W	34.23117	136.110781	7	56.020085	43.76067	1.571429
33	2700-3600	Total	27.17047	245.697377	963	23.999743	14.778936	0.559709
33	3600-4500	E-N	6.410494	32.077363	25	33.14965	27.967353	0.8
33	3600-4500	E-S	6.410494	32.077363	10	53.81515	43.119021	1.4
33	3600-4500	E-W	6.410494	32.077363	0			
33	3600-4500	N-S	76.84841	287.372094	545	24.186089	14.715691	0.537615
33	3600-4500	N-E	76.84841	287.372094	8	21.825763	15.507262	0.75
33	3600-4500	N-W	76.84841	287.372094	20	28.985348	20.209869	0.7
33	3600-4500	W-N	0.825265	6.65344	1	34.863522	16.791259	2
33	3600-4500	W-S	0.825265	6.65344	4	31.044735	26.731519	0.75
33	3600-4500	W-E	0.825265	6.65344	0			
33	3600-4500	S-N	30.48056	116.295725	389	23.586239	13.457857	0.529563
33	3600-4500	S-E	30.48056	116.295725	20	21.731377	14.226045	0.6
33	3600-4500	S-W	30.48056	116.295725	4	55.740589	44.077787	1.5
33	3600-4500	Total	28.64118	287.372094	1026	24.653317	15.105591	0.561404

- Signalized RCUT- 500 ft. U-Turn Crossover spacing- Critical Ratio- 0.10

Run-1	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
36	900-1800	E-N	24.37012	77.64934	81	43.447683	36.437575	0.876543
36	900-1800	E-S	24.37012	77.64934	15	56.582758	44.726787	1.533333
36	900-1800	E-W	24.37012	77.64934	1	25.949114	14.449905	2
36	900-1800	N-S	65.46632	267.90986	486	23.689473	14.259293	0.518519
36	900-1800	N-E	65.46632	267.90986	11	33.821299	24.414784	1.090909
36	900-1800	N-W	65.46632	267.90986	21	20.493527	14.504527	0.52381
36	900-1800	W-N	1.879197	18.395791	5	56.451502	41.688701	1.6
36	900-1800	W-S	1.879197	18.395791	3	30.617837	26.020956	0.666667
36	900-1800	W-E	1.879197	18.395791	2	49.841415	38.275283	2
36	900-1800	S-N	30.07065	157.139081	367	20.506787	11.299633	0.498638
36	900-1800	S-E	30.07065	157.139081	14	24.415837	14.812917	0.714286
36	900-1800	S-W	30.07065	157.139081	13	84.786292	69.155082	1.923077
36	900-1800	Total	30.44657	267.90986	1019	25.665617	16.443953	0.591757
36	1800-2700	E-N	22.01033	73.963088	62	47.710388	41.355534	0.854839
36	1800-2700	E-S	22.01033	73.963088	16	34.407689	24.51944	1.125
36	1800-2700	E-W	22.01033	73.963088	4	57.452761	48.309786	1.25
36	1800-2700	N-S	58.87833	210.932383	509	23.077068	13.621555	0.550098
36	1800-2700	N-E	58.87833	210.932383	8	61.602354	49.272824	1.625
36	1800-2700	N-W	58.87833	210.932383	18	28.796501	20.032637	0.777778
36	1800-2700	W-N	1.48018	12.196335	2	45.057984	28.227393	1.5
36	1800-2700	W-S	1.48018	12.196335	3	33.438777	28.965414	0.666667
36	1800-2700	W-E	1.48018	12.196335	1	82.566861	70.422733	2
36	1800-2700	S-N	36.95527	192.487332	380	22.587588	12.373966	0.578947
36	1800-2700	S-E	36.95527	192.487332	23	23.321799	16.306315	0.521739
36	1800-2700	S-W	36.95527	192.487332	6	81.615741	66.291211	1.833333
36	1800-2700	Total	29.83103	210.932383	1032	25.560213	16.013961	0.613372
36	2700-3600	E-N	29.33463	106.914824	78	52.825648	45.546795	1.012821
36	2700-3600	E-S	29.33463	106.914824	12	52.006332	41.211448	1.583333
36	2700-3600	E-W	29.33463	106.914824	0			
36	2700-3600	N-S	46.46066	196.340342	477	20.654536	11.429229	0.486373
36	2700-3600	N-E	46.46066	196.340342	6	20.765908	12.710961	0.833333
36	2700-3600	N-W	46.46066	196.340342	12	17.997951	10.755953	0.583333
36	2700-3600	W-N	3.491248	26.48776	5	55.616531	38.185712	1.4
36	2700-3600	W-S	3.491248	26.48776	7	27.600083	22.820513	0.714286
36	2700-3600	W-E	3.491248	26.48776	1	57.589649	44.979168	2
36	2700-3600	S-N	27.93281	160.54295	334	21.892164	12.469112	0.538922
36	2700-3600	S-E	27.93281	160.54295	22	22.655219	15.429025	0.590909
36	2700-3600	S-W	27.93281	160.54295	4	65.903468	52.06651	1.75
36	2700-3600	Total	26.80484	196.340342	958	24.572177	15.461698	0.580376
36	3600-4500	E-N	24.37618	99.761829	73	43.269018	36.330578	0.917808
36	3600-4500	E-S	24.37618	99.761829	13	50.533859	37.811728	1.307692
36	3600-4500	E-W	24.37618	99.761829	3	77.424464	65.258544	2
36	3600-4500	N-S	39.89827	226.047011	463	21.224798	12.119963	0.509719
36	3600-4500	N-E	39.89827	226.047011	3	63.013019	50.017093	1.666667
36	3600-4500	N-W	39.89827	226.047011	20	19.634126	12.279187	0.55
36	3600-4500	W-N	4.630716	19.449784	10	69.20655	50.481215	1.9
36	3600-4500	W-S	4.630716	19.449784	3	67.751066	61.694648	1
36	3600-4500	W-E	4.630716	19.449784	3	61.840392	49.665722	1.666667
36	3600-4500	S-N	35.35241	139.049964	360	25.356446	14.534965	0.644444
36	3600-4500	S-E	35.35241	139.049964	27	22.764899	13.663525	0.592593
36	3600-4500	S-W	35.35241	139.049964	6	56.718256	45.872643	1.333333
36	3600-4500	Total	26.06439	226.047011	984	26.037375	16.323445	0.635163

Run-2	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
35	900-1800	E-N	21.94231	61.926581	77	41.58793	35.466035	0.818182
35	900-1800	E-S	21.94231	61.926581	19	35.644354	25.434004	1
35	900-1800	E-W	21.94231	61.926581	3	70.17655	60.758861	1.333333
35	900-1800	N-S	65.46281	264.252735	488	21.807433	12.416891	0.497951
35	900-1800	N-E	65.46281	264.252735	3	29.427812	23.199391	0.666667
35	900-1800	N-W	65.46281	264.252735	29	30.096528	20.58708	0.827586
35	900-1800	W-N	1.064472	6.950372	3	20.142141	9.440442	1
35	900-1800	W-S	1.064472	6.950372	3	55.035192	49.378709	1
35	900-1800	W-E	1.064472	6.950372	1	15.216678	7.599756	1
35	900-1800	S-N	38.39919	169.139499	357	24.992336	14.649777	0.605042
35	900-1800	S-E	38.39919	169.139499	22	20.610224	11.429827	0.636364
35	900-1800	S-W	38.39919	169.139499	6	37.106418	29.070548	1
35	900-1800	Total	31.7172	264.252735	1011	25.25443	15.788705	0.591494
35	1800-2700	E-N	20.63683	75.38253	67	43.643819	37.899448	0.80597
35	1800-2700	E-S	20.63683	75.38253	22	45.288587	34.063098	1.272727
35	1800-2700	E-W	20.63683	75.38253	0			
35	1800-2700	N-S	54.16812	259.643935	492	22.178406	12.721996	0.53252
35	1800-2700	N-E	54.16812	259.643935	5	60.8303	48.398197	1.4
35	1800-2700	N-W	54.16812	259.643935	19	19.446242	11.3229	0.631579
35	1800-2700	W-N	2.717501	25.564035	6	47.376629	30.936337	1.666667
35	1800-2700	W-S	2.717501	25.564035	6	32.50111	27.640068	0.666667
35	1800-2700	W-E	2.717501	25.564035	2	47.982729	36.46639	2
35	1800-2700	S-N	30.15819	147.234504	381	22.619369	12.75728	0.543307
35	1800-2700	S-E	30.15819	147.234504	19	21.191633	13.376484	0.631579
35	1800-2700	S-W	30.15819	147.234504	7	51.247695	37.893182	1.428571
35	1800-2700	Total	26.92016	259.643935	1026	24.81528	15.408694	0.594542
35	2700-3600	E-N	25.31821	108.444139	72	48.060484	41.637806	0.847222
35	2700-3600	E-S	25.31821	108.444139	10	37.252513	25.874404	1.3
35	2700-3600	E-W	25.31821	108.444139	3	39.082515	31.011488	1
35	2700-3600	N-S	46.46913	196.412204	477	20.05123	10.978572	0.498952
35	2700-3600	N-E	46.46913	196.412204	4	17.336298	10.154091	1
35	2700-3600	N-W	46.46913	196.412204	20	23.240122	14.517645	0.6
35	2700-3600	W-N	1.242717	16.775377	1	40.193541	20.22876	2
35	2700-3600	W-S	1.242717	16.775377	4	19.843292	15.480142	0.5
35	2700-3600	W-E	1.242717	16.775377	4	41.68186	30.925495	1.5
35	2700-3600	S-N	34.78205	162.094337	380	23.641232	13.81726	0.536842
35	2700-3600	S-E	34.78205	162.094337	18	27.266537	19.616481	0.611111
35	2700-3600	S-W	34.78205	162.094337	5	72.020177	58.183444	1.6
35	2700-3600	Total	26.95303	196.412204	998	24.218009	15.047968	0.56513
35	3600-4500	E-N	29.00817	107.05032	72	51.592786	44.32338	0.944444
35	3600-4500	E-S	29.00817	107.05032	18	54.340169	42.791151	1.388889
35	3600-4500	E-W	29.00817	107.05032	3	89.808306	77.387007	2
35	3600-4500	N-S	41.48615	215.037616	471	21.69594	11.882662	0.526539
35	3600-4500	N-E	41.48615	215.037616	2	49.7201	32.390752	2
35	3600-4500	N-W	41.48615	215.037616	17	18.158622	10.854485	0.588235
35	3600-4500	W-N	2.821173	18.420085	9	58.656542	41.352304	1.777778
35	3600-4500	W-S	2.821173	18.420085	2	13.748918	8.399491	0.5
35	3600-4500	W-E	2.821173	18.420085	2	24.614114	17.244778	1
35	3600-4500	S-N	27.2385	138.847193	348	22.828299	12.796485	0.571839
35	3600-4500	S-E	27.2385	138.847193	21	17.722148	11.467345	0.380952
35	3600-4500	S-W	27.2385	138.847193	4	74.31365	59.313005	1.75
35	3600-4500	Total	25.1385	215.037616	969	25.60109	15.886924	0.613003

Run-3	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
37	900-1800	E-N	25.5252	89.412565	84	47.90572	41.120514	0.904762
37	900-1800	E-S	25.5252	89.412565	17	38.001729	28.465117	1.117647
37	900-1800	E-W	25.5252	89.412565	1	87.520652	75.79542	2
37	900-1800	N-S	54.68219	203.081748	484	21.477857	11.704581	0.514463
37	900-1800	N-E	54.68219	203.081748	11	44.993361	34.151332	1.272727
37	900-1800	N-W	54.68219	203.081748	13	16.059435	9.799794	0.461538
37	900-1800	W-N	5.0908	33.285234	10	71.132315	52.967923	1.7
37	900-1800	W-S	5.0908	33.285234	3	46.882474	39.998228	1
37	900-1800	W-E	5.0908	33.285234	1	57.868331	45.42656	2
37	900-1800	S-N	24.23821	123.327195	332	18.119723	9.567112	0.448795
37	900-1800	S-E	24.23821	123.327195	22	19.042223	11.116075	0.636364
37	900-1800	S-W	24.23821	123.327195	9	63.509229	51.204159	1.555556
37	900-1800	Total	27.3841	203.081748	987	24.085828	14.953067	0.572442
37	1800-2700	E-N	23.3684	83.623111	66	47.426422	40.745804	0.924242
37	1800-2700	E-S	23.3684	83.623111	16	35.390306	25.558087	1.3125
37	1800-2700	E-W	23.3684	83.623111	5	36.142659	24.812613	1.2
37	1800-2700	N-S	58.87054	222.778776	503	21.729504	11.983623	0.54672
37	1800-2700	N-E	58.87054	222.778776	5	50.109684	37.71057	1.4
37	1800-2700	N-W	58.87054	222.778776	23	25.705419	17.333585	0.695652
37	1800-2700	W-N	3.089819	24.705185	6	43.114703	24.862837	1.666667
37	1800-2700	W-S	3.089819	24.705185	2	47.445837	41.695876	1
37	1800-2700	W-E	3.089819	24.705185	5	73.908883	60.998652	2
37	1800-2700	S-N	34.34126	138.367548	377	25.441949	14.525316	0.607427
37	1800-2700	S-E	34.34126	138.367548	20	28.708886	19.810106	0.75
37	1800-2700	S-W	34.34126	138.367548	2	61.704435	51.003588	1.5
37	1800-2700	Total	29.91751	222.778776	1030	25.884603	15.872833	0.635922
37	2700-3600	E-N	15.69399	51.031931	56	43.999498	38.05005	0.839286
37	2700-3600	E-S	15.69399	51.031931	14	37.62408	28.415912	1.214286
37	2700-3600	E-W	15.69399	51.031931	1	4.72895	0	0
37	2700-3600	N-S	40.08208	184.900473	470	19.316494	10.301037	0.493617
37	2700-3600	N-E	40.08208	184.900473	1	2.996122	0	0
37	2700-3600	N-W	40.08208	184.900473	25	18.668215	12.033792	0.44
37	2700-3600	W-N	2.319596	13.116788	4	65.960052	48.971402	1.75
37	2700-3600	W-S	2.319596	13.116788	4	60.204022	54.029206	1
37	2700-3600	W-E	2.319596	13.116788	2	8.001225	2.700507	0.5
37	2700-3600	S-N	35.39307	161.812469	335	24.915931	14.654467	0.597015
37	2700-3600	S-E	35.39307	161.812469	18	27.505699	18.57456	0.666667
37	2700-3600	S-W	35.39307	161.812469	6	60.782938	47.408184	1.666667
37	2700-3600	Total	23.37218	184.900473	936	23.794004	14.547435	0.577991
37	3600-4500	E-N	23.77174	83.017522	60	51.11747	44.375404	0.95
37	3600-4500	E-S	23.77174	83.017522	10	73.451049	57.498263	2.3
37	3600-4500	E-W	23.77174	83.017522	1	99.436882	87.34176	2
37	3600-4500	N-S	60.65877	244.778746	503	22.611617	13.035398	0.526839
37	3600-4500	N-E	60.65877	244.778746	2	89.173431	72.208312	2
37	3600-4500	N-W	60.65877	244.778746	19	27.976389	18.825504	0.789474
37	3600-4500	W-N	1.081838	6.900823	2	26.716316	17.425947	1
37	3600-4500	W-S	1.081838	6.900823	4	38.068024	34.86622	0.5
37	3600-4500	W-E	1.081838	6.900823	0			
37	3600-4500	S-N	28.77818	136.54883	360	24.367896	14.147474	0.569444
37	3600-4500	S-E	28.77818	136.54883	16	18.366132	12.46862	0.375
37	3600-4500	S-W	28.77818	136.54883	4	81.436024	67.191049	1.75
37	3600-4500	Total	28.57263	244.778746	981	26.077765	16.431625	0.599388

Run-4	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
38	900-1800	E-N	23.44337	78.174567	85	39.694846	33.778456	0.8
38	900-1800	E-S	23.44337	78.174567	10	54.033547	43.188371	1.5
38	900-1800	E-W	23.44337	78.174567	2	16.712305	7.118866	0.5
38	900-1800	N-S	48.75335	184.630991	472	21.374128	12.145361	0.529661
38	900-1800	N-E	48.75335	184.630991	5	61.132554	48.218957	1.4
38	900-1800	N-W	48.75335	184.630991	12	17.967253	11.695701	0.416667
38	900-1800	W-N	2.347338	19.716417	8	51.526491	34.672817	1.625
38	900-1800	W-S	2.347338	19.716417	3	24.487229	21.89956	0.333333
38	900-1800	W-E	2.347338	19.716417	2	58.139674	45.86999	2
38	900-1800	S-N	27.23749	109.98131	349	21.216474	11.591678	0.538682
38	900-1800	S-E	27.23749	109.98131	18	15.838708	8.938816	0.5
38	900-1800	S-W	27.23749	109.98131	5	52.793956	41.165972	1.4
38	900-1800	Total	25.44539	184.630991	971	23.803552	14.704829	0.584964
38	1800-2700	E-N	25.3779	82.47777	68	50.550571	43.904993	0.882353
38	1800-2700	E-S	25.3779	82.47777	16	46.521297	36.753901	1.1875
38	1800-2700	E-W	25.3779	82.47777	2	34.525437	22.691894	2
38	1800-2700	N-S	66.47374	285.345092	518	24.13521	13.855874	0.581081
38	1800-2700	N-E	66.47374	285.345092	1	14.444068	5.586643	1
38	1800-2700	N-W	66.47374	285.345092	22	26.341503	18.241502	0.681818
38	1800-2700	W-N	3.234763	25.925564	4	47.158863	31.824096	1.5
38	1800-2700	W-S	3.234763	25.925564	7	28.296929	23.332321	0.714286
38	1800-2700	W-E	3.234763	25.925564	3	75.312758	63.734132	2
38	1800-2700	S-N	25.89565	137.089713	367	21.527922	11.954668	0.536785
38	1800-2700	S-E	25.89565	137.089713	14	25.788482	17.924933	0.642857
38	1800-2700	S-W	25.89565	137.089713	2	14.006666	7.78174	1
38	1800-2700	Total	30.24551	285.345092	1024	25.63406	15.955985	0.610352
38	2700-3600	E-N	25.67763	98.607003	81	46.29328	39.727669	0.864198
38	2700-3600	E-S	25.67763	98.607003	19	56.134621	45.76956	1.315789
38	2700-3600	E-W	25.67763	98.607003	3	74.68074	62.859479	1.666667
38	2700-3600	N-S	54.79519	284.495764	481	21.388087	12.849464	0.486486
38	2700-3600	N-E	54.79519	284.495764	5	89.615775	73.370704	2
38	2700-3600	N-W	54.79519	284.495764	16	28.621586	19.699076	0.6875
38	2700-3600	W-N	2.717939	24.965809	2	40.831554	24.602108	1
38	2700-3600	W-S	2.717939	24.965809	5	35.579436	28.901582	1
38	2700-3600	W-E	2.717939	24.965809	4	37.687891	28.727075	1
38	2700-3600	S-N	27.87283	127.454468	334	22.469842	12.633908	0.532934
38	2700-3600	S-E	27.87283	127.454468	20	20.293864	11.62585	0.65
38	2700-3600	S-W	27.87283	127.454468	9	54.813655	42.869206	1.444444
38	2700-3600	Total	27.7659	284.495764	979	25.585791	16.634789	0.582227
38	3600-4500	E-N	24.82174	120.929613	71	48.642298	41.236182	0.985915
38	3600-4500	E-S	24.82174	120.929613	17	50.827697	40.014962	1.235294
38	3600-4500	E-W	24.82174	120.929613	3	55.685098	47.053083	1.333333
38	3600-4500	N-S	50.48635	210.609148	507	22.28241	12.573503	0.571992
38	3600-4500	N-E	50.48635	210.609148	6	40.42545	28.483454	1.166667
38	3600-4500	N-W	50.48635	210.609148	16	22.177845	14.694998	0.625
38	3600-4500	W-N	2.617654	13.552009	6	45.378462	28.097799	1.666667
38	3600-4500	W-S	2.617654	13.552009	5	55.402724	49.174176	1
38	3600-4500	W-E	2.617654	13.552009	1	1.7136	0	0
38	3600-4500	S-N	30.03158	140.857955	353	23.841125	13.81477	0.592068
38	3600-4500	S-E	30.03158	140.857955	23	22.635914	14.539034	0.652174
38	3600-4500	S-W	30.03158	140.857955	7	65.576397	53.321358	1.571429
38	3600-4500	Total	26.98933	210.609148	1015	25.936833	16.284421	0.642365

Run-5	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
39	900-1800	E-N	23.65775	86.540614	74	46.632966	40.010732	0.878378
39	900-1800	E-S	23.65775	86.540614	13	53.22773	41.055738	1.538462
39	900-1800	E-W	23.65775	86.540614	4	57.083055	44.768637	1.5
39	900-1800	N-S	36.88792	180.095858	484	19.204501	10.434257	0.456612
39	900-1800	N-E	36.88792	180.095858	2	1.195931	0	0
39	900-1800	N-W	36.88792	180.095858	14	12.31431	6.509189	0.357143
39	900-1800	W-N	3.414503	37.125604	2	75.366029	55.951571	2
39	900-1800	W-S	3.414503	37.125604	8	28.600371	24.055355	0.5
39	900-1800	W-E	3.414503	37.125604	3	48.16772	38.906861	1.333333
39	900-1800	S-N	21.17355	100.538573	321	19.239814	10.690923	0.46729
39	900-1800	S-E	21.17355	100.538573	13	10.595114	5.706801	0.307692
39	900-1800	S-W	21.17355	100.538573	3	84.399752	70.686161	1.666667
39	900-1800	Total	21.28343	180.095858	941	22.244269	13.766209	0.518597
39	1800-2700	E-N	24.00584	79.195665	75	43.250226	36.968703	0.786667
39	1800-2700	E-S	24.00584	79.195665	14	43.249845	32.905998	1.285714
39	1800-2700	E-W	24.00584	79.195665	0			
39	1800-2700	N-S	43.52398	185.938339	502	22.006248	12.699606	0.511952
39	1800-2700	N-E	43.52398	185.938339	3	26.42875	19.914095	0.666667
39	1800-2700	N-W	43.52398	185.938339	22	20.310451	12.731842	0.5
39	1800-2700	W-N	3.066261	19.767474	8	46.255972	34.714693	1.125
39	1800-2700	W-S	3.066261	19.767474	5	33.147693	28.142434	0.8
39	1800-2700	W-E	3.066261	19.767474	0			
39	1800-2700	S-N	30.62179	151.821886	365	23.496923	13.389403	0.567123
39	1800-2700	S-E	30.62179	151.821886	16	27.562261	18.496242	0.75
39	1800-2700	S-W	30.62179	151.821886	5	67.600504	55.884718	1.6
39	1800-2700	Total	25.30447	185.938339	1015	24.939586	15.595376	0.578325
39	2700-3600	E-N	39.43206	128.831182	99	50.87822	43.015585	1
39	2700-3600	E-S	39.43206	128.831182	14	49.182422	38.526992	1.428571
39	2700-3600	E-W	39.43206	128.831182	2	13.340596	3.413567	0.5
39	2700-3600	N-S	44.34018	194.88314	467	20.249664	11.418937	0.490364
39	2700-3600	N-E	44.34018	194.88314	3	43.821973	30.441733	1.666667
39	2700-3600	N-W	44.34018	194.88314	14	14.647593	7.598673	0.5
39	2700-3600	W-N	2.236384	18.889162	6	75.542169	56.667312	2
39	2700-3600	W-S	2.236384	18.889162	3	21.136554	16.140927	0.666667
39	2700-3600	W-E	2.236384	18.889162	2	40.020209	26.462131	2
39	2700-3600	S-N	37.72242	146.647072	363	24.60278	14.555549	0.606061
39	2700-3600	S-E	37.72242	146.647072	21	26.213217	18.173572	0.666667
39	2700-3600	S-W	37.72242	146.647072	3	57.407778	44.484261	1.666667
39	2700-3600	Total	30.93276	194.88314	997	25.873137	16.625087	0.61986
39	3600-4500	E-N	27.06964	97.329736	76	47.005591	39.920851	0.934211
39	3600-4500	E-S	27.06964	97.329736	9	53.056937	41.922225	1.444444
39	3600-4500	E-W	27.06964	97.329736	2	58.885475	48.065005	1.5
39	3600-4500	N-S	40.44011	171.378627	479	21.270867	11.181408	0.511482
39	3600-4500	N-E	40.44011	171.378627	6	56.662967	41.072765	1.833333
39	3600-4500	N-W	40.44011	171.378627	22	30.653724	21.320759	0.772727
39	3600-4500	W-N	2.690331	19.748454	7	41.382363	29.242616	1.142857
39	3600-4500	W-S	2.690331	19.748454	5	31.932572	26.819183	0.8
39	3600-4500	W-E	2.690331	19.748454	2	43.495844	29.838388	2
39	3600-4500	S-N	37.16964	177.532591	410	22.910856	13.123719	0.570732
39	3600-4500	S-E	37.16964	177.532591	21	27.359125	18.345186	0.666667
39	3600-4500	S-W	37.16964	177.532591	6	44.353321	31.465387	1.5
39	3600-4500	Total	26.84243	177.532591	1045	25.015557	15.245971	0.605742

- Signalized RCUT- 500 ft. U-Turn Crossover spacing- Critical Ratio- 0.15

Run-1	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
40	900-1800	E-N	85.90111	171.548889	117	83.856317	73.845095	1.247863
40	900-1800	E-S	85.90111	171.548889	23	51.271909	38.791213	1.26087
40	900-1800	E-W	85.90111	171.548889	2	65.661478	53.415724	1.5
40	900-1800	W-N	3.97064	25.145837	5	69.14882	50.340268	1.8
40	900-1800	W-S	3.97064	25.145837	5	56.432038	50.178805	1
40	900-1800	W-E	3.97064	25.145837	6	30.678562	23.007082	1
40	900-1800	S-N	24.525	113.965284	307	21.104052	12.165366	0.504886
40	900-1800	S-E	24.525	113.965284	15	26.629597	19.252328	0.6
40	900-1800	S-W	24.525	113.965284	9	57.246292	43.296419	1.666667
40	900-1800	N-S	43.7575	229.329678	456	20.728748	11.112494	0.515351
40	900-1800	N-E	43.7575	229.329678	0			
40	900-1800	N-W	43.7575	229.329678	15	20.831725	13.977617	0.533333
40	900-1800	Total	39.53856	229.329678	960	30.304303	20.801797	0.645833
40	1800-2700	E-N	71.99019	152.862757	108	76.669046	67.508919	1.185185
40	1800-2700	E-S	71.99019	152.862757	25	81.456756	66.027912	1.72
40	1800-2700	E-W	71.99019	152.862757	5	88.739949	74.154958	1.2
40	1800-2700	W-N	6.251509	39.800706	6	56.898295	39.724326	1.666667
40	1800-2700	W-S	6.251509	39.800706	10	46.277556	39.498845	0.9
40	1800-2700	W-E	6.251509	39.800706	7	40.599916	27.787346	1.571429
40	1800-2700	S-N	28.07739	126.626909	336	23.325811	13.511973	0.568452
40	1800-2700	S-E	28.07739	126.626909	23	37.589038	27.27708	0.913043
40	1800-2700	S-W	28.07739	126.626909	2	59.226062	48.258854	1.5
40	1800-2700	N-S	42.68633	217.712705	478	21.280732	11.661109	0.556485
40	1800-2700	N-E	42.68633	217.712705	2	68.368122	54.048997	1.5
40	1800-2700	N-W	42.68633	217.712705	16	21.384385	13.85281	0.625
40	1800-2700	Total	37.25135	217.712705	1018	30.766492	20.931187	0.688605
40	2700-3600	E-N	55.34193	133.188557	115	68.74032	59.714801	1.147826
40	2700-3600	E-S	55.34193	133.188557	23	53.82552	39.056763	1.73913
40	2700-3600	E-W	55.34193	133.188557	2	68.033212	52.797536	2
40	2700-3600	W-N	3.346572	31.165574	5	33.404845	23.159649	1
40	2700-3600	W-S	3.346572	31.165574	6	42.213526	36.865146	0.666667
40	2700-3600	W-E	3.346572	31.165574	3	35.51367	26.939728	1
40	2700-3600	S-N	32.81276	139.00119	341	24.7023	14.751972	0.548387
40	2700-3600	S-E	32.81276	139.00119	20	23.796039	15.376309	0.65
40	2700-3600	S-W	32.81276	139.00119	5	54.672106	41.559253	1.4
40	2700-3600	N-S	46.2482	253.52603	460	20.559893	11.201185	0.521739
40	2700-3600	N-E	46.2482	253.52603	6	20.374429	14.312939	0.666667
40	2700-3600	N-W	46.2482	253.52603	19	26.241842	17.889788	0.736842
40	2700-3600	Total	34.43737	253.52603	1005	28.912632	19.316403	0.649751
40	3600-4500	E-N	57.62758	139.601883	100	62.187318	53.740944	1.04
40	3600-4500	E-S	57.62758	139.601883	23	54.136619	41.430467	1.434783
40	3600-4500	E-W	57.62758	139.601883	8	30.996236	22.825407	0.5
40	3600-4500	W-N	0.964758	11.772249	3	73.540251	55.254224	2
40	3600-4500	W-S	0.964758	11.772249	1	31.316597	25.592361	1
40	3600-4500	W-E	0.964758	11.772249	2	27.36979	14.653477	2
40	3600-4500	S-N	34.40762	171.590603	363	26.071424	15.588718	0.600551
40	3600-4500	S-E	34.40762	171.590603	21	30.540684	22.045165	0.714286
40	3600-4500	S-W	34.40762	171.590603	6	43.806039	32.946896	1.333333
40	3600-4500	N-S	53.64494	217.043626	485	24.087201	14.182759	0.560825
40	3600-4500	N-E	53.64494	217.043626	5	36.996164	25.176247	1.2
40	3600-4500	N-W	53.64494	217.043626	23	24.331095	15.797148	0.695652
40	3600-4500	Total	36.66122	217.043626	1040	29.628391	19.632162	0.660577

Run-2	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
41	900-1800	E-N	108.9627	177.437066	114	113.9689	100.024545	1.622807
41	900-1800	E-S	108.9627	177.437066	16	89.041244	74.484422	1.8125
41	900-1800	E-W	108.9627	177.437066	3	91.357691	73.824929	2.333333
41	900-1800	W-N	4.811521	38.625068	6	49.683774	30.309554	1.666667
41	900-1800	W-S	4.811521	38.625068	9	37.170762	32.595567	0.666667
41	900-1800	W-E	4.811521	38.625068	5	50.727087	37.959361	1.8
41	900-1800	S-N	29.10606	133.939187	336	21.639311	12.009223	0.541667
41	900-1800	S-E	29.10606	133.939187	18	17.395153	10.081287	0.555556
41	900-1800	S-W	29.10606	133.939187	8	65.993376	52.400452	1.625
41	900-1800	N-S	58.97061	229.522983	467	25.010602	14.867594	0.5803
41	900-1800	N-E	58.97061	229.522983	4	46.987206	37.19968	1
41	900-1800	N-W	58.97061	229.522983	10	21.146299	13.455023	0.6
41	900-1800	Total	50.46273	229.522983	996	35.912343	25.445099	0.73494
41	1800-2700	E-N	62.68775	138.359637	98	90.139278	75.502729	1.908163
41	1800-2700	E-S	62.68775	138.359637	28	88.210369	71.323992	2.107143
41	1800-2700	E-W	62.68775	138.359637	2	67.881506	55.36131	1.5
41	1800-2700	W-N	4.143888	19.810244	13	49.727461	33.463741	1.307692
41	1800-2700	W-S	4.143888	19.810244	2	77.16477	71.046142	1
41	1800-2700	W-E	4.143888	19.810244	4	37.41466	27.227344	1.5
41	1800-2700	S-N	27.17435	121.285869	355	23.766462	13.812269	0.557746
41	1800-2700	S-E	27.17435	121.285869	18	30.413052	22.47987	0.666667
41	1800-2700	S-W	27.17435	121.285869	2	74.375486	63.537775	1.5
41	1800-2700	N-S	38.62688	171.329595	478	21.875565	12.339852	0.539749
41	1800-2700	N-E	38.62688	171.329595	3	21.926148	15.094842	1
41	1800-2700	N-W	38.62688	171.329595	15	31.684531	22.561375	0.8
41	1800-2700	Total	33.15822	171.329595	1018	31.945574	21.522903	0.746562
41	2700-3600	E-N	50.24887	119.779721	106	63.946058	54.674735	1.160377
41	2700-3600	E-S	50.24887	119.779721	18	62.305451	47.055336	1.555556
41	2700-3600	E-W	50.24887	119.779721	3	37.670305	28.721058	0.666667
41	2700-3600	W-N	2.368265	25.264571	8	33.041576	22.283304	1
41	2700-3600	W-S	2.368265	25.264571	5	13.484444	9.022836	0.6
41	2700-3600	W-E	2.368265	25.264571	4	28.159582	19.849446	0.75
41	2700-3600	S-N	23.76802	127.938127	295	21.336534	11.846695	0.532203
41	2700-3600	S-E	23.76802	127.938127	15	22.436731	13.899904	0.733333
41	2700-3600	S-W	23.76802	127.938127	4	56.412006	42.352537	1.75
41	2700-3600	N-S	47.02151	180.89233	486	20.606976	11.518126	0.524691
41	2700-3600	N-E	47.02151	180.89233	4	90.359166	74.4004	2
41	2700-3600	N-W	47.02151	180.89233	12	24.256279	14.046341	0.666667
41	2700-3600	Total	30.85166	180.89233	960	27.063711	17.675115	0.638542
41	3600-4500	E-N	83.1602	166.314737	104	90.57183	80.460813	1.25
41	3600-4500	E-S	83.1602	166.314737	30	49.197136	36.584281	1.4
41	3600-4500	E-W	83.1602	166.314737	5	40.583835	30.002613	1
41	3600-4500	W-N	5.729756	32.316953	11	56.876046	39.891509	1.454545
41	3600-4500	W-S	5.729756	32.316953	6	61.104383	55.225362	0.833333
41	3600-4500	W-E	5.729756	32.316953	2	40.04496	26.748409	1.5
41	3600-4500	S-N	28.98027	126.977294	354	23.011322	13.004202	0.553672
41	3600-4500	S-E	28.98027	126.977294	18	33.309413	23.194852	0.833333
41	3600-4500	S-W	28.98027	126.977294	4	67.486362	54.07017	1.75
41	3600-4500	N-S	48.86888	230.536929	521	21.531053	11.731307	0.545106
41	3600-4500	N-E	48.86888	230.536929	3	92.424484	76.129275	2
41	3600-4500	N-W	48.86888	230.536929	9	21.370968	15.117655	0.555556
41	3600-4500	Total	41.68478	230.536929	1067	30.80925	20.761813	0.669166

Run-3	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
42	900-1800	E-N	56.40108	166.647412	100	67.502712	59.233771	1.04
42	900-1800	E-S	56.40108	166.647412	22	35.218717	25.044515	1.090909
42	900-1800	E-W	56.40108	166.647412	3	37.687563	27.833731	1
42	900-1800	W-N	4.668339	27.371996	7	44.691306	28.897507	1.571429
42	900-1800	W-S	4.668339	27.371996	6	42.608498	36.170598	0.833333
42	900-1800	W-E	4.668339	27.371996	4	23.51942	15.643299	1
42	900-1800	S-N	33.1553	167.867906	326	23.689316	14.015448	0.54908
42	900-1800	S-E	33.1553	167.867906	14	30.949402	21.710791	0.785714
42	900-1800	S-W	33.1553	167.867906	8	52.212302	40.69541	1.375
42	900-1800	N-S	42.57593	183.796819	440	21.775505	12.106901	0.518182
42	900-1800	N-E	42.57593	183.796819	7	32.517295	23.882786	1
42	900-1800	N-W	42.57593	183.796819	21	26.009071	16.529492	0.714286
42	900-1800	Total	34.20016	183.796819	958	28.42323	18.872257	0.628392
42	1800-2700	E-N	64.2461	164.96728	102	68.850374	59.717695	1.176471
42	1800-2700	E-S	64.2461	164.96728	36	105.80529	87.397484	1.972222
42	1800-2700	E-W	64.2461	164.96728	2	46.946329	39.469256	0.5
42	1800-2700	W-N	1.258119	11.749042	5	70.852712	51.784602	2
42	1800-2700	W-S	1.258119	11.749042	2	41.18769	35.507907	1
42	1800-2700	W-E	1.258119	11.749042	2	66.417432	53.079335	2
42	1800-2700	S-N	33.65937	155.464331	342	25.87703	14.782512	0.649123
42	1800-2700	S-E	33.65937	155.464331	31	28.554156	18.676975	0.774194
42	1800-2700	S-W	33.65937	155.464331	4	77.159049	62.430638	1.75
42	1800-2700	N-S	45.51143	192.520379	479	22.377102	11.956425	0.569937
42	1800-2700	N-E	45.51143	192.520379	2	97.056695	81.1421	2
42	1800-2700	N-W	45.51143	192.520379	20	30.011521	20.424928	0.9
42	1800-2700	Total	36.16875	192.520379	1027	32.182892	21.358119	0.736125
42	2700-3600	E-N	105.5425	165.568055	119	118.40717	105.641273	1.495798
42	2700-3600	E-S	105.5425	165.568055	23	140.11895	115.48502	2.434783
42	2700-3600	E-W	105.5425	165.568055	6	100.65318	81.140651	2
42	2700-3600	W-N	2.29031	18.983787	5	81.273375	62.239676	2
42	2700-3600	W-S	2.29031	18.983787	4	17.354958	13.712452	0.5
42	2700-3600	W-E	2.29031	18.983787	0			
42	2700-3600	S-N	28.04348	111.770832	335	21.768105	12.455425	0.528358
42	2700-3600	S-E	28.04348	111.770832	13	34.853939	24.210992	0.846154
42	2700-3600	S-W	28.04348	111.770832	7	66.509131	52.436921	1.714286
42	2700-3600	N-S	36.70298	164.696212	449	19.58851	10.146071	0.501114
42	2700-3600	N-E	36.70298	164.696212	5	26.958002	18.502981	1
42	2700-3600	N-W	36.70298	164.696212	20	26.173211	17.295837	0.7
42	2700-3600	Total	43.14482	165.568055	986	36.569341	26.296902	0.711968
42	3600-4500	E-N	39.18861	121.20685	100	47.579006	40.04627	0.93
42	3600-4500	E-S	39.18861	121.20685	21	79.509674	64.851488	1.809524
42	3600-4500	E-W	39.18861	121.20685	1	82.886113	71.092616	2
42	3600-4500	W-N	3.0384	19.985254	6	45.456191	29.115457	1.666667
42	3600-4500	W-S	3.0384	19.985254	3	38.872978	34.254747	0.666667
42	3600-4500	W-E	3.0384	19.985254	4	63.549595	50.849471	2
42	3600-4500	S-N	27.1427	121.742366	335	24.989249	14.569147	0.597015
42	3600-4500	S-E	27.1427	121.742366	10	14.017745	6.023395	0.5
42	3600-4500	S-W	27.1427	121.742366	2	48.85739	32.647067	1.5
42	3600-4500	N-S	38.78713	178.913539	449	21.8886	12.06887	0.554566
42	3600-4500	N-E	38.78713	178.913539	6	44.686004	33.429047	1.333333
42	3600-4500	N-W	38.78713	178.913539	16	21.407801	13.537641	0.625
42	3600-4500	Total	27.03921	178.913539	953	27.494184	17.587353	0.658972

Run-4	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
43	900-1800	E-N	66.9251	141.020877	109	81.662466	71.897016	1.238532
43	900-1800	E-S	66.9251	141.020877	27	60.598975	48.228202	1.333333
43	900-1800	E-W	66.9251	141.020877	5	46.489933	35.983365	1
43	900-1800	W-N	4.944809	24.478723	9	62.354362	47.383107	1.555556
43	900-1800	W-S	4.944809	24.478723	9	32.907181	27.662246	0.777778
43	900-1800	W-E	4.944809	24.478723	6	31.327724	22.312042	1
43	900-1800	S-N	29.5989	128.677224	330	24.121354	13.841273	0.581818
43	900-1800	S-E	29.5989	128.677224	17	17.272882	11.700791	0.470588
43	900-1800	S-W	29.5989	128.677224	4	62.674635	47.6645	1.75
43	900-1800	N-S	50.48712	224.118108	481	21.538433	12.179999	0.528067
43	900-1800	N-E	50.48712	224.118108	6	69.83796	55.065658	1.833333
43	900-1800	N-W	50.48712	224.118108	26	17.619865	11.00644	0.461538
43	900-1800	Total	37.98898	224.118108	1029	30.667314	20.952834	0.667638
43	1800-2700	E-N	53.01806	145.052755	98	65.4365	56.873197	1.091837
43	1800-2700	E-S	53.01806	145.052755	25	46.261876	34.586402	1.28
43	1800-2700	E-W	53.01806	145.052755	5	42.446693	32.149899	1.6
43	1800-2700	W-N	2.210484	25.881668	4	54.19309	36.939912	1.75
43	1800-2700	W-S	2.210484	25.881668	5	25.235517	19.462401	0.6
43	1800-2700	W-E	2.210484	25.881668	4	34.551591	24.398989	1.5
43	1800-2700	S-N	28.88188	170.122153	347	23.55717	13.412752	0.541787
43	1800-2700	S-E	28.88188	170.122153	18	26.387855	18.426576	0.611111
43	1800-2700	S-W	28.88188	170.122153	7	57.540584	45.047173	1.428571
43	1800-2700	N-S	63.37221	259.014867	507	24.965646	14.741605	0.556213
43	1800-2700	N-E	63.37221	259.014867	5	67.224464	54.458723	1.6
43	1800-2700	N-W	63.37221	259.014867	28	17.410367	10.330432	0.5
43	1800-2700	Total	36.87066	259.014867	1053	29.245976	19.257762	0.641975
43	2700-3600	E-N	28.39334	101.452965	95	43.841911	37.419502	0.810526
43	2700-3600	E-S	28.39334	101.452965	25	65.675535	52.941304	1.48
43	2700-3600	E-W	28.39334	101.452965	2	66.935083	54.649302	1.5
43	2700-3600	W-N	3.615011	33.8153	8	47.279094	31.638942	1.5
43	2700-3600	W-S	3.615011	33.8153	5	51.759239	46.101405	0.8
43	2700-3600	W-E	3.615011	33.8153	1	1.193818	0	0
43	2700-3600	S-N	27.20167	145.593665	348	20.26121	10.661797	0.522989
43	2700-3600	S-E	27.20167	145.593665	12	18.721826	10.061943	0.583333
43	2700-3600	S-W	27.20167	145.593665	6	72.761299	60.504222	1.666667
43	2700-3600	N-S	29.18015	142.001792	421	19.338484	10.262812	0.489311
43	2700-3600	N-E	29.18015	142.001792	4	39.461465	27.142149	1
43	2700-3600	N-W	29.18015	142.001792	10	14.323196	6.841038	0.4
43	2700-3600	Total	22.09754	145.593665	937	24.262191	15.115261	0.582711
43	3600-4500	E-N	84.09483	164.720942	104	87.270627	76.943398	1.298077
43	3600-4500	E-S	84.09483	164.720942	22	49.953779	38.785863	1.181818
43	3600-4500	E-W	84.09483	164.720942	3	98.495532	85.285717	2
43	3600-4500	W-N	2.960122	13.716022	5	49.441654	35.43366	1.2
43	3600-4500	W-S	2.960122	13.716022	4	27.80037	21.547108	1
43	3600-4500	W-E	2.960122	13.716022	3	66.872358	54.966094	2
43	3600-4500	S-N	23.51482	119.575435	319	23.093238	13.389553	0.545455
43	3600-4500	S-E	23.51482	119.575435	16	20.107126	12.331629	0.5
43	3600-4500	S-W	23.51482	119.575435	5	74.587385	63.875187	1.4
43	3600-4500	N-S	45.30659	193.941145	471	23.678871	13.774971	0.56051
43	3600-4500	N-E	45.30659	193.941145	6	37.488684	26.486557	1.333333
43	3600-4500	N-W	45.30659	193.941145	14	22.071276	14.679529	0.571429
43	3600-4500	Total	38.96909	193.941145	972	31.664315	21.790029	0.670782

Run-5	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
44	900-1800	E-N	36.69179	119.4511	100	52.849981	44.990851	1.01
44	900-1800	E-S	36.69179	119.4511	24	49.222494	38.283418	1.333333
44	900-1800	E-W	36.69179	119.4511	9	52.846126	42.039298	1.222222
44	900-1800	W-N	3.58211	19.597976	5	26.806906	14.165916	1
44	900-1800	W-S	3.58211	19.597976	7	34.05734	28.5637	0.857143
44	900-1800	W-E	3.58211	19.597976	2	63.570681	49.488671	2
44	900-1800	S-N	23.02634	107.61884	274	20.847704	11.771994	0.489051
44	900-1800	S-E	23.02634	107.61884	31	18.829966	12.125231	0.516129
44	900-1800	S-W	23.02634	107.61884	6	65.458549	51.944267	1.666667
44	900-1800	N-S	36.55509	168.969195	423	20.926551	11.854414	0.508274
44	900-1800	N-E	36.55509	168.969195	6	78.097453	63.878711	1.666667
44	900-1800	N-W	36.55509	168.969195	14	21.64919	12.772027	0.785714
44	900-1800	Total	24.96383	168.969195	901	26.363914	17.375766	0.615982
44	1800-2700	E-N	44.59952	119.99485	96	58.962491	51.214224	1.020833
44	1800-2700	E-S	44.59952	119.99485	26	55.717667	44.329887	1.384615
44	1800-2700	E-W	44.59952	119.99485	2	44.432677	32.615036	1.5
44	1800-2700	W-N	2.507413	25.056082	7	30.217851	16.761522	1.142857
44	1800-2700	W-S	2.507413	25.056082	10	19.191892	14.317843	0.7
44	1800-2700	W-E	2.507413	25.056082	4	42.978862	32.816764	1.5
44	1800-2700	S-N	27.84939	153.733251	371	22.840379	12.648557	0.530997
44	1800-2700	S-E	27.84939	153.733251	18	18.78664	10.895413	0.722222
44	1800-2700	S-W	27.84939	153.733251	6	73.02522	58.814432	1.666667
44	1800-2700	N-S	50.44571	215.652106	468	24.062742	13.824247	0.589744
44	1800-2700	N-E	50.44571	215.652106	4	56.572759	41.801054	1.75
44	1800-2700	N-W	50.44571	215.652106	20	29.415324	20.103032	0.8
44	1800-2700	Total	31.35051	215.652106	1032	28.19703	18.223624	0.656008
44	2700-3600	E-N	41.32738	146.565294	99	57.684348	49.982003	1.020202
44	2700-3600	E-S	41.32738	146.565294	37	58.176273	44.667975	1.297297
44	2700-3600	E-W	41.32738	146.565294	5	57.952094	48.1607	1.2
44	2700-3600	W-N	3.200761	31.476714	0			
44	2700-3600	W-S	3.200761	31.476714	10	25.394844	19.242639	0.8
44	2700-3600	W-E	3.200761	31.476714	6	54.772991	42.156582	1.833333
44	2700-3600	S-N	25.30612	103.864456	313	20.833949	12.150638	0.514377
44	2700-3600	S-E	25.30612	103.864456	21	22.726403	14.215531	0.619048
44	2700-3600	S-W	25.30612	103.864456	6	62.48929	49.634204	1.666667
44	2700-3600	N-S	47.27617	183.886364	460	22.165225	12.064337	0.552174
44	2700-3600	N-E	47.27617	183.886364	5	57.590635	39.834892	2
44	2700-3600	N-W	47.27617	183.886364	18	22.926996	14.161782	0.666667
44	2700-3600	Total	29.27761	183.886364	980	27.55661	18.051291	0.646939
44	3600-4500	E-N	46.18461	146.316546	95	61.754225	53.9333	1.010526
44	3600-4500	E-S	46.18461	146.316546	18	66.19272	52.871021	1.611111
44	3600-4500	E-W	46.18461	146.316546	3	57.917019	46.883628	1.333333
44	3600-4500	W-N	2.801177	18.273525	5	37.142016	24.692407	1.2
44	3600-4500	W-S	2.801177	18.273525	4	28.402918	22.999894	0.75
44	3600-4500	W-E	2.801177	18.273525	5	62.343677	49.919176	2
44	3600-4500	S-N	25.57106	130.099095	347	21.845216	12.39649	0.538905
44	3600-4500	S-E	25.57106	130.099095	16	28.776233	19.533741	0.8125
44	3600-4500	S-W	25.57106	130.099095	3	57.663066	49.368033	1.333333
44	3600-4500	N-S	43.16221	185.024215	476	22.125807	12.395448	0.544118
44	3600-4500	N-E	43.16221	185.024215	2	48.501335	31.834387	2
44	3600-4500	N-W	43.16221	185.024215	22	27.126857	18.985603	0.772727
44	3600-4500	Total	29.42977	185.024215	996	27.391856	17.896447	0.634538

- Signalized RCUT- 500 ft. U-Turn Crossover spacing- Critical Ratio- 0.20

Run-1	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
45	900-1800	E-N	156.3532	241.217918	112	153.03817	133.382727	2.125
45	900-1800	E-S	156.3532	241.217918	21	164.85853	139.991913	3
45	900-1800	E-W	156.3532	241.217918	4	112.46044	97.789344	2
45	900-1800	W-N	3.916828	24.817151	10	57.498937	39.147568	1.6
45	900-1800	W-S	3.916828	24.817151	6	21.023635	16.850124	0.333333
45	900-1800	W-E	3.916828	24.817151	2	54.911217	42.803289	1.5
45	900-1800	S-N	23.40055	103.092194	316	20.396633	10.901813	0.506329
45	900-1800	S-E	23.40055	103.092194	18	18.311147	11.183523	0.5
45	900-1800	S-W	23.40055	103.092194	6	43.737298	33.358515	1.333333
45	900-1800	N-S	30.22082	147.334608	423	18.33453	9.253713	0.44208
45	900-1800	N-E	30.22082	147.334608	4	48.937081	38.037143	1.25
45	900-1800	N-W	30.22082	147.334608	16	24.323008	15.569269	0.75
45	900-1800	Total	53.47285	241.217918	938	39.702434	28.795353	0.757996
45	1800-2700	E-N	308.5414	335.834281	99	210.70868	179.991162	3.090909
45	1800-2700	E-S	308.5414	335.834281	24	265.68361	228.077285	4.375
45	1800-2700	E-W	308.5414	335.834281	4	249.94868	208.590191	4.25
45	1800-2700	W-N	4.277869	19.314013	9	54.29045	37.157408	1.555556
45	1800-2700	W-S	4.277869	19.314013	8	25.215153	21.701233	0.375
45	1800-2700	W-E	4.277869	19.314013	6	23.396889	15.486497	1
45	1800-2700	S-N	29.77988	120.960319	320	26.785273	16.36486	0.634375
45	1800-2700	S-E	29.77988	120.960319	20	29.101575	19.825539	0.75
45	1800-2700	S-W	29.77988	120.960319	4	48.564296	37.658127	1.5
45	1800-2700	N-S	38.61983	160.553165	440	23.641847	13.079408	0.586364
45	1800-2700	N-E	38.61983	160.553165	2	47.937587	36.251883	1.5
45	1800-2700	N-W	38.61983	160.553165	24	21.558914	13.552724	0.541667
45	1800-2700	Total	95.30475	335.834281	960	51.489953	38.192597	0.988542
45	2700-3600	E-N	329.9419	336.650754	110	208.08416	174.866645	3.618182
45	2700-3600	E-S	329.9419	336.650754	20	217.00384	184.093261	3.8
45	2700-3600	E-W	329.9419	336.650754	9	213.19347	179.598184	3.666667
45	2700-3600	W-N	5.563131	25.382546	12	43.903253	31.431567	1.166667
45	2700-3600	W-S	5.563131	25.382546	11	44.60086	38.65466	0.909091
45	2700-3600	W-E	5.563131	25.382546	1	101.57858	88.69963	2
45	2700-3600	S-N	22.92993	127.580203	304	20.891088	10.939134	0.503289
45	2700-3600	S-E	22.92993	127.580203	20	22.275131	15.617225	0.6
45	2700-3600	S-W	22.92993	127.580203	4	50.997975	39.662059	1.25
45	2700-3600	N-S	41.23651	210.550066	438	21.854474	11.926183	0.552511
45	2700-3600	N-E	41.23651	210.550066	10	42.455057	33.021381	1.1
45	2700-3600	N-W	41.23651	210.550066	13	24.223733	16.478861	0.692308
45	2700-3600	Total	99.91786	336.650754	952	49.978158	36.753421	1.013655
45	3600-4500	E-N	330.2218	337.538838	96	220.47204	190.300373	3.177083
45	3600-4500	E-S	330.2218	337.538838	24	211.12629	173.243422	4.75
45	3600-4500	E-W	330.2218	337.538838	1	209.59647	177.371774	4
45	3600-4500	W-N	3.179216	22.295925	8	34.137561	15.549753	1.5
45	3600-4500	W-S	3.179216	22.295925	5	37.131225	31.508109	0.8
45	3600-4500	W-E	3.179216	22.295925	7	43.496779	30.865355	1.857143
45	3600-4500	S-N	21.6084	91.712908	315	21.376098	12.286048	0.526984
45	3600-4500	S-E	21.6084	91.712908	16	16.848836	10.975732	0.5
45	3600-4500	S-W	21.6084	91.712908	8	69.818367	57.505674	1.625
45	3600-4500	N-S	43.66949	195.595241	464	23.923304	12.697325	0.609914
45	3600-4500	N-E	43.66949	195.595241	4	41.924434	31.21399	1.25
45	3600-4500	N-W	43.66949	195.595241	24	16.692365	9.140974	0.458333
45	3600-4500	Total	99.66973	337.538838	972	47.773153	34.818525	0.965021

Run-2	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
46	900-1800	E-N	153.6295	235.109975	113	160.24763	139.32758	2.309735
46	900-1800	E-S	153.6295	235.109975	23	156.16651	130.676625	2.652174
46	900-1800	E-W	153.6295	235.109975	1	178.67141	154.342586	2
46	900-1800	W-N	4.328268	37.421534	10	41.92652	25.082113	1.3
46	900-1800	W-S	4.328268	37.421534	10	31.258948	25.834165	0.7
46	900-1800	W-E	4.328268	37.421534	1	99.092445	86.899504	2
46	900-1800	S-N	28.61329	129.479014	294	24.207436	13.663007	0.588435
46	900-1800	S-E	28.61329	129.479014	16	25.978228	15.969168	0.6875
46	900-1800	S-W	28.61329	129.479014	6	88.288193	74.451428	1.833333
46	900-1800	N-S	33.58357	177.386571	400	20.042434	10.392319	0.51
46	900-1800	N-E	33.58357	177.386571	10	53.777048	39.248874	1.7
46	900-1800	N-W	33.58357	177.386571	17	24.416484	17.268862	0.647059
46	900-1800	Total	55.03867	235.109975	901	44.108349	32.255394	0.857936
46	1800-2700	E-N	297.8137	335.903455	95	227.53566	192.691114	3.8
46	1800-2700	E-S	297.8137	335.903455	13	288.72591	236.997117	5.461538
46	1800-2700	E-W	297.8137	335.903455	2	188.58529	154.304477	3
46	1800-2700	W-N	4.172328	25.021368	10	66.988323	48.560375	1.8
46	1800-2700	W-S	4.172328	25.021368	5	20.451803	16.857237	0.4
46	1800-2700	W-E	4.172328	25.021368	5	33.879618	22.130823	1
46	1800-2700	S-N	25.57083	117.355095	323	24.097211	13.378491	0.609907
46	1800-2700	S-E	25.57083	117.355095	23	18.629101	11.165365	0.521739
46	1800-2700	S-W	25.57083	117.355095	4	43.443534	30.442014	1.25
46	1800-2700	N-S	37.9228	176.127837	454	22.721277	12.114066	0.548458
46	1800-2700	N-E	37.9228	176.127837	7	39.762082	29.30905	1
46	1800-2700	N-W	37.9228	176.127837	16	30.625736	20.601603	0.8125
46	1800-2700	Total	91.36992	335.903455	957	48.231436	34.597879	0.988506
46	2700-3600	E-N	329.0377	341.359039	104	247.96604	209.09727	4.461538
46	2700-3600	E-S	329.0377	341.359039	20	298.18788	249.835739	5.45
46	2700-3600	E-W	329.0377	341.359039	3	215.18049	179.228726	3
46	2700-3600	W-N	5.699555	32.04808	10	63.396109	43.715699	1.8
46	2700-3600	W-S	5.699555	32.04808	5	33.147658	27.658089	0.8
46	2700-3600	W-E	5.699555	32.04808	7	45.694113	33.558631	1.428571
46	2700-3600	S-N	28.71281	161.85332	302	22.971086	12.689933	0.559603
46	2700-3600	S-E	28.71281	161.85332	21	19.91063	11.268656	0.619048
46	2700-3600	S-W	28.71281	161.85332	8	61.051332	49.364925	1.5
46	2700-3600	N-S	45.8699	188.483186	465	21.925511	12.261758	0.544086
46	2700-3600	N-E	45.8699	188.483186	3	29.805467	19.658282	1
46	2700-3600	N-W	45.8699	188.483186	10	21.639585	14.839621	0.5
46	2700-3600	Total	102.33	341.359039	958	54.136015	40.150192	1.115866
46	3600-4500	E-N	326.6175	337.663361	102	200.74909	173.608222	2.529412
46	3600-4500	E-S	326.6175	337.663361	37	208.54533	172.591303	3.567568
46	3600-4500	E-W	326.6175	337.663361	5	154.63891	130.814172	2
46	3600-4500	W-N	4.967233	26.406961	12	49.077199	30.355498	1.75
46	3600-4500	W-S	4.967233	26.406961	6	55.831411	50.490716	0.833333
46	3600-4500	W-E	4.967233	26.406961	2	7.611059	1.889259	0.5
46	3600-4500	S-N	25.93503	134.890603	339	21.798145	12.348056	0.536873
46	3600-4500	S-E	25.93503	134.890603	26	27.815791	18.779106	0.730769
46	3600-4500	S-W	25.93503	134.890603	4	55.143234	42.591898	1.5
46	3600-4500	N-S	32.29571	146.709878	434	21.470396	11.420251	0.56682
46	3600-4500	N-E	32.29571	146.709878	8	33.849174	22.981179	1.125
46	3600-4500	N-W	32.29571	146.709878	13	29.649736	18.658302	0.846154
46	3600-4500	Total	97.45386	337.663361	988	48.798242	36.07934	0.910931

Run-3	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
47	900-1800	E-N	227.8468	335.592083	109	204.07828	175.956343	3.12844
47	900-1800	E-S	227.8468	335.592083	12	167.85774	136.07922	3.333333
47	900-1800	E-W	227.8468	335.592083	3	164.38511	129.178699	3
47	900-1800	W-N	6.140922	42.673533	6	57.132078	38.258391	1.666667
47	900-1800	W-S	6.140922	42.673533	10	36.517953	30.608741	0.8
47	900-1800	W-E	6.140922	42.673533	8	45.388523	33.505958	1.125
47	900-1800	S-N	28.19473	145.935832	305	22.89497	12.981863	0.590164
47	900-1800	S-E	28.19473	145.935832	23	22.876678	15.424959	0.608696
47	900-1800	S-W	28.19473	145.935832	6	66.132867	52.327655	1.666667
47	900-1800	N-S	37.98301	184.168347	469	20.619716	10.73379	0.471215
47	900-1800	N-E	37.98301	184.168347	5	63.265923	49.897675	1.6
47	900-1800	N-W	37.98301	184.168347	17	19.666835	12.30763	0.470588
47	900-1800	Total	75.04138	335.592083	973	45.272662	33.015917	0.881809
47	1800-2700	E-N	324.0515	335.915571	103	191.11415	161.90829	3.116505
47	1800-2700	E-S	324.0515	335.915571	29	232.72784	191.317086	4.482759
47	1800-2700	E-W	324.0515	335.915571	2	249.29961	191.422812	6
47	1800-2700	W-N	7.437466	37.836812	17	54.885839	37.728389	1.411765
47	1800-2700	W-S	7.437466	37.836812	6	33.951226	27.947925	0.833333
47	1800-2700	W-E	7.437466	37.836812	6	39.946412	28.318582	1.333333
47	1800-2700	S-N	25.22196	124.380828	326	22.543195	12.845764	0.539877
47	1800-2700	S-E	25.22196	124.380828	19	25.753104	18.211394	0.631579
47	1800-2700	S-W	25.22196	124.380828	1	74.672884	57.334998	2
47	1800-2700	N-S	38.38727	172.796305	464	23.575052	12.842013	0.564655
47	1800-2700	N-E	38.38727	172.796305	3	73.310063	55.707745	2
47	1800-2700	N-W	38.38727	172.796305	17	28.456619	20.820859	0.764706
47	1800-2700	Total	98.77455	335.915571	993	48.201903	34.901731	0.977845
47	2700-3600	E-N	327.5575	341.338482	107	227.21438	192.099194	3.831776
47	2700-3600	E-S	327.5575	341.338482	12	235.84349	194.327098	4.5
47	2700-3600	E-W	327.5575	341.338482	3	188.61481	159.235901	4.333333
47	2700-3600	W-N	4.52442	38.449976	7	42.051427	27.023988	1.142857
47	2700-3600	W-S	4.52442	38.449976	12	34.593787	29.628821	0.75
47	2700-3600	W-E	4.52442	38.449976	3	81.630875	69.670679	2
47	2700-3600	S-N	28.00813	118.557698	319	21.658765	12.462894	0.53605
47	2700-3600	S-E	28.00813	118.557698	29	26.08727	17.766173	0.655172
47	2700-3600	S-W	28.00813	118.557698	9	56.853455	46.328073	1.333333
47	2700-3600	N-S	44.02551	179.46775	393	24.12174	13.789819	0.603053
47	2700-3600	N-E	44.02551	179.46775	4	54.304891	39.1231	1.75
47	2700-3600	N-W	44.02551	179.46775	27	26.168137	16.69717	0.740741
47	2700-3600	Total	101.0289	341.338482	925	51.073777	37.894619	1.044324
47	3600-4500	E-N	328.552	341.322827	99	216.46924	182.19648	3.434343
47	3600-4500	E-S	328.552	341.322827	30	219.99353	181.736455	4.2
47	3600-4500	E-W	328.552	341.322827	3	173.13234	144.250642	3
47	3600-4500	W-N	4.833786	25.52774	10	29.171725	16.235874	1.1
47	3600-4500	W-S	4.833786	25.52774	13	33.311989	28.434014	0.769231
47	3600-4500	W-E	4.833786	25.52774	2	94.630224	82.853557	2
47	3600-4500	S-N	25.97985	110.740979	346	22.392667	12.677039	0.554913
47	3600-4500	S-E	25.97985	110.740979	15	29.903635	21.166005	0.733333
47	3600-4500	S-W	25.97985	110.740979	6	67.183089	55.956577	1.333333
47	3600-4500	N-S	39.04454	222.589317	410	22.932099	12.896742	0.558537
47	3600-4500	N-E	39.04454	222.589317	3	45.233409	28.91668	1.666667
47	3600-4500	N-W	39.04454	222.589317	18	22.816518	15.136795	0.666667
47	3600-4500	Total	99.60253	341.322827	955	50.274099	36.970017	1.002094

Run-4	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
48	900-1800	E-N	163.6037	201.094448	108	185.38066	162.237995	2.62037
48	900-1800	E-S	163.6037	201.094448	20	193.63922	166.52509	3.15
48	900-1800	E-W	163.6037	201.094448	2	115.25314	96.973637	2
48	900-1800	W-N	3.448429	31.182329	5	56.767863	41.378744	1.6
48	900-1800	W-S	3.448429	31.182329	8	34.588872	29.643234	0.625
48	900-1800	W-E	3.448429	31.182329	4	41.453395	32.553708	1
48	900-1800	S-N	24.61428	134.642142	300	21.84815	12.603368	0.54
48	900-1800	S-E	24.61428	134.642142	7	9.695188	4.733179	0.285714
48	900-1800	S-W	24.61428	134.642142	6	53.327103	41.288934	1.5
48	900-1800	N-S	39.86835	183.135765	433	20.551863	10.7956	0.526559
48	900-1800	N-E	39.86835	183.135765	5	55.74204	43.241655	1.4
48	900-1800	N-W	39.86835	183.135765	20	18.706494	11.75609	0.5
48	900-1800	Total	57.8837	201.094448	918	45.037948	33.56003	0.85512
48	1800-2700	E-N	289.4339	340.939174	101	216.92547	189.162255	2.990099
48	1800-2700	E-S	289.4339	340.939174	26	245.33063	207.616376	4.153846
48	1800-2700	E-W	289.4339	340.939174	3	246.20567	210.386869	3.666667
48	1800-2700	W-N	5.924059	24.835743	7	38.387264	22.11856	1.285714
48	1800-2700	W-S	5.924059	24.835743	13	45.550783	40.460741	0.769231
48	1800-2700	W-E	5.924059	24.835743	4	50.684015	41.049063	1.25
48	1800-2700	S-N	22.30029	111.827653	295	22.706153	12.806488	0.589831
48	1800-2700	S-E	22.30029	111.827653	18	28.311291	19.785203	0.722222
48	1800-2700	S-W	22.30029	111.827653	3	90.331314	74.662854	2
48	1800-2700	N-S	43.89736	171.203992	466	24.490762	13.774882	0.609442
48	1800-2700	N-E	43.89736	171.203992	1	95.122415	77.0101	2
48	1800-2700	N-W	43.89736	171.203992	22	25.790685	17.685447	0.681818
48	1800-2700	Total	90.3889	340.939174	959	51.766858	38.814193	0.979145
48	2700-3600	E-N	328.8758	341.335065	108	208.06684	176.746806	3.462963
48	2700-3600	E-S	328.8758	341.335065	24	246.79287	208.760984	4.291667
48	2700-3600	E-W	328.8758	341.335065	2	206.34352	175.898741	3
48	2700-3600	W-N	5.026321	19.850258	7	59.578832	42.147074	1.714286
48	2700-3600	W-S	5.026321	19.850258	7	48.231068	42.714573	0.857143
48	2700-3600	W-E	5.026321	19.850258	4	57.025173	43.802856	2
48	2700-3600	S-N	29.92989	132.369552	321	23.114568	13.004094	0.5919
48	2700-3600	S-E	29.92989	132.369552	19	25.213192	17.177821	0.684211
48	2700-3600	S-W	29.92989	132.369552	5	84.217696	70.31858	1.8
48	2700-3600	N-S	27.31631	147.376595	387	18.855577	9.418448	0.475452
48	2700-3600	N-E	27.31631	147.376595	3	20.433152	14.468908	0.666667
48	2700-3600	N-W	27.31631	147.376595	22	17.648628	9.676342	0.590909
48	2700-3600	Total	97.78707	341.335065	909	50.446972	37.374555	1.012101
48	3600-4500	E-N	327.0448	335.907872	96	210.64409	182.669673	3.270833
48	3600-4500	E-S	327.0448	335.907872	31	285.46481	233.566121	6.032258
48	3600-4500	E-W	327.0448	335.907872	1	328.42308	283.764739	5
48	3600-4500	W-N	5.391733	26.150846	15	53.314239	36.213241	1.666667
48	3600-4500	W-S	5.391733	26.150846	10	20.430198	16.119042	0.5
48	3600-4500	W-E	5.391733	26.150846	5	32.169915	22.210061	1.2
48	3600-4500	S-N	23.62991	133.237943	324	22.104261	12.498576	0.533951
48	3600-4500	S-E	23.62991	133.237943	19	25.057573	15.749226	0.631579
48	3600-4500	S-W	23.62991	133.237943	3	61.109042	51.039301	1.333333
48	3600-4500	N-S	35.1008	160.348669	421	22.747434	12.026425	0.598575
48	3600-4500	N-E	35.1008	160.348669	2	28.136471	19.416625	1
48	3600-4500	N-W	35.1008	160.348669	22	27.56966	19.608784	0.727273
48	3600-4500	Total	97.79181	335.907872	949	51.238363	37.841186	1.054795

Run-5	Attributes							
Sim-run	Interval	Direction	QLEN	Max. Qlength	VEHS(ALL)	Veh. Delay	Stopped Delay	Stops
49	900-1800	E-N	265.7923	335.819088	104	207.41047	180.580954	2.75
49	900-1800	E-S	265.7923	335.819088	25	223.76608	186.679484	3.8
49	900-1800	E-W	265.7923	335.819088	3	247.28256	213.266949	4.333333
49	900-1800	W-N	2.440443	18.7293	5	43.508104	27.774306	1.6
49	900-1800	W-S	2.440443	18.7293	6	41.89236	36.476124	0.833333
49	900-1800	W-E	2.440443	18.7293	2	25.40108	13.095372	2
49	900-1800	S-N	31.80024	150.423337	342	21.975012	12.065811	0.532164
49	900-1800	S-E	31.80024	150.423337	20	25.554221	17.275318	0.65
49	900-1800	S-W	31.80024	150.423337	8	86.150525	71.172849	1.875
49	900-1800	N-S	43.47908	241.035882	429	19.479514	10.456119	0.477855
49	900-1800	N-E	43.47908	241.035882	3	39.622075	28.408114	1.333333
49	900-1800	N-W	43.47908	241.035882	16	27.455631	18.037802	0.6875
49	900-1800	Total	85.87802	335.819088	963	47.82658	35.692655	0.873313
49	1800-2700	E-N	329.055	341.32166	99	212.10688	181.842393	3.434343
49	1800-2700	E-S	329.055	341.32166	19	260.19209	218.518574	5.210526
49	1800-2700	E-W	329.055	341.32166	7	266.34207	220.643342	5.142857
49	1800-2700	W-N	2.350453	18.999778	2	45.150452	26.596087	2
49	1800-2700	W-S	2.350453	18.999778	6	37.560009	33.267631	0.666667
49	1800-2700	W-E	2.350453	18.999778	8	25.714011	14.71902	1.25
49	1800-2700	S-N	33.10338	187.83183	362	23.343959	13.679157	0.569061
49	1800-2700	S-E	33.10338	187.83183	17	31.939754	22.960941	0.823529
49	1800-2700	S-W	33.10338	187.83183	2	48.330196	34.488266	1.5
49	1800-2700	N-S	39.70394	202.82041	446	22.958397	13.016746	0.547085
49	1800-2700	N-E	39.70394	202.82041	7	43.918945	30.389193	1.142857
49	1800-2700	N-W	39.70394	202.82041	25	17.95804	9.732473	0.56
49	1800-2700	Total	101.0532	341.32166	1000	48.413977	35.741975	0.982
49	2700-3600	E-N	329.8425	341.367892	106	221.59393	186.049121	3.943396
49	2700-3600	E-S	329.8425	341.367892	14	239.70527	196.423955	4.214286
49	2700-3600	E-W	329.8425	341.367892	2	216.89147	182.040907	4
49	2700-3600	W-N	4.41559	20.033786	8	55.663503	38.84615	1.375
49	2700-3600	W-S	4.41559	20.033786	5	27.81578	22.756545	0.6
49	2700-3600	W-E	4.41559	20.033786	5	22.703388	17.207836	0.4
49	2700-3600	S-N	20.58239	114.425235	285	20.450068	11.471417	0.498246
49	2700-3600	S-E	20.58239	114.425235	20	22.237381	15.335667	0.6
49	2700-3600	S-W	20.58239	114.425235	3	71.813452	59.196899	1.666667
49	2700-3600	N-S	25.24325	108.693506	390	17.810467	9.358252	0.476923
49	2700-3600	N-E	25.24325	108.693506	4	70.634956	56.208622	1.75
49	2700-3600	N-W	25.24325	108.693506	18	17.031485	10.638615	0.5
49	2700-3600	Total	95.02094	341.367892	860	48.8374	36.238978	1.002326
49	3600-4500	E-N	329.9128	335.894885	93	219.85078	185.411464	4.010753
49	3600-4500	E-S	329.9128	335.894885	26	320.14227	274.865114	5.423077
49	3600-4500	E-W	329.9128	335.894885	2	416.69513	363.196487	7
49	3600-4500	W-N	3.320707	25.326277	6	54.283411	38.083839	1.666667
49	3600-4500	W-S	3.320707	25.326277	7	42.012852	37.216833	0.714286
49	3600-4500	W-E	3.320707	25.326277	4	49.55992	38.329863	1.5
49	3600-4500	S-N	24.87877	127.782573	334	22.123889	11.962012	0.58982
49	3600-4500	S-E	24.87877	127.782573	20	24.055769	17.29521	0.6
49	3600-4500	S-W	24.87877	127.782573	3	56.431593	41.779595	1.666667
49	3600-4500	N-S	33.56059	150.836946	454	22.283004	12.106385	0.539648
49	3600-4500	N-E	33.56059	150.836946	2	74.940874	56.466204	2
49	3600-4500	N-W	33.56059	150.836946	25	18.317558	10.15131	0.48
49	3600-4500	Total	97.91822	335.894885	976	50.394811	36.975473	1.04918